RĒZEKNES TEHNOLOĢIJU AKADĒMIJA
Inženieru fakultāte

REZEKNE ACADEMY OF TECHNOLOGIES
Faculty of Engineering

VIDE. TEHNOLOĢIJA. RESURSI

XII starptautiskās zinātniski praktiskās konferences materiāli
2019.gada 20.-22.jūnijs

1.SĒJUMS

ENVIRONMENT. TECHNOLOGY. RESOURCES

Proceedings of the 12th International Scientific and Practical Conference
June 20 – 22, 2019

Volume I

Rēzekne
2019

VIDE. TEHNOLOĢIJA. RESURSI. 12. starptautiskās zinātniski praktiskās konferences materiāli. 2019.gada 20.-22. jūnijs. *1.sējums.* Rēzekne: Rēzeknes Tehnoloģiju akadēmija, 2019. 373 lpp.

ENVIRONMENT. TECHNOLOGY. RESOURCES. Proceedings of the 12th International Scientific and Practical Conference on June 20-22, 2019. *Volume I,* Rezekne: Rezekne Academy of Technologies, 2019. pp. 373.

Rekomendējusi publicēšanai Rēzeknes Tehnoloģiju akadēmijas Zinātnes padome
2019. gada 23. maijā.
Recommended for publication by the Scientific Council of Rezekne Academy of Technologies on May, 23 rd, 2019.

NATIONAL DEVELOPMENT PLAN 2020

EUROPEAN UNION
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ERDF co-funded project "Funding of international projects in research and innovation at Rezekne Academy of Technologies" No. 1.1.1.5/18/I/012

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Print ISSN 1691-5402
Online ISSN 2256-070X

Published by Rezekne Academy of Technologies, 2019

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Environment and Resources

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 16-19

Return Migration Trends in Latvia: Re-attracting the Main Human Resource for Sustainable Regional Development

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***Abstract*—This study is devoted to the research of human resources as a main source of sustainable regional development in Latvia. It is focused on two key concepts of human capital and migration. The aim of the study is to explore return migration geographies by looking at young return migrants as a resource and preconditions for sustainable regional development essential to Latvia.**

Return migration to the regions of Latvia is examined by two main research questions. What are the most recent return migrant characteristics in Latvia? How does return migration of young Latvians translates into regional geographies of return migration?

Drawing on most recent available statistical data we elaborate on the return migration trends in Latvia, look at particular geographies of return migrants to the regions of Latvia. Findings show that return migrants are working age accompanied with their offspring's, majority not married and return from another European country to the capital and other largest cities and surrounding municipalities. Even more, only ethnicity and country of previous residence serve as return migration predictor.

***Keywords*— return migration, regions, geography, and regional development**

I. Introduction

Even thought, the majority of recent studies on migration issues in Latvia focus on emigration which in terms of numbers and topicality allocates the leading positions among researchers in Latvia [1, 2, 3]. However, depopulation issues like elsewhere in Europe particularly in peripheral parts along with demographic challenges push to seek return migration as resource of available human capital. There are studies on return migration in Latvia [4; 5, 6]. Similar to studies elsewhere in Europe aspects of internal regional geography of emigration and also return migration are examined and also noting the presence of importance of contemporary circular movements in Europe [7, 8, 9].

Human capital in the view of migration processes manifests as migrant's individual gain and investment in the form of knowledge including languages, information, ideas, obtained skills and professional competences among migrants are particularly worthy [10]. It was previously found that return migrants to more rural and peripheral parts bring potential of knowledge-based development [11].

Traditionally, return migrants are seen as potential human capital that can be reinvested in the country of origin. At the individual level, the attraction to the region or city of origin has important emotional aspect and belonging to the certain place [12, 6] as well as support of family [13]. Return migration decision making process is not easy it is combination of personal, family, cultural and also economic aspects [14, 15]. But turbulent politic and economic events as Brexit, refugee crisis and terrorism can be important trigger to promote return migration to more peripheral parts of the EU under the conditions if individual labour market niche thus economic needs are satisfied.

Despite the level of satisfaction, self-valued gains from the international experience and difficulties individual needs to overcome upon return feeling of belonging and longing for home often overcome the economic aspects of return [5].

Upon return reintegration process commence including re-accustomed in local environment and similar to the previous studies on Lithuanian and polish return migrants [13, 16].

Following research questions are addressed in this study:

1. What are the most recent return migrant characteristics in Latvia?
2. How does return migration of young Latvians translates into regional geographies of return migration?

II. DATA AND METHODS

This study is based on descriptive and inferential statistics analysis of officially available data on return migration to Latvia provided by the Central Statistical Bureau of Latvia [17]. In the analysis we consider years 2014, 2015 and 2016 and also average calculations for

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4117

these years for several characterising features. Analysed data set is structured according to administrative data sets thus allowing identifying and distinguishing Latvian origin return migrant cohort from the overall in-migration turnover.

The framework of the study consists of three steps:

(1) we provide descriptive statistics on current return migrants to Latvia, considering three years (2014, 2015, 2016) and following variables: gender, age group, civil status, region of origin and country of previous residence. Countries of previous residence are coded: ES -28 (European Union countries), EFTA (European Free Trade Association countries), CIS (Commonwealth of Independent States countries) and other countries.

(2) we provide the regional municipality level analysis (see Figure 1) where only the share of young (aged 15 – 34) migrants are analysed and visualised on the map.

(3) we use inferential statistics and perform multinomial logistic regression in order to analyse predictors for regional differences of young return migrants in Latvia.

III. RESULTS AND DISCUSSION

Table 1 shows the main features and dynamics of return migrants to Latvia in 3 year period. In terms of gender balance in 2014 nearly 60% of return migrants were men, but in 2016 the proportion has changed and is rather equal (52 % men and 48% women). Age group structure of return migrants shows that constant majority of return migrants are aged 25 to 45 years of age accompanied with the second largest return migrant group aged 0 to 15 years of age suggesting that working age families with children are returning. Family status over the three year period remains rather steady with just over 70% per cent single, divorced and widowed persons who return and nearly 30% of married return migrants.

TABLE 1

CHARACTERISTICS OF RETURN MIGRANTS TO LATVIA IN PERIOD FROM 2014 – 2016

	2014	**2015**	**2016**	*Average*
Gender				
Man	59.0%	55.4%	51.6%	*55.6%*
Women	41.0%	44.6%	48.4%	*44.4%*
Age group				
0-15	19.8%	25.1%	25.6%	*23.2%*
16-25	8.1%	9.3%	9.0%	*8.8%*
26-45	45.3%	43.5%	44.0%	*44.3%*
46-61	21.3%	15.9%	15.0%	*17.7%*
62+	5.6%	6.2%	6.5%	*6.0%*
Civil status				
Single, divorced, widowed	73.1%	74.5%	71.2%	*73.0%*
Married	26.9%	25.5%	28.8%	*27.0%*
Region of origin				
Rīga	32.2%	34.5%	33.7%	*33.4%*
Pierīga	17.3%	14,7%	15.7%	*16.0%*
Latgale	15.6%	15.4%	16.0%	*15.7%*
Zemgale	11.8%	12.8%	12.1%	*12.2%*
Kurzeme	12.8%	13.0%	12.9%	*12.9%*
Vidzeme	10.2%	9.5%	9.6%	*9.8%*
Country of previous residence				
EU-28	82.5%	82.1%	83.0%	*82.5%*
EFTA	1.9%	2.5%	2.6%	*2.3%*
CIS	10.2%	9.3%	7.8%	*9.2%*
Other	5.4%	6.1%	6.6%	*6.0%*

Regional geography of return migration to Latvia shows that the majority return to core parts of Latvia. This corresponds to other studies core regions outnumber the returnees because of range of economic options [18]. On average in three year period 33% returned to Riga and 16% returned to Pieriga region. Among the statistical regions of Latvia in year 2016 the highest share returned to Latgale (16%), followed by Kurzeme (12.9%) and Zemgale (12.1%), but around 10% returned to Vidzeme. On average, 200-400 return migrants per year have returned to other cities of the Republic of Latvia. In terms of regions patterns of return migration the highest rates of return migration are typical of those municipalities that include cities that act as local economic and labour market centres. The most prominent examples are the counties of Talsi, Tukums and Ogre, which include centres of regional importance. In addition, Tukums and Ogre counties are located near Riga.

Geography of countries of previous residence shows that substantial majority returned from other European countries (83% in 2016).

In order to see the potential of return migrants as a human resource which is a precondition for sustainable regional development essential to Latvia we explored the geographies of current return migrants.

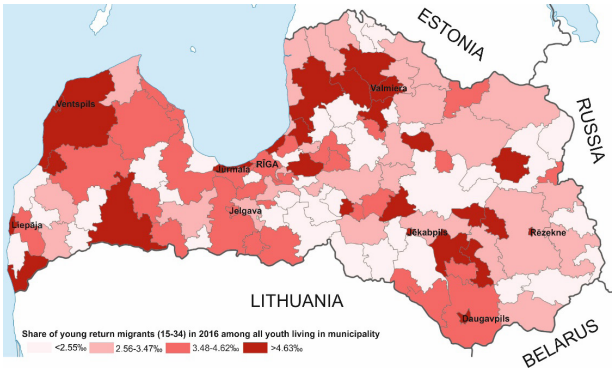

Fig 1. The share of young return migrants (15-34) in 2016 among all youth living in municipality

Results (Figure 1) reveal that young people aged 15 to 34 more prone to return to the cities (Rīga, Liepāja, Ventspils, etc.) as well as municipalities located around

cities attract most of young migrants who returned in Latvia. These findings accentuate the importance of economic activity as a driver for return migration as there attraction points of return migration are in or near cities. Unemployment rate in Ventspils, Valmiera, Rēzekne, Daugavpils, Jelgava in 2016 was at least by 2% lower in the cities than in corresponding statistical region of these cities [19]. In Riga unemployment rate was less than 2 %, but in Jekabpils, Liepaja and Jūrmala unemployment rate was higher than in statistical region on average. We assume that these findings explain why the municipalities near Jekabpils, Liepāja and Jūrmala do not attract young migrants to a similar extent as other cities in Latvia.

TABLE 3
REGIONAL DIFFERENCES AMONG YOUNG RETURN (15 – 34) MIGRANTS IN LATVIA, 2016

Variable	Rīga (n=479) OR (95% CI)	Vidzeme (n=148) OR (95% CI)	Kurzeme (n=210) OR (95% CI)	Zemgale (n=169) OR (95% CI)	Latgale (n=207) OR (95% CI)
Gender (base: Female)					
Male	1.09 (.80/1.41)	1.14 (.80/1.61)	1.16 (.85/1.60)	1.06 (.76/1.45)	1.23 (.89/1.69)
Age (base: 25-34)					
15-24	.98 (.68/1.41)	.85 (.51/1.39)	1.47(.98/2.22)	1.22 (.76/1.90)	1.14 (.74/1.76)
Civil status (base: married)					
Single	1.12 (.83/1.50)	1.07 (.72/1.59)	.92 (.64/1.31)	.85 (.59/1.24)	1.06 (.74/1.52)
Ethnicity (base: other)					
Latvian	**.58 (.36/.92)***	**3.94 (1.38/11.21)***	.70 (.40/1.21)	.62 (.35/1.11)	**.46 .25/.79)***
Russian	1.06 (.64/1.76)	1.25 (.40/3.93)	**.27 (.14/.52)****	.49 (.26/.95)	1.33 (.72/2.43)
Country of previous residence (base: other)					
EU 28	1.41 (.80/2.50)	**6.69 (1.56/30.11)***	**6.30 (2.28/17.39)****	**4.13 (1.59/10.76)****	**6.70 (2.20/20.37)****
EFTA	.59 (.18/1.90)	**9.65 (1.72/53.98)***	1.87 (.36/9.72)	1.08 (.18/6.49)	3.25 (.59/18.02)
CIS	**2.92 (1.28/6.67)***	1.25 (.01/15.40)	**4.58 (1.21/17.36)***	2.03 (.51/8.16)	**4.43 (1.13/17.30)***

*Note. Reference group: Pierīga (n=244). OR = Odds Ratio. SE = Standard Error. 95% CI = Confidence Interval. * p<.05; ** p<.01*

Municipalities located near to the border (except western part of country) and eastern parts of Latvia (Latgale) are less attractive to young return migrants. Border areas and parts of Latgale region can be classified as peripheral with minor economic activity as well as long term aging thus also depopulation processes and ethnic segmentation. For example, the unemployment rate at the end of 2016 in Latgale region was the highest in country (18%). This was two times higher than in other statistical regions and more than three times higher than in Riga [19].

A Multinomial Logistic Regression was used to analyse predictors for regional differences of young return migrants (Table 1). In analysis we used five predictors (variables). The reference category for the outcome variable was 'Pierīga region'. Each of the other five categories was compared to this reference group. The main interest of current analysis was focused on the relationship between gender, age, family status, ethnicity and country of previous residence. Results show that the differences among regions are based on two variables – ethnicity and country of previous residence. The probability of return to Riga is higher for return migrants previously residing in CIS countries, but less for ethnic Latvians. The situation in Vidzeme is quite opposite. The results suggest that young Latvian migrants from EU 28 and EFTA countries more likely choose to return to Vidzeme. Ethnic Russian young return migrants less likely choose Kurzeme region for return destination. However, Kurzeme region attracts young return migrants from EU 28 and CIS countries. Young return migrants from EU 28 countries more likely will choose Zemgale region upon their return to Latvia. The probability to return to Latgale is higher for young migrants from EU 28 and CIS countries, but less for Latvians.

We explain the findings by ethnic compositions of statistical regions of Latvia. Young Latvian migrants less likely return to the regions where high share of Russian speaking population is located (Riga and Latgale – 54%), but more likely choose Vidzeme (Russian speaking population is less than 13%) [20]. Findings related to the country of previous residence of the return migrants partly confirm our assumption as well. Young migrants from CIS countries more often choose to return to Riga and Latgale. However, surprising that also Kurzeme region more likely attract young return migrants from CIS countries, although share of

Russian speaking population is only 24%.

IV. CONCLUSIONS

The study aims to provide new knowledge on regional geographies of return migration to Latvia. By doing this we addressed two research questions. Firstly we looked at characteristics of the current return migrants. The analysis suggest that in 2016 gender proportion of return migrants is rather equal and there are also no gender based preferences in terms of region of return. Majority of the returnees are working age accompanied with their offsprings, but the share of close to retirement age constitute around 7% of all returnees in 2016. Majority return migrants come from other European countries and return to the core parts.

Secondly we explore regional geographies of the return and seek the preconditions of return migration within the characteristics of particular returnees. The findings suggest that only ethnicity and country of previous residence play role in the choice of the return migration destination. Young returnees after return settle in Riga, other major cities or local municipalities around the cities, but the return location is closely linked to the unemployment rate at the particular territory. More distant, peripheral areas of Latvia have lower potential of return.

There is a statistically significant result among ethnic Latvians who display higher probability to return from another European or EFTA country to Vidzeme, but lower probability to return to Riga and Latgale, but at the same time ethnic Russians act directly opposite. Ethnic Russians have lower probability to return to Kurzeme region. Return migrants from CIS countries show higher probability to return to Riga, Kurzeme and Latgale.

ACKNOWLEDGMENTS

This paper was supported by the project 1.1.1.2/ VIAA/1/16/184.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 20-23

Saving Resources in the Construction of Hydroelectric Power Plants

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***Abstract*—The article describes run-of-the-river hydroelectric power plants. The authors specify the importance of performing technical and economic calculations in justifying the large-sized units of the water-supplying channel of a run-of-the-river hydroelectric power plant: turbine pits and suction (discharge) pipes. The study shows that the amount of construction work and the total cost of building a hydroelectric power plant depend on the size of these water supply units. The research objective is to analyze the validity of establishing the main dimensions of the suction pipes for modern technical and economic conditions. The researchers use the discounted income method. The calculations are performed for a hydroelectric power plant with an elbow suction pipe. The analysis of how the operating conditions of a hydroelectric power plant influence the savings of construction resources is carried out. The analysis shows that saving construction resources by reducing the length of the suction pipe is justified if the hydroelectric power plamt is designed to work only at peak power loads. For hydroelectric power plants operating at semi-peak or base power loads, the additional construction costs would be appropriate if leading to the decrease in pressure loss and to the increase in electricity generation.**

Keywords*—hydroelectric power plant, water supply units, saving construction resources, justification of the size of water supply units.

I. Introduction

Hydropower Plants are complex objects for multiple purposes. They are constructed for satisfying needs of various water users: supplying energy for settlement industrial enterprises, ensuring river navigation, melioration, creating reservoirs, protecting territories from flooding, etc. At their construction and operation ecological conditions and limitations should be taken into account. Some of them are considered in [1] and [2].

Hydroelectric power plants play an important role in providing electricity to various consumers during peak periods of the daily power load, since they have very high maneuvering capabilities [3], [4]. At the same time, such power plants imply significant construction costs, especially when erecting run-of-the-river hydroelectric power stations on lowland rivers [5], [6]. Costs are determined by the use of natural resources: soil, sand, crushed stone, stone, as well as expensive parts containing steel (fittings, embedded elements, metal structures) and cement (placing mass concrete in the construction, manufacturing of reinforced concrete elements) [7], [8].

In order to exclude unreasonable expenses related to expensive building materials during the construction of hydroelectric power plants, designers strive to reduce the geometric dimensions of the large-sized parts of the hydroelectric power plant building, which include the main elements of the water supply system: water intake, turbine pit and suction (discharge) pipe (Fig. 1). However, it should be noted that an excessive decrease in the dimensions of these units leads to an increase in the flow velocity and significantly deteriorates the hydraulic conditions of the water flow. These factors cause flow pressure losses and the decrease in electricity output, i.e. the amount of electricity, the most important resource for which the hydroelectric power plants are built, transferred to consumers is decreased [9], [10]. Thus, when determining the size of large-sized units of the power plant water supply, it is necessary to take into account these multidirectional influencing factors and compare possible options from technical and economic perspectives [11], [12].

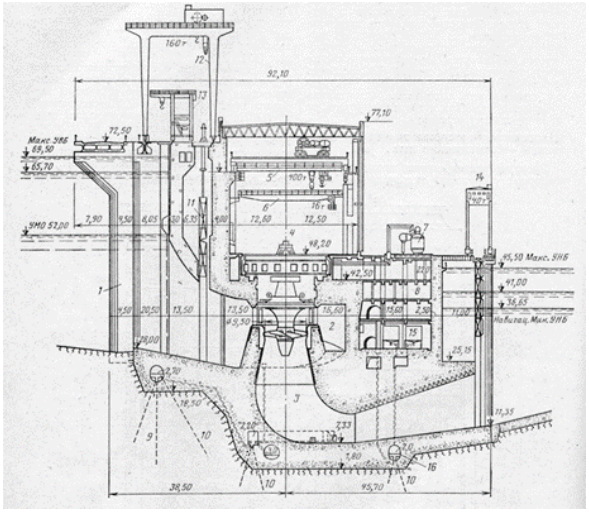

Fig. 1. Building of the run-of-the-river power plant with an elbow pipe: 1 - water intake, 2 - turbine pit, 3 - suction pipe

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4103

The objective of the studies is to analyze the validity of the main designated dimensions of one of the most critical large-sized components of the run-of-the-river hydroelectric power plant water supply – suction (discharge) pipes in terms of modern technical and economic conditions.

Materials and methods

The studies were carried out for a run-of-the-river hydroelectric power plant with parameters close to those of hydroelectric power plants built on the Volga River (Russia) on non-rocky soils. The modular buildings of these hydropower plants are equipped with large-diameter vertical water turbines. Suction pipes of such large hydropower units have elbow type designs (Fig. 1). Compared with axial vertical suction pipes, this form allows for less depth of the foundation of the modular building and less construction work during its erection. The minimum size of the vertical part of the suction pipe is subject to the requirements of the manufacturer of water turbines. These minimum dimensions are approved for the Volga hydroelectric plants [13].

The length of the diffuser (expanding in a vertical plane) part of the suction pipe does not affect the depth of the modular building, but affects the amount of concrete used and the volume of excavation for laying concrete. In order to save building resources (first, concrete), in the course of construction, the suction pipe was also designed as short as possible. Below are the studies of the feasibility of such a solution from the point of view of present day conditions.

The initial parameters of the examined variations of the geometric dimensions of the suction pipe are close to the approved parameters of the largest hydroelectric power plants on the Volga River [13]. Table I lists the main parameters.

In the calculations, we considered the variations of a suction pipe with an increased length toward the downstream by the value of ΔL. For each option, we counted the increase in the use of construction resources in terms of money ΔP according to the formula:

$$\Delta P=\sum c_i W_i+\sum s_i W_i \quad (1)$$

where c_i is the cost of i building resource (concrete, soil), s_i is the cost of performing the works for the i resource, W_i is i construction resource volume.

TABLE I.

The Main Initial Parameters of the Hydroelectric Power Plant and the Suction Pipe

Number	Parameter	Value
1	Hydro power plant hydraulic unit capacity, thousand kW	120
2	Head, m	24
3	Water turbine diameter, m	8.2
4	Estimated water consumption, m^3/s	560
5	Initial length of the suction pipe (relative to the turbine diameter)	3.5

However, the increase in the length of the diffuser part of the suction pipe causes an increase in the area of its output section. Thus, the average speed of the water flow in the output section decreases, which causes a decrease in the loss of velocity head in the output section by the value of Δh:

$$\Delta = \left(\frac{\alpha V^2}{2g} \quad \frac{\alpha V_1^2}{2g}\right) \quad (2)$$

where V and V_1 are the average flow rates of water in the output section of the initial version and the version with an extended diffuser section, respectively, α is the coefficient of uneven velocity of the water flow.

Reducing head loss, in turn, results in additional power ΔN and additional power generation ΔE, and, consequently, extra income ΔD from selling additional electricity, respectively, by the values [14]:

$$\Delta N=9{,}81\eta Q\Delta h \quad (3)$$

$$\Delta E=\Delta NT_N \quad (4)$$

$$\Delta D=\Delta Eb \quad (5)$$

where η is the efficiency of the hydroelectric unit, Q is water consumption, T_N is the relative annual number of hours of use of hydropower capacity, b is the rate per 1 kWh of electricity.

Obtaining additional income took place for a number of subsequent years T of hydroelectric power plant operation. For adequate comparison of the additional income with additional expenses, the former was changed to match the initial year, taking into account the discount rate:

$$\Delta D_d = \sum_{t=0}^{T} \Delta D_t (1+R)^{-t} \quad (6)$$

where ΔD_t is the value of additional income per year t, T is the considered calculation period, t is the current year, R is the value of the discount rate.

The ranges of variable parameters for the study of the influence of the suction pipe length are given in Table II.

TABLE II.

Variable parameters

Number	Parameter	Value
1	Increasing the length of the suction pipe, m	from 0 to 24
2	Hours of use of installed capacity per year, hours	from 1000 up to 7000
3	Electricity rate in the first year, rub/kWh	from 3.4 to 4.8
	Dynamics of electricity rate,% per year	from 0 to 10
4	Additional single costs for construction work, thousand rubles/m^3	from 6 to 12
5	Discount rate, %	from 0.02 to 0.08
6	Calculation period, years	from 5 to 20

Results and discussion

Analytical calculations were carried out using computational tools, and the results were presented in graphical form. Fig. 2 shows the calculated dependences of the additional costs of construction resources on increasing length of the suction pipe for different prices of concrete. Studies have shown that the values of the additional costs do not depend on the hydroelectric power plant operating conditions and are determined directly by the ΔL parameter.

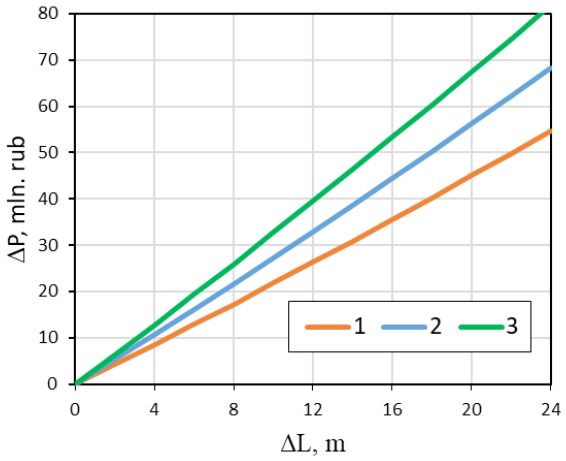

Fig. 2. The growth of additional costs while increasing the length of the suction pipe with the parameters: 1 - c_i = 8000 rubles, 2 - c_i = 10,000 rubles, 3 - c_i = 12000 rubles

Fig. 3 shows the results of calculations of the dependencies between the additional revenue of the hydroelectric power plant in current prices and the extension of suction pipe length for different values of T_N. The graphs show that the ΔD value significantly depends on the power plant operation mode within the daily load curve - the number of hours of power use. Moreover, the increase of T_N leads to an increases of ΔD.

Examples of the dependence of the discounted income and additional construction costs are shown in Fig. 4. The dependences are determined for the period T=10 years for different parameters T_N with the discount rate R=0.06.

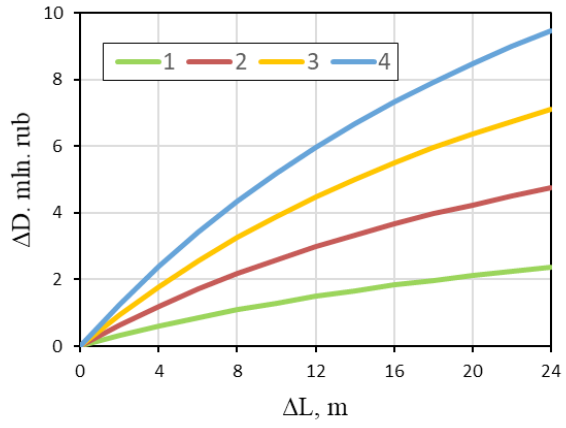

Fig. 3. The growth of additional annual income while increasing the length of the suction pipe with the parameters: 1 - T_N = 1000 hours, 2 - T_N = 2000 hours, 3 - T_N = 3000 hours, T_N = 4000 hours

The overview of the family of the obtained curves shows that for the considered ranges of changes in the operating conditions of the hydropower unit, the initial extension of the suction pipe first causes an increase in economic effect. However, with further increase in the dimensions of the pipe, the effect of the additional electricity generation decreases more intensively, which also causes a decrease in the overall economic effect.

The data obtained indicate that at small number of hours of use of hydroelectric power plant (which is typical of hydroelectric power plants operating at peak times of daily power load curve), the increasing length of the suction pipe has practically no overall economic effect. However, for hydroelectric power plants operating at the semi-peak and base daily power loads, increasing the length of the suction pipe can provide a significant effect. So, at T_N = 3000 hours for the considered parameters of a hydroelectric power plant, an extension of the pipe is economically justified for the whole range ΔL from 0 to 17.4 m. The maximum effect of 5.5 million rubles can be obtained at ΔL = 8.0 m. This value can be considered optimal for the length of the suction pipe variable parameter.

The results obtained are important for the correct selection of the main geometrical parameters of the water supply units and can be used in establishing the sizes of the suction pipes in the designs of hydroelectric power plants.

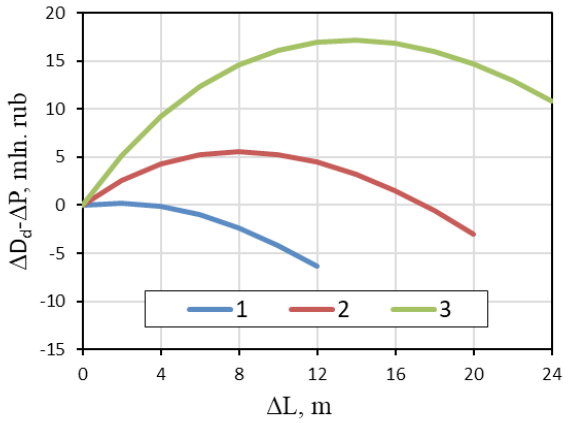

Fig. 4. Difference curve of the discounted income for the period T=10 years and additional construction costs with increasing length of the suction pipe for the parameters: 1 - T_N = 2000 hours, 2 - T_N = 3000 hours, 3 - T_N = 4000 hours

Conclusions

The main conclusions of the research can be formulated as follows:

1. For hydroelectric run-of-the-river power plants with elbow suction pipes, saving construction resources by reducing the length of the suction pipe is justified if the hydropower station is designed to work only at peak power loads.
2. For hydroelectric power plants operating at semi-peak or base power loads, the additional construction costs would be appropriate if leading to the increase in electricity generation.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 24-28

Calculation of Target Reliability SAIDI for Distribution Lines

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***Abstract*—in modern distribution lines reliability indicators are attached great importance. In regulations of the Russian Federation indicated the reliability indicators, which must be counted by Grid Company. SAIDI is one of them. In this article you can see the author's calculation of reliability indicator SAIDI for the distribution lines. Also there are an example of this calculation and comparing with the real measure, which we have taken from software complex «Accident».**

Keywords — SAIDI, electricity supply restoring, distribution line, the electrical consumer.

I. Introduction

In the order of the Ministry of Energy of the Russian Federation № 1256 are used two indicators of reliability for the territorial Grid Company. One of them is a system average interruption frequency index (SAIFI) and another one is a customer average interruption duration index (CAIDI). This situation made it necessary to formulate methods of calculating the reliability of the final electrical consumers [1]. In this article the technique of calculating reliability indicator SAIDI.

Overview of Russian and foreign publications [2-9] was showed that the reliability of the SAIDI can only be determined according to the statistical information of exploitation. Thus, you can obtain an assessment of indicators of reliability the line before reconstruction.

During the engineering of the new or the reconstructing distribution line, we should to assess its reliability. Such assessment is required primarily for feasibility study of construction or reconstruction of distribution lines. In this regard, the purpose of this work is to obtain a reliability indicator calculation methodology SAIDI distribution lines in the engineering phase. This confirms the relevance of this article.

II. Materials and methods

SAIDI is the average outage duration for each customer served, and is calculated as:

$$SAIDI = \frac{\sum_{i=1}^{n} T_{sum,i} N_i}{N_T} \text{ [h]}, \quad (1)$$

where $T_{sum,i}$ – the annual outage time for the i-th place, N_i - the number of customers in the i-th place, N_T - the total number of customers served, n – number of plots.

Estimated time to restore electricity consumers of the 1st section and those that cannot be included, when the i-station is damaged is calculated as:

$$t_{REC,i} = t_{beg,i} + t_{search,i} + t_{loc,i} + t_{on,i} + t_{sweap,i} + t_{rep,i}, \quad (2)$$

where $t_{beg,i}$ – the time from the moment of blackout to the search, $t_{search,i}$ – while searching for a damaged, $t_{loc,i}$ – the localization of the damaged, $t_{on,i}$ – time to include those loads that can be included in absence in the schema of the damaged site, $t_{sweap,i}$ – time to crawl the damaged, $t_{rep,i}$ – time to repair the damaged section and incorporate loads of online/offline users to start repairs. The time from the moment of blackout till the beginning of searching is calculated as:

$$t_{beg} = t_{\text{inf}} + t_{waiting} + t_{transport}, \quad (3)$$

where t_{inf} – the time from the moment of blackout to receipt of this, $t_{waiting}$ – operational readiness, $t_{transport}$ – time spending on the move.

Take time from the moment of blackout to the search for damage t_{beg}=1 h.

Take time to repair the damaged section and incorporate loads of online/offline users to top repair $trep=5$ h.

Time to restore electricity other electrical consumers who may be included, if the damage is in the i-th plot is calculated as:

$$t_{rec,i} = t_{beg,i} + t_{search,i} + t_{loc,i} + t_{on,i} = t_{REC,i} - (t_{sweep,i} + t_{rep,i}). \quad (4)$$

Time to sweap the simplest part of electricity transmission line is calculated as:

$$t_{sweap,i} = \frac{L_{i\,i}}{2v} + \frac{L_i - L}{2\alpha v}, \quad (5)$$

where L_i − full length reporting line section; L_{Mi} − the length of the of electricity transmission line; v − average crawl speed; α − coefficient that takes account of the increase in crawl speed lines, when mobile group return from a spur. The simplest part of electricity transmission line is such a part of the line where no switchgear equipment and devices accelerating search of damage.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4054

In the absence of data exploitation on annual downtime of consumers in the distribution lines, index SAIDI is calculated as:

$$SAIDI = \frac{\sum_{i=1}^{n} N_{off,i} t_{est.rec,i} N_i}{N_T} \text{ [h]}, \quad (6)$$

where $t_{est.rec,i}$ – estimated recovery time of electricity consumer in the first place, n – number of plots.

Calculation of indicator SAIDI before reconstruction

Find SAIDI for the line in Figure 1.

For this purpose make a table to calculate the amount of failure of the 1st phase. An example of one of such tables I is below.

TABLE I.
CALCULATION OF THE NUMBER OF BLAC KOUTS PLOT № 1

№	Equipment	Number	Failure rate, year^{-1}	The average number of failures per year
1	low-oil circuit breaker	1	0.008	0.008
2	Non-isolated overhead line	5.27	0.25	1.3175
3	Transformer station	4	0.03	0.12
4	Disconnector	3	0.01	0.03
Total:				1.48

Example of calculation for 1-line:

$$\lambda_{\Sigma 1} = n_1 \cdot \lambda_1 = 1 \cdot 0.008 = 0.008 \ \frac{\text{failure}}{\text{year}}. \quad (7)$$

We assume that the transformer station has a switch or there is a wireman, who can make a switch. The length of a given line in km. Average crawl speed line installed 4 km/h. Coefficient α is 1,25. The average speed of cars along the lines is 40 km/h. Switching is t_{switch}=3 min.

We divide the original schema on 4 independent sites, that can be accessed using the disconnectors (Figure 1). On the concept will find distance between switching devices (Table II). Find transport time from one switching apparatus to another (Table III).

TABLE II.
CALCULATION OF DISTANCES

	D1	D2	D3
Q	0.05	1.56	3.6
D1	-	1.51	3.55
D2	-	-	2.04

TABLE III.
CALCULATION OF THE TRANSPORT TIME

	D1	D2	D3
Q	0.00	0.04	0.09
D1	-	0.04	0.09
D2	-	-	0.05

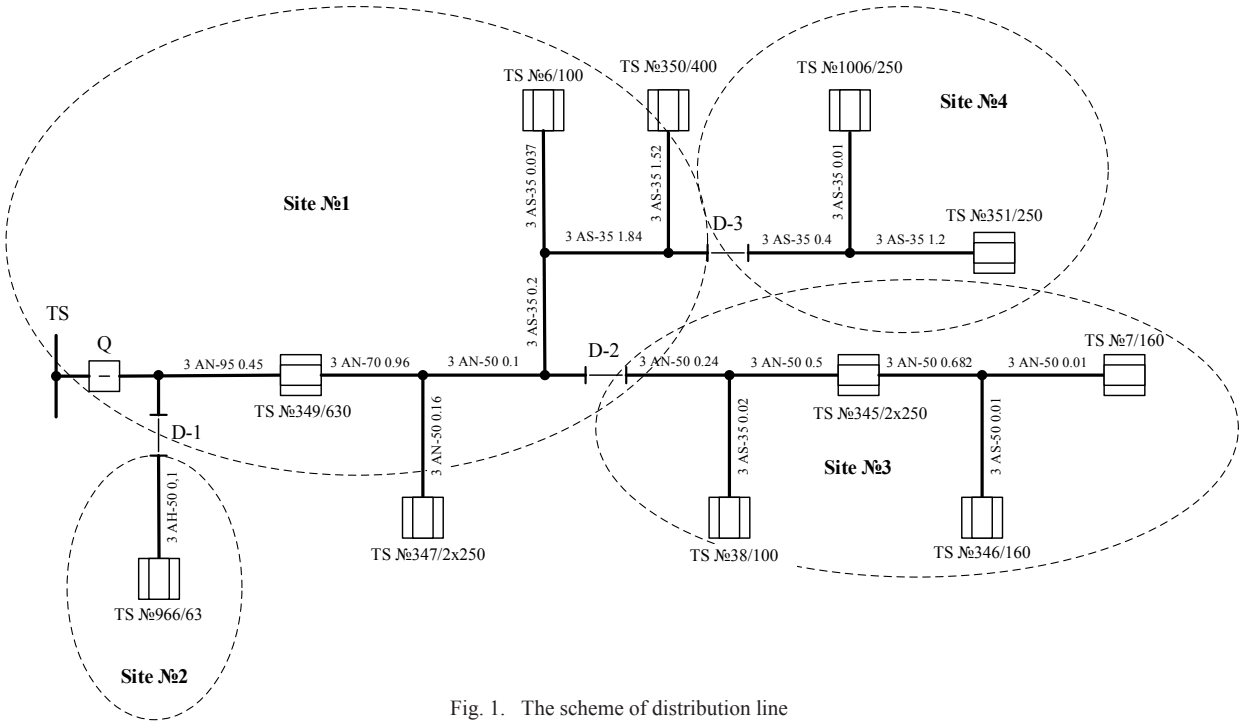

Fig. 1. The scheme of distribution line

Example of calculation of wiremen moving time from Q to D1:

$$t_{transport.D1} = \frac{l_{Q-D1}}{V_{wiremen}} = \frac{0,05}{40} \approx 0 \text{ h}. \quad (8)$$

Time to crawl sites look and bring in table IV.

TABLE I.
CALCULATION OF TIME CRAWLING SITES

№	L	L_m	v	α	t_{swep}
1	5.27	3.55	4	1.25	0.83
2	0.1	0	4	1.25	0.02
3	1.462	1.422	4	1.25	0.19
4	1.61	1.6	4	1.25	0.20

Example of calculation for 1-St line:

$$t_{sweap1} = \frac{L_1}{2v} + \frac{L_1 - L_{j\,1}}{2\alpha v} = \frac{5,27}{2 \cdot 4} + \frac{5,27 - 3,55}{2 \cdot 1,25 \cdot 4} = 0,83 \text{ h.} \quad (9)$$

To calculate the time of restoration of power supply in the event of a short circuit on all possible sections of the line, we will draw up a control scheme for the process of restoration of power supply for this line.

In the diagram, the circle marked the detach operation switching apparatus, a square operation switching on. If the circle is marked with a dashed line, it means that the wireman only goes to the switching device, and enable/ disable operation does not produce. The outcome of the incorporation of the switch is marked with an additional rectangle: white-black is enabled-disabled. Duration of operations moving, repair and crawl is shown on the diagram above.

Under the scheme of control (Figure 2) prepare the equation to calculate the recovery time of power supply тві,j, where i - lot number scheme, j - user number. Let's consider a formula to calculate the recovery time of power supply lines for different sites. Example of calculation for the accident at site 1.

Recovery time for the electricity consumers of the 1-st site of power distribution lines:

$$t_{REC1} = t_Q + t_{Q-D1} + t_{D1-D2} + t_{D2-D3} + 4t_{transport} + t_{sweap1} + t_{rep}. \quad (10)$$

The number of electricity consumers of offline users when an accident on the 1-St station Ncust1=11.

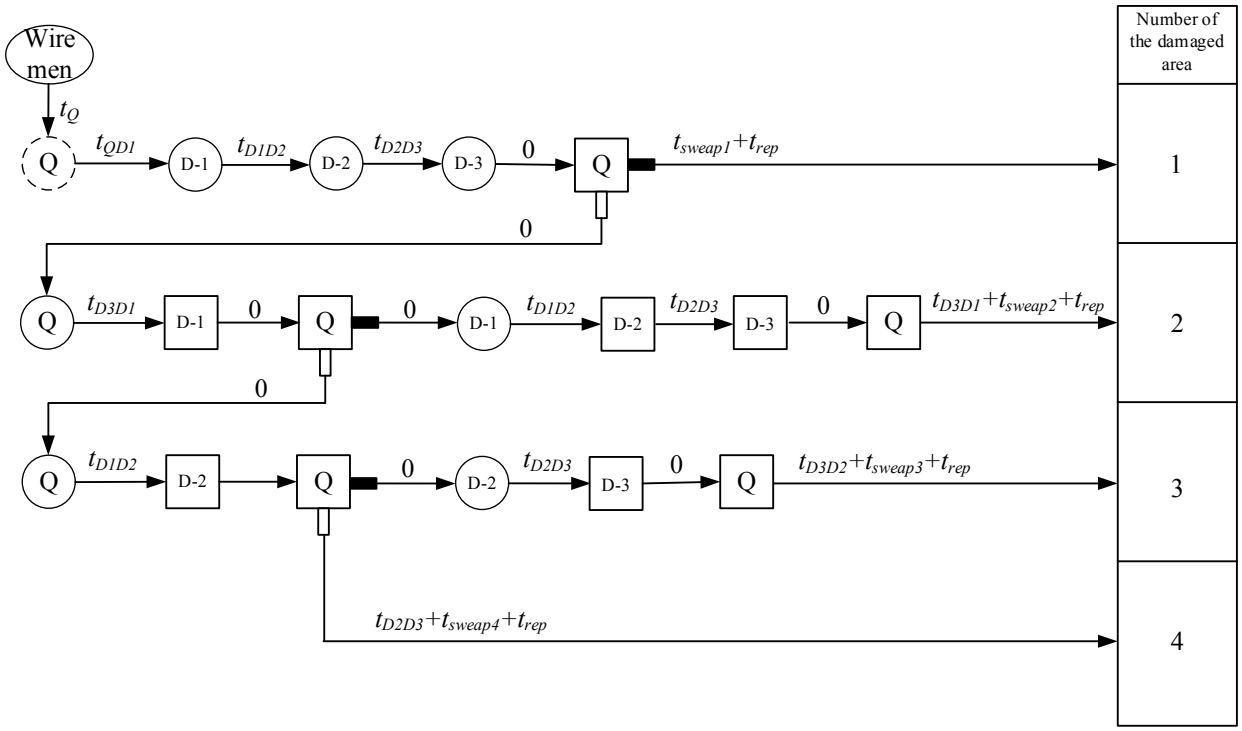

Fig. 2.Control scheme of power supply recovery process in the distribution line before the reconstruction

Find SAIDI for the distribution line before the reconstruction. For this purpose make a table V

TABLE I.
CALCULATION OF SAIDI BEFORE RECONSTRUCTION

№	N_{offi}	$T_{rec.i1}$	$N_{cust.i1}$	$T_{rec.i2}$	$N_{cust.i2}$	***SAIDIi***
1	1.48	7.1	11	0	0	10.54
2	0.1	6.9	1	1.86	10	0.22
3	0.61	7.6	4	1.87	7	2.41
4	0.46	6.9	2	1.67	9	1.20
Total:						14.37

Example of calculation for SAIDI in an accident on 1 site:

$$SAIDI_1 = \frac{N_{off1} \cdot \left(t_{REC1} \cdot N_{cust1} + t_{REC2} \cdot N_{cust2}\right)}{N_{cust}} = \quad (11)$$

$$= \frac{1,48 \cdot \left(7,1 \cdot 11 + 0 \cdot 0\right)}{11} = 10,54 \text{ h.}$$

Thus the SAIDI to reconstruction will be 14.7 h.

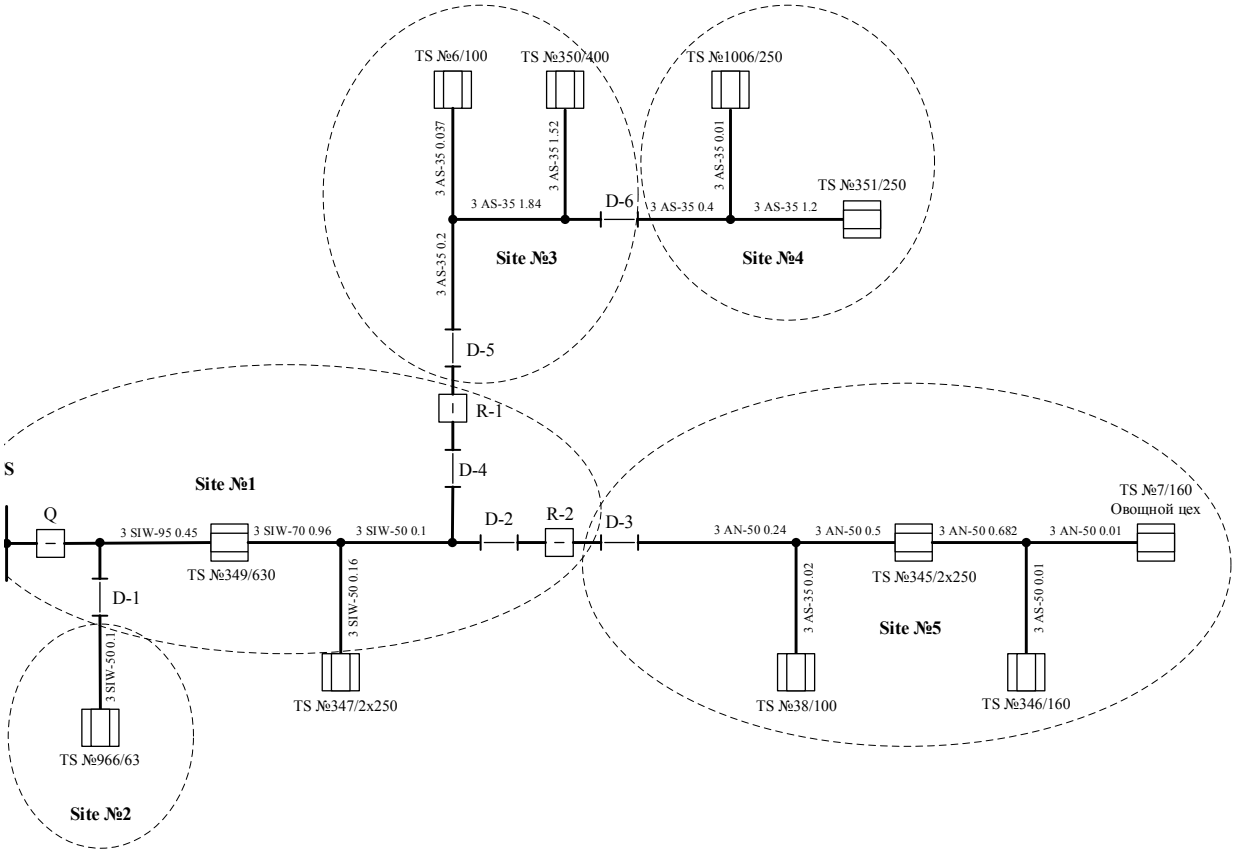

Fig. 1. Distribution Diagram of the line after reconstruction

Calculation of indicator SAIDI after reconstruction we divide the original scheme to 5 independent sites, which can be accessed using the disconnectors (Figure 3). Prepare a table to calculate the amount of bounce of the 1st phase. An example of one of such tables is below.

TABLE VI

CALCULATION OF THE NUMBER OF BLACKOUTS PLOT

№	Equipment	Number	Failure rate, year^{-1}	The average number of failures per year
1	Macuum load-breaking switch	3	0.004	0.012
2	Overhead line with insulated conductors	1.67	0.08	0.134
3	Transformer station	2	0.03	0.06
4	Disconnector	3	0.01	0.03
Total:				0.236

We did not do the example of calculation here, because they are like a calculating of SAIDI before reconstruction. Time to crawl sites look and bring in table VII.

TABLE VII

CALCULATION OF TIME CRAWLING SITES

№	L	L_m	v	α	t_{swep}
1	1.67	1.51	4	1.25	0.22
2	0.1	0	4	1.25	0.02
3	3.6	2.04	4	1.25	0.61
4	1.61	1.6	4	1.25	0.20
5	1.462	1.432	4	1.25	0.19

Recovery time for calculation of electricity short-circuit in all possible areas lines compose a recovery process for this line (Figure 4).

Control scheme make up the equation to calculate the recovery time of power supply $t_{RECi,j}$. Let's consider a formula to calculate the recovery time of power supply lines for different sites.

The accident at site 1

Recovery time for the electricity consumers of the 1-st site of power distribution lines:

$$t_{REC1} = t_Q + t_{Q-D1} + 2t_{transport} + t_{sweap1} + t_{rec} \qquad (12)$$

The number of electricity consumers of offline users when an accident on the 1-St station Ncust1=11.

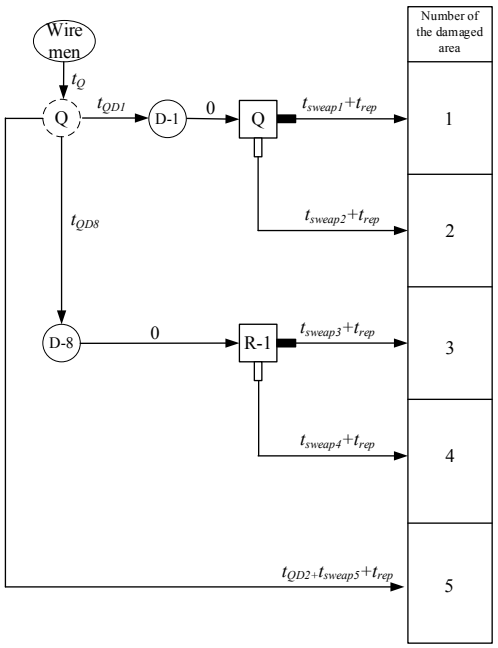

Fig. 2. Recovery process control scheme of power supply in the distribution line after reconstruction

Find index SAIDI for the distribution line after reconstruction. SAIDI after reconstruction will be 6.07 h.

TABLE VIII
CALCULATION OF SAIDI AFTER RECONSTRUCTION

№	N_{offi}	$T_{REC.i1}$	$N_{cust.i1}$	$T_{REC.i2}$	$N_{cust.i2}$	***SAIDIi***
1	0.236	6.32	11	0	0	1.49
2	0.078	6.12	1	1.1	10	0.12
3	0.98	6.8	4	0	0	2.42
4	0.46	6.39	2	1.19	2	0.63
5	0.62	6.23	4	0	0	1.40
Total:						6.07

I. RESULTS AND DISCUSSION

Thus, after the reconstruction of the distribution line, the SAIDI indicator decreased from 14.74 hours to 6.07 hours. As shown by experimental data for the 10 kV distribution line of the Pskov region, the SAIDI indicator is 15.6 hours. The obtained theoretical values of the SAIDI indicator before reconstruction differs from the value obtained according to the operation, no more than 10%. This confirms the right way of calculating the SAIDI indicator.

IV.CONSULTION

The article presents the first developed calculating of SAIDI for distribution lines during the engineering phase. An example of calculating SAIDI for the typical distribution lines before and after reconstruction was present. The developed technique can be used for a feasibility study for the construction of new distribution lines or for the reconstruction of existing ones with the aim of increasing reliability.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 29-35

Development Possibilities of the Green Economy in Latvia (Example of Rezekne Municipality)

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***Abstract*—Preserving natural capital is important topic in 21st century in order to ensure prosperity by sustaining qualitative ecosystem services that are both - non-material and material benefits provided by nature. As research outlines, green economy is based on three pillars of sustainable development - social, economic and environmental. It was concluded, that the main principles of the green economy are sustainable development, which stimulates economic growth, reduces poverty, while placing natural capital as a major asset; development adapted to the interests and opportunities of each country, regions and local areas ensuring participation of the population, social inclusion; promotion of green industries (renewable energy, waste management, sustainable agriculture); efficient use of natural resources.**

Research paper analyses the current situation and future potential of Latvia in the implementation of the green economy, taking as the example evaluation of the situation in the Rezekne Municipality. Research methods such as logical constructive method, document analysis, and interviews were used to gather, analyse and reflect information which was then used to create evaluation model that was used in the focus group to assess weaknesses and potential of Rezekne Municipality, for example, potential in the production of gas from waste. Also important is education of society and their involvement in non-governmental organizations, and the development of the greener way of thinking, where there are noticeable weaknesses. It is possible to take direct examples from other countries (case studies from Finland, France, Lithuania, and Great Britain) that already have experience and real results.

***Keywords*— green economy, municipality, sustainable development.**

I. Introduction

Over the last 100 years, mankind has changed world's ecosystems to such an extent that it has never been in its history. Consumption and production have caused various and rather severe environmental problems such as water scarcity, soil erosion, loss of ecosystems and biodiversity, natural cataclysms, climate change, etc. in many parts of the world. Some of these negative changes are irreversible. These changes are happening due to the rapidly growing consumption of food, water, wood, fuel, minerals and other materials. This is the part of the traditional linear economic model: resources-products-waste. Today that kind of thinking is considered unsustainable by policy makers and consumers alike.

Millennium Ecosystem Assessment (2013) revealed alarming statistics that 60% of the ecosystems are experiencing a global decline, so environmental renewal is recognized as crucial action [1]. Hence, sustainable development has become a necessity, otherwise humanity will not be able to fully exist. Successful investments in clean energy, energy efficiency, environmentally friendly construction, organic farming, waste recycling and waste generation can create an inevitable compromise between environmental protection and economic progress. It is recognized that the green economy can improve employment and reduce poverty while protecting and preserving natural capital [2]. It should also be emphasized that it is not just about investing in green sectors as positive results will only be visible after implementing a common strategic shift from a traditional economic model to a green economy that also includes a change in consumer lifestyle and consumption [3]. Regional and local level authorities and organisations play a key role in the green economy as they develop and shape economic, political and social policies at local, regional and national levels, impacting non-governmental organizations, businesses and citizens [4].

The aim of the research is to study the concept of green economy and its development opportunities in Latvia taking into account the example of Rezekne municipality and experience of other countries.

Methodology of the research: document analysis, interviews (example of France, Finland), focus group interview in Rezekne municipality. Employees of Rezekne Municipality Development Planning Department were selected as focus group participants, since it is this department that is responsible for the municipalities' development program, attraction of investments, public relations, establishment and planning of the territory, implementation of projects and other activities related to development. It is therefore necessary to assess whether

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4078

activities of Development planning department are in accordance with the nature and principles of the green economy.

II. THE CONCEPT OF GREEN ECONOMY

The green economy as a concept is increasingly used worldwide highlighting the growing need to focus on a form of development that provides sustainability. The 2008 crisis gave a significant impetus to the concept of a green economy because the crisis focused not only on financial losses but also on the labour market and the housing market, which reflected the imbalance of the existing economic model [5]. United Nations Environment Programme included green economy as one of its crucial topics and defined it as an economic model that improves people's well-being and creates social justice while reducing environmental risks [6]. This definition is also directly based on the internationally recognized 3 pillars of sustainable development (Figure 1).

Sustainable development is based on the need to optimise and find the balance between economic development, social systems and environmental preservation. Without these 3 pillars, humanity will not be able to provide functioning economy, a harmonious society and a healthy environment.

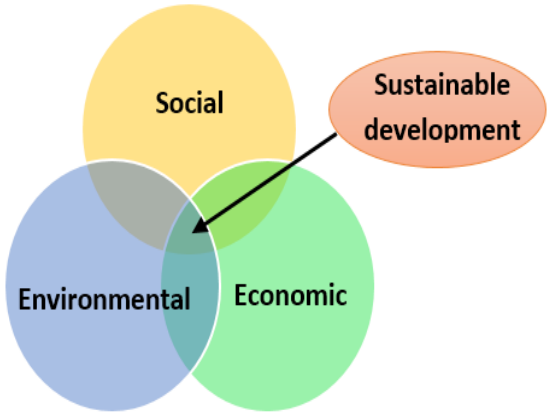

Figure 1. **The three pillars of sustainable development [7].**

Figure 1 reflects the need for united action in all 3 areas to achieve sustainable development at the crossroads of all three pillars. The environmental pillar includes solutions to the challenges in energy, biodiversity, natural resources and pollution. The objective of the economic pillar is to ensure development, efficiency and stability, while the social pillar covers social inclusion, empowerment and institutional and administrative cooperation with citizens and in the interests of the citizens. Some sources also mention the fourth pillar, which includes 'culture', thus emphasizing the promotion of cultural diversity and the protection of human rights [8], but according to the authors of the research, this can also be attributed to the social pillar.

As highlighted in the European Environment Agency report [9], the concept of a green economy is not yet clearly defined, although it was first mentioned already in 1989 in a study by leading environmental economists working for the British government [10]. Most commonly used definition is the previously mentioned United Nations Environment programmes version that "a green economy is one that results in improved well-being and social equity, while significantly reducing environmental risks and ecological scarcities (2011). European Environment Agency defines green economy as the "one that generates increasing prosperity while maintaining the natural systems that sustain us" (2014). Authors of the research noted that although the EU institutions (including the European Commission) are actively involved in the implementation of sustainability and green economy activities, no formal definition of the green economy has been proposed.

After the research authors can define green growth as a social and political movement of interaction and development of social, economic and environmental capital, which has led to a new concept of economic development - a green economy that emphasizes the need for increased attention to environmental aspects to provide also economic benefits and prosperity.

After analysing information from various sources, the authors of the paper came to the conclusion that the principles of the green economy are:

- Sustainable development, which stimulates economic growth and therefore reduces poverty, while putting natural capital at the forefront;
- Development tailored to the interests and opportunities of each country and its regions and local areas;
- Defining and coordinating concrete and clear policies at all levels of government with specific objectives and deadlines;
- Ensuring citizens' participation, social inclusion, stability;
- Involvement and cooperation of all stakeholders;
- Growth are measured by different indicators without focusing so much on GDP growth;
- Promotion of green industries (renewable energy, waste management, sustainable agriculture, etc.);
- Efficient use of natural resources and GHG reduction to mitigate climate change.

III. EXPERIENCE OF IMPLEMENTING GREEN ECONOMIC ASPECTS IN OTHER COUNTRIES AND REGIONS

Finland

The municipality of Turku is the oldest and one of the largest cities in Finland. The population in this municipality reaches almost 200 thousand, of which 40 thousand people are students. Within the framework of the study, the author contacted Alina Heywood, one of the members of the Green Party of the Turku Municipal Council. Her party is working in the direction of the green economy, and she shared her experience of working in the municipality in an interview. Alina admits that she has been interested in ways to help people and nature since childhood, without threatening nature and without affecting the climate. It was one of the reasons why she was already involved in party activities at the age of 16, which, in the authors' opinion, also partly shows the

importance of environmental education from an early age and the public's initiative and ability to engage in activities.

The Green Party was founded in 1987, the founders of this party were the activists of the Koijärvi-movement (Koijarvi Movement), which united to save Lake Koijarvi from drying out as an important bird nesting site. The main values of the party are responsibility, freedom and care for nature. Currently, the party is also working to achieve a fair employment system and to reduce unemployment, as well as to reduce poverty and improve the education system.

All decisions in the Turku municipality are taken by the municipal administration, the council and committees that focus on specific areas. The city council is elected every four years in municipal elections and thus takes all final decisions. The Green Party has become the second largest party in the Turku municipality, so it has been more likely to influence decisions in recent years. The Green Party has implemented a number of successful projects in the city, such as the creation of a new development strategy to turn Turku into a modern city that attracts more young people and, by 2029, to become a city that is free of carbon emissions. There was also recently launched a city bicycle sharing system to create a cycling friendly environment. In the future, the Green Party plans to renew the tram movement in the city of Turku, which would promote the use of public transport. The Green Party fellow believes that the key preconditions for sustainable social and municipal development are the awareness of the past and current problems and planning of the future, as well as critical thinking. A.Hieywood believes that sustainable decisions are made when the municipality is aware of the real situation and decision-making takes place in a transparent and open way, rather than hiding the process from the public.

Lithuania

An important aspect of sustainable development, which is currently being implemented in Lithuania, is the introduction of a waste recycling system. On February 12, 2018, the media reported the construction of a "revolutionary" waste and biomass cogeneration unit in Vilnius district. The total cost of the project is EUR 350 million provided by a loan from the European Investment Bank (190 million) and EU support. The construction of a cogeneration plant is the largest energy project in Lithuania and aims to reduce the amount of disposed household waste, reduce energy prices, reduce emissions and improve security of energy supply [11]. The work is scheduled to start at the end of 2019, and it will be one of the most modern of its kind in Europe. The construction process will provide 750 jobs, while the station itself will have 100 jobs and will be able to supply half of the customers using heating and electricity system of the Vilnius district. It should reduce the costs of fuel by 13 million euros and save 10 million euros on waste management. After survey of population, 72% of the residents supported the construction of the station [12]. This project was based on the fact that a waste sorting plant was opened a few years ago, which collects waste from the entire Vilnius district. In total, there are 11 waste sorting plants in Lithuania - two waste sorting plants in Kaunas and one for each of Vilnius, Klaipeda, Šiauliai, Panevėžys, Alita, Marijampolė, Utena, Telšiai and Taurage [13]. Thus, it can be concluded that Lithuania has made significant investments in waste management, which Latvia could take as an example, only in this case large investments are needed. Without the support and strategic approach of the European Union it is impossible to implement these changes at national and regional level.

France

Roubaix, the municipality in northern France is a great example of how the municipality itself can shape its active policy towards sustainability to a large extent, regardless of the shortcomings of national legislation. The former employee of the municipality of Roubaix and now the zero-waste activist Lucie Dupont informed the author of the interview that the northern region, and especially the municipality of Roubaix, was long regarded as the most underdeveloped and "poorest" since the region was formerly industrial based, but over time many of the factories have closed. Since waste policy is set at national level and organized by associations and regions, local government was not able to influence it, so it was decided to carry out activities within the municipality itself. In the local elections in 2014, a party that was different from the traditional won because their strategic goal was implementing a waste-free direction in the municipality.

In order to attract residents to start a waste-free lifestyle, in 2015, the municipality of Roubaix launched a 1-year voluntary challenge for families and 100 households applied for the first challenge. According to L.Duponte, the expenditures of the municipality itself were not big - small scales for waste weighting for each family and the salary for one additional municipal employee (part-time) had to be provided. Employee informed, helped and evaluated the results of the families involved in the challenge a few days a week. The results were significant among these families - 25% of households reduced their waste by 80% and 70% of households reduced their waste by 50% [14]. Involving families in such an activity was a key driver of the strategy.

The waste-free strategy also included activities in schools that focused on reducing lunch surpluses, implementing composting and using non-disposable tableware. As a result, management wants to introduce specific guidelines for schools that can be promoted outside of the municipality of Roubaix. Businesses and shops were motivated to incorporate a waste-free strategy into their business models, saving resources and finances, for example, by offering their product without unnecessary packaging, selling in bulk, etc. As this type of lifestyle develops among the public, there is a growing demand for the "right kind" of services that businesses and shops can offer. These municipal methods for promoting sustainability and changing consumption habits and behaviour of consumers are an inspiring example of how positive results can be achieved without investing large amounts of money but properly motivating and inspiring.

Great Britain

Green economy initiatives have not always been successful. One of the most unsuccessful initiatives has

been the Green Deal policy of the British government, launched in 2013, when citizens were offered to introduce energy-saving technologies into their homes by including them in an energy bill, the so-called "pay-as-you–save" model [15]. Citizens were able to take energy-saving measures in their homes, such as installing housing insulation, improving the heating system, testing the design of the house, installing double glazing of windows, and installing appliances that produce energy from renewable energy sources (solar cells / panels, heat pumps) [16].Unfortunately, the initiative only lasted for 2.5 years and only ended because it did not produce the desired result. The initiative was participated by only 6,000 dwellings per year and a total of 14,000 dwellings, although it was planned that 14 million households would be involved in the program by 2020, i.e. 2 million a year [17]. Overall, it was concluded that there are 3 main reasons for failing (1) ineffectual regulation of the initiative; (2) limited financial gain; (3) wrong approach to consumer preferences [18].

The unsuccessful regulation of the initiative manifested because, in order to make an attractive offer for citizens, no specific requirements were set for improvement, so the result was unclear, so more expensive measures like renovation were excluded. Financial benefits were hampered by the fact that the Green Deal rates were much higher than the market rates. In turn, the biggest drawback was the wrong approach to consumers. The green deal was only positioned as financial savings, but it is too narrow a direction, although the financial aspect is significant. Initiative marketing did not focus on people's needs such as the positive impact of the initiative on comfort, well-being and health [19], [20]. From the case of the UK, it can be concluded that national activities need to be planned with particular care, and a great deal of emphasis should be placed on the motivation of the people and their willingness to give them what they want, including the aspects of green technology, so that innovation becomes demanded among the population. Successful green initiative also requires successful marketing to achieve its positive impact.

As can be seen from the examples of European countries examined, green economy activities should be started by identifying their significance at the national level, incorporating its principles into the national level development planning documents, followed by the example of the regional and local government strategy. The British and Finnish municipalities shows examples where the first way of action to a green economy was the creation of an appropriate sustainable strategy. It is also important to identify the weaknesses in each area and administration that allow them to be corrected. Activities also need to be implemented in the regions in order to achieve steady development and offer equal opportunities to all citizens of the country. Public participation has played an important role in these examples, and the potential and image of green activities have been promoted by associations and movements. It should also be accepted that sometimes the implementation of the activities can immediately fail to deliver the expected results and even fail as in the case of the UK. Thus the approach to the consumers should change and also appropriate communication plan with the public for the green activities should develop.

IV. IMPLEMENTATION OF THE GREEN ECONOMY ASPECTS IN REZEKNE MUNICIPALITY

The local level is very important for the implementation of green economy activities, therefore the authors choose to evaluate the situation in Rezekne municipality as the largest municipality in Latvia in terms of territory and in the largest municipality in Latgale by population [21]. The local level includes municipalities, organizations, entrepreneurs, associations and schools. Focus group task - to evaluate the development level of each criteria in 3 pillars according to 5 categories (not developed / poorly developed / moderately developed / well developed / well developed). The rating is formed by at least 3 of the 4 focus group participants voting for the recognition of one particular rating as appropriate to the local municipality situation. In addition, the authors commented on the main aspects of the discussion and substantiated the evaluation. The authors in Table 1 summarized the focus group assessment on the assessment of green economy development criteria. Evaluations "not developed" and "poorly developed" were combined, but the evaluation "excellent" was not included, since none of the criteria was evaluated like that in the focus group.

Table 1. Green Economy Development Criteria Breakdown by Assessment (created by authors)

Not developed / poorly developed		Assessment of the criterion		
		Moderately developed	**Well developed**	
Criterion	**Economic pillar**	- Implementing effective technologies in business - Development of eco-tourism - Eco product development / export - Activities of social enterprises - Implementation of green public procurement	- Companies operating in the green sector - Employment - Development of infrastructure - Development of housing infrastructure - Tourism and recreation facilities - Voluntary quality management initiatives	- Entrepreneurship - Development level of domestic production - Implementation of investment projects
	Social pillar	- Involvement of political parties in environmental issues; - Resolving demographic challenges - Integration of different society groups	- Environmental education in schools; - Development of international cooperation networks for development - Municipal partnerships; - Public participation in decision-making process - Activities of non-governmental organizations / associations	- Sustainable development in planning documents; - Environmental protection plans and the achievement of their goals; - Access to education; - Availability of public services - Satisfaction with life
	Environmental pillar	- RES usage in households - Waste-free policies - Certification of energy efficient buildings - Heating networks and their technical condition - Brownfield revitalisation; - Use of nature-based solutions; - Use of environmentally friendly vehicles.	- Operation of hydroelectric power stations; - Use of renewable energy in companies; - Waste sorting and recycling; - Energy efficiency - Limiting water consumption; - Provision of a centralized and decentralized sewerage system; - Development of protected areas; - Public transport network; - Availability of bicycle paths.	- Renewable energy resources and their use; - The operation of the waste management system as a whole; - Availability of waste collection areas; - Land-fill management; - Publicly available green landscapes; - Water purification systems; - Flood risk mitigation system; - Prevention of pollution risks; - Quality of ground and surface water resources; - Management of agricultural land; - Organic/ biological farming; - Biodiversity; - Forest resource management; - Identification of areas at risk of pollution; - Road safety.

Evaluation of the economic pillar

In general, it can be concluded that entrepreneurship is developed in Rezekne municipality, but the level of unemployment is still quite high, so there is potential for even bigger business development as there is human resources. More than half of the county's businesses operate in the agricultural sector, so they are subject to a great deal of climate and weather changes. There are not many businesses operating in any kind of green industries, also not many would introduce effective use of technology for environmental protection rather than cost reduction. Attraction of investment in the area is largely due to EU funding that makes development dependent on European policy priorities. As it was concluded, there is great potential for eco-tourism development in the region, as there is a rather large range of water resources that can provide tourism /recreation services, as well as the production of eco-products, but this is still at a development stage, partly due to lack of cooperation between companies/domestic producers. Social entrepreneurship, although not developed in the region, is a potential future trend. This kind of business cannot replace traditional one but can make a big contribution to society as a whole. The Social Business Act, adopted at the end of 2017, states that "A social enterprise is a limited liability company that has been granted the status of a social enterprise in accordance with the procedures laid down in this law and has a positive economic impact (e.g. providing social services, inclusive civil societies, development, education, support for science, protection and preservation of the environment, protection of animals or safeguarding cultural diversity)". Therefore it can be concluded that it is also a sustainable business model, as it directly develops the economy, employment, inclusion of different social groups and the environmental aspects.

Evaluation of the social pillar

The social pillar encompasses many diverse aspects where sustainable governance and public involvement can be mentioned as the key. The authors of the paper analysed development documents of the municipality, which can be evaluated positively, although the concept of green economy does not appear in them. However, the aim of the development program and strategy is one - sustainable development, which in turn is a concept closely linked to the green economy. The implementation of the green economy activities ensures this kind of development. As assessed by the focus group, the inclusion of the public in decision-making can have some improvements, as this criterion has been assessed as moderately developed.

When conducting the analysis of municipality development planning documents, the authors concluded that the most important documents in Rezekne Municipality are the Sustainable Development Strategy of Rezekne Municipality 2033 and the Rezekne Municipality Development Program 2019-2023. The following strategic objectives in the documents are: an orderly environment, a creative and educated person and a well-developed business. In general, it can be concluded that the greatest emphasis in the municipality development strategy is on the development of human capital and the promotion of entrepreneurship, while the environmental aspects are emphasized in general as the preservation of natural resources and ensuring an attractive living environment. Environmental aspects are analysed and addressed in the Environmental Report. Compared to the experience of other countries, in particular with the Turku municipality of Finland, it can be concluded that political will plays a major role in development, but it is not emphasize or used in political sphere. At this point, there is no specific development goals in the municipality and sustainable development in the green economy is not emphasized.

After studying the theoretical information base and practical examples from other countries, it can be concluded that public involvement in decision making is very important, if not decisive for the development of a successful policy. Within the focus group, it was concluded that public involvement in decision-making, such as public consultation, is relatively cumbersome. The greatest involvement occurs when there are some significant changes in a particular area, such as environmental pollution, reforms. In order to promote the involvement of the population and draw attention to integration problems, the project CRISCO takes place in the Rezekne municipality. During the project activities representatives of the municipalities' rural units did reports on problems of integration and published them in order to draw the attention of the wider public. Within the framework of the project, the Citizens Advice Council addressed a problem concerning new company that wanted to start unclear recycling enterprise in the village of Strūžāni. As local people were worried about the quality of the environment and there was no clear plan provided by the entrepreneur, this issue drew attention from local governments and the State Environment Service's. Violations were detected and the company's operation was stopped until their issue elimination. According to the authors, this case demonstrates that the interest of the population is of great importance for providing good living environment.

Evaluation of the environmental pillar

The environmental pillar includes the use of renewable energy, waste management, green infrastructure, water and land management, sustainable transport and many other aspects. The management of water resources and land resources is generally good. The main problem is the lack of land, as large farmers have already bought most of the area and small farmers who usually are producers of biological production are not able to compete with the price. It is therefore necessary to motivate large farms to consider the idea of producing and exporting organic products, or producing products that have much more added value.

Regarding the use of renewable energy, companies usually lack funding for such large investments, but there are some cases where it is even beneficial. In general, it can be concluded that regulatory enactments related to renewable energy are poor. There are no national legislation, including mandatory procurement components, to encourage entrepreneurs to use renewable energy. Energy efficiency is only topical where EU funds are invested and it is mostly public infrastructure.

Waste management is gradually evolving as a result of EU requirements. The waste-free/ zero-waste policy is currently underdeveloped, but there is possibility to take the great example from the Roubaix municipality in France. The development of a sustainable transport system and the use of environmentally friendly means of transport, following the conclusions of the focus group, may be cumbersome due to the size of the territory in terms of distance that people need to drive and the lack of electric car charging stations.

The potential of Rezekne Municipality to implement green economy activities

It can be concluded that some aspect of green economy is poorly developed in Rezekne Municipality, nevertheless these criteria have the greatest development potential. There is need for attention to the balancing and developing areas of economic activities (mining, construction, alternative energy facilities, etc.) with nature protection interests such as management of existing densely populated and built-up areas, development and efficiency of sewerage and water supply systems, brownfield revitalisation, educating the public about environmentally friendly actions and resource management, as well as building new roads, efficient manufacturing facilities, expanding the range of services in tourism and recreation.

V. CONCLUSIONS

Sustainable development in the 21st century is a necessity for countries around the world, taking into account health and the environment arising from the unsustainable management of natural resources. Concepts of green economy and green growth have been very topical in the last decades in seeking solutions that could satisfy consumers' wishes and preserve natural capital in

order to make responsible use of ecosystem services on which people's well-being depends to the same extent as on economic development. The green economy is based on the three pillars of sustainable development - social, economic and environmental - where only the three together can balance successful growth. The main difference between the traditional and the green economy is that the traditional is based on the use of natural fossil resources, which is both non-renewable and causes pollution and climate change. Developed countries and international organizations are interested in promotion of the concept of the green economy through economic development and implementation of activities based on efficiency, innovation and renewable natural resources.

In order to more actively implement green economy activities, support from policy makers is needed, and the involvement of local authorities. Local activities combine the interests of all stakeholders in a single vision that can be embedded in development planning documents or as an independent strategy for the green economy. Sustainable development assessment can clearly identify weaknesses with the greatest potential for development, but political will, financial support, public education and society participation in processes are needed to change the situation.

The greatest development potential for Rezekne municipality is in promotion of entrepreneurship, gas production from waste, society involvement in non-governmental organizations to boost green thinking, as well as using direct examples from other countries' municipalities (France, Lithuania, Finland, etc.) who already have experience and real results. Employees of Rezekne municipality should take into account the criteria as "poorly developed" or "medium-developed" (e.g. energy efficiency, ecotourism, social entrepreneurship, brownfield revitalisation, integration of society groups) and include measures for their improvement into the next development plan, to ensure the well-being of citizens and the quality of ecological services.

Latvian municipalities should use the positive aspects of other countries to implement green activities such as hiring an additional employee to promote green economy activities; offering support to associations that educate and motivate citizens to be accountable to the environment; providing financial support in addition to environmental education activities in schools; implementing waste-free initiatives; investing in increasing the use of renewable energy resources; developing strategic plans, taking into account global trends, in order to ensure positive changes in the lifestyle and perception of the population and to improve the competitiveness and development of local governments and thus of the state.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 36-38

Analysis of Means of Imitation Modeling Used for the Study of Management Processes in Medical Institutions

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***Abstract*—The article considers the common media of event and multiparadigmatic modelling, as applied to the modelling of the processes of medical institutions to serve the public. The possibilities of managing these processes and optimizing the use of available resources are considered. Formulated recommendations on the use of computer environments in the analysis of business processes and processes of care for the population.**

***Keywords*—Analysis, medical, modelling, queuing theory.**

I. Introduction

In solving the problems of optimizing and increasing the effectiveness of management processes in health care institutions, one of the most effective research methods consists in organizing and conducting computational experiments with model representations of the object of research - the administrative structure of a medical institution, its individual components (registry, doctor's reception, laboratory services, hospital, etc.) or business processes (exchange of medical data, management accounting, medical examination, rendering of copper Insskoy aid and so on.).

Recently, in Russian [8–20] and foreign [1–7] scientific publications, the issues of simulation modelling of the activities of health organizations have been widely covered. At the same time, models at different levels and directions are built and investigated: "operating" [1], "managing the spread of diseases" [16], "first aid" [5,8], "prophylactic medical examination" [17]. "Management of patients' appeals" [8-10,15,17,19], "management of business processes in a medical organization" [11-15,18,20,5], etc. The purpose of such works is to assess the use of resources of a medical organization and to increase the efficiency of their use and the availability of medical services by patients from healthcare institutions using specialized information technologies of simulation modelling. Imitation (simulation) models make it possible to evaluate, for example, how effectively a medical institution functions in a given working situation, what the burden will be on medical personnel, how quickly the patient will receive medical care from the moment they go to a hospital, etc.

From the point of view of managers of medical organizations, it is methods of simulation that allow to evaluate and compare the effectiveness of a particular strategy of providing patients with access to the resources of a medical institution [8-10,15,19,2]. Simulation models also make it possible to overcome the limitations of analytical methods for conducting model studies of the economic and managerial aspects of health [11-13,18,20]. It should be noted that the technology of simulation modelling has such an important advantage over other approaches to the construction and application of models, such as the preservation in the model mappings of the structural features of the organization of the objects of study (in our case, medical organizations), as well as schemes and mechanisms of interaction between the real components of these structures with a friend.

II. Methodology

It is known that simulation modelling is based on the following sections of mathematics: control theory, queuing theory, operations research, information processes theory, logistics theory, similarity theory, experiment planning theory. These and other branches of mathematics allowed us to create a number of information environments that implement various approaches and principles of reflecting real objects, real processes of managing healthcare institutions in their simulation models. We note some of these approaches, which are quite widely reflected in the practice of simulation modelling of the activities of medical organizations in serving the public, as well as in analyzing the business processes taking place in them.

GPSS (General Purpose Simulating System) simulation language (see usage examples [15,19]), which allows you to build a GPSS model of a technological process of a medical organization or its subdivision as a queuing system, on the basis of which information on loading of individual sections of a medical institution , the presence of queues, the average length of stay of the patient in the system and other data.

IDEF (Integrated Computer Aided Manufacturing Definition) methodology (see application examples in [11-13,18]), included in the SADT recommendations (Structured

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4097

Analysis and Design Technique, Structured Analysis and Design Technique), which is used in analyzing business processes in a medical organization. This methodology uses a process approach [11, 18] to formalize the activities of medical institutions and, in general, well reflects the semantics of the subject area - the objects and relationships between them, as well as their main characteristics: execution time and cost of the process, necessary resources (human and material).

The technology of visual direct simulation based on the Unified Modelling Language UML (see [16,20] for examples), which allows interactively investigating event-driven business processes (including in dynamics) on the model , reflecting the real business processes occurring in the study of the original object (medical institution). Simulation models in the UML environment allow you to recreate the process of passing an object through networks and queues, to make calculations and automatically collect statistical results of model experiments.

The method of discrete event modelling [8-10,3,6,7], based on the use of Matlab high-level simulation language toolkit (Matrix Laboratory - matrix laboratory), which provides the researcher with an interactive environment for programming, numerical calculations and visualization of results. Matlab incorporates an extension package for organizing model studies of systems with discrete states - the Simulink visual simulation and situational modelling environment with the SimEvents library (for details on building models, see [8-11]). As an alternative to Simulink & SimEvents, the Arena Simulation system can be used, an example of which is used in modelling the work of a medical institution described in [3]. The availability of ready-made model blocks in SimEvents, the possibility of creating subunits from them, allows you to build well-structured simulation models and reproduce in model conditions the structures of complex discrete control processes (applying patients to the registry, visiting a doctor, undergoing medical procedures, etc.) in health care institutions and investigating the latter as queuing systems.

The above approaches do not fully cover the range of technical and information techniques for constructing simulation models of medical organizations. Known [15,6] multi-agent methodology of simulation modelling, in particular AnyLogic computer system [14]. Multi-agent technologies allow using model objects (modelling individual patients), location objects (reflecting the possible location of agents), as well as the event characteristics of agents (transition from location to location, changing health status) in the model system to reproduce various epidemiological situation, assess the effectiveness of anti-epidemic measures, calculate the risks of economic damage from the development of the epidemic.

III. Discussion

Analysis of the directions and capabilities of computer simulation tools for management processes in health care organizations listed in section II of this article revealed the following points:

1. The activity of any medical institution that provides health protection and the provision of medical services to the population as an object of research can be viewed from several points of view: first, as a system for managing stochastic structural medical, economic, and administrative components operating under certain resource constraints (medical services, medical personnel); secondly, as a queuing system that provides processing of requests from patients for the provision of medical care or receiving treatment and preventive services; thirdly, as an information-processing environment with developed information-process relations between components, possessing a certain functionality and implementing the necessary business processes in the provision of medical services to patients; fourthly, as a multi-connected medical and economic infrastructure, multivariate use, aimed at providing a variety of more or less regulated processes of medical services to the population.

2. To build a simulation model, it is often necessary to construct a preliminary description of the subject area, taking into account the specific goals of organizing model studies, orientation, terms and notations of selected model computer tools of simulation modelling, ways of visualizing the results of virtual model experiments, ways of interpreting them when developing practical recommendations for organizing activities health care institutions in the provision of medical care and medical diagnostician iCal services to the population, the implementation of health technology, medical and preventive, administrative, economic, financial and other business processes.

3. When studying the characteristics of serving the population in health care institutions, analysing the effectiveness and quality of the provision of treatment-and-prophylactic and medical-technological services to patients, the most effective approach to organizing model studies is to represent a medical institution as a mass service system [8-11,15,19]. This approach allows you to build software or structural models of the studied system objects (reception, reception at the doctor, receiving medical services, visiting diagnostic laboratories, etc.) and using the results of model experiments to obtain information about the loading of individual windows of the registry, the presence of queues, the average length of stay of the patient in queues at the doctor's office, the average time spent by the patient at the doctor's office, the number of denials of service during the working day, etc. It should be noted here that the Simulink & SimEvents discrete-event modelling package, which is an extension of Matlab, has a more efficient model tool, which, compared to the GPSS simulation language, has such an important advantage as effective algorithmizing of data processing at the level of structural notations with controlled settings Simulink & SimEvents effective tools for graphical interpretation of simulation results.

4. For analysing the complexity and efficiency of the implementation of business processes in a medical institution (medical technology, treatment-diagnostic, administrative, economic, organizational) it is preferable to use computer simulation technology using the process approach [11-13,16,18,20]. Such technologies should well reflect the semantics of the subject area - the objects and connections between them, as well as their main characteristics: the time of execution and the cost of the process, the necessary resources (human, material, financial).

Applied to the problems of studying business processes, simulation technologies based on the IDEF methodology (in particular, the BPMN software - Business Process Model and Notation, notation and business process model), which, unlike the unified modelling language UML, were originally "sharpened" are more effective. on the model visual reconstruction of the organizational structures of institutions,

the flow of actions (business processes) in them, the processes of information exchange between the components of the structures, internal and external information and ravlyaetsya streams. The BPMN environment allows the model to reproduce three groups of business processes:

- Private business processes that describe the internal activities of the organization - they are combined into a separate pool, while the control flow is inside the pool and cannot cross its boundaries. The message flow, on the other hand, crosses the pool boundaries to display the interaction between different private business processes.
- Abstract (open) business processes that are needed to display the interaction between two private business processes. In an open business process, only those actions that are involved in communication with other processes are shown.
- Interaction processes (global). They display interactions between two or more entities (structural elements of an organization). These interactions are determined by the sequence of actions that process messages between participants.

The use of a unified modelling language UML also makes it possible in general to investigate on models the organization of business processes in specific medical organizations. However, UML is more focused on integrated modelling of event-driven business processes that take place in dynamics, while it is mainly aimed at solving problems of visualization, design and documentation of software systems and, to a lesser extent, at modelling business processes.

5. When solving localized tasks of simulation modelling of medical institutions, such as organizing the activities of a medical institution in case of epidemics, emergencies, etc. It is advisable to use either a multi-agent simulation methodology, if the situation under study has a pronounced stochastic nature, or a discrete-event modelling method, when there is some a priori information about the statistical characteristics of the spread of a disease or about the occurrence of an emergency. Finally, if it is necessary to analyse the effectiveness of organizational patterns of business processes in a medical institution that is transferred to serve the population during mass epidemics or in the event of an emergency, it is advisable to use IDEF simulation methodologies.

IV. Conclusion

The elements of the analysis presented in the article make it possible to determine the preferred computer tools and, accordingly, model tools for recreating simulation images (preferably well visualized using graphical notations of selected software) of the objects of study — components of a medical institution, its administrative structural units, business processes, data exchange processes between structural units or business processes, external and internal information on currents. The quality and efficiency of model experiments, the convergence of simulation results and their practical significance in the substantive interpretation and transfer to the actual conditions of functioning of a medical organization largely depends on how successfully the computer system of simulation modelling of a health care institution is selected.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 39-43

Analysis of Composite Biomass Fuels Properties

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***Abstract*—There is a growing interest about the possibility of exploiting the local biomass as an energy source. The main resource for biofuel production in Latvia is wood. Water plants, like common reed, growing in nearly all of the water reservoirs in Latvia, and all cultivate plants and residues of cereal crops, also can be good alternative for solid bio fuels production. The aim of this paper is to analyze possibilities to make composite fuels from these recourses. The study reveals research of ash content and highest burning heat value in different composite biomass fuels. It contains analysis of samples obtained from various local Latvian biomass types, i.e. reed, wood, flax spray, hay, hemp and peat, by combining them in different proportions.**

The study contains optimal combining proportions of different biomass types for composite fuel production basing on the ash content and burning heat in them.

The results of the study show that the value of wood highest burning heat is higher than another biomass types like reed, peat, hay, hemp and flax spray. It means that combining of different biomass types with wood, will reduce the calorific value of composite biomass.

Also, wood is a fuel with a low ash content, and admixture of various biomass types available in Latvia, as well as admixture of coal dust to the wood in composite duels, increases ash content in the respective fuels.

In order to increase the burning heat and decrease ash content value to the optimal level and to diversify raw materials necessary for biomass fuel generating process, the authors analyze possibilities of using composite fuels by combining wood and coal dust.

Keywords*—highest burning heat value, ash content, biomass, *common reed, wood, peat, composite fuels, cereal crops.

I. INTRODUCTION

Approximately 14-16% of the total energy consumed in the world comes from renewable energy sources (RES), 10% of the total energy is generated by bioenergy [1]. Bioenergy is a type of energy produced from biomass, including thermal energy, electrical energy and various biofuels [2;1]. RES to be used in Latvia are local resources. Using such resources contributes to regional development, creation of new jobs in agriculture, forestry and processing industry; it also promotes studies of RES and related issues [3]. Forest products have the highest energy potential in Latvia (about 13,000 GWh*year^{-1}) [4]. In addition to using traditional firewood for energy production, logging residues such as branches and stumps are increasingly used. A lot of research has been conducted in the world [5; 6; 7] and in Latvia [8] related to the study of wood potential, sustainable preparation and use of wood biomass, exploration and optimisation of combustion processes. One study direction involves the use of wood growing in forests, however recent research conducted by many scientists shows that short rotation plantations on agricultural land can also be successfully used for energy production [9, 10]. Currently, production and use of wood pellets has been growing rapidly in Latvia, mainly due to the possibility to automate heating processes. Wood pellets are one of Latvia's export goods. Wood resources are not inexhaustible, therefore there is a need for diversification of the raw material for pellet production. Various plant biomass could also be used in pellet production. One of the most suitable plants for energy production that has been widely studied in the world is reed canary grass (*Phalaris arundinacea L.*) [11;12,13]. It is suitable for energy production in Latvia [9; 14;15;16]. Hemp (*Cannabis sativa L.*) [17;18] and flax (*Linum usitissimum L.*) [19;20] biomass, as well as peat and many other plants can also be used. Another plant that could be used for energy production in Latvia is reed (*Phragmites australis (Cav.) Trin. Ex Steud.*) growing in natural and artificial water bodies [21]. Research by scientists from other countries also reveals that reed can be used as a raw material for fuel production [22;23]. However, in order to use these plants in pellet production successfully, one should know their properties. Energetic properties of various plant biomass are different from those of wood; usually the heat of combustion of plant biomass is lower [24], while the ash content is higher, which can cause problems during its combustion. Therefore, the authors raise the hypothesis that plant biomass could be successfully combusted together with wood by adding it as an additional fuel. In order to see the impact of adding different plant biomass on the properties of composite pellets, the authors studied the changes in the highest heat of combustion and in the ash content depending on the amount of another fuel added to the wood.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4043

II. MATERIALS AND METHODS

The study used industrially produced wood pellets ground into powder using a mill. Various types of local biomass available in Latvia were added to the wood chips, i.e. reeds, flax shives, peat, hay, hemp fibre, as well as coal dust, that had previously been dried and ground into powder. In order to determine the ash content and highest burning heat value dependence on the amount of various types of biomass added to the wood, respective samples were prepared and analysed in the different proportions (Table 1).

TABLE 1.

Proportions of composite fuels used in the research

Sample number	Content of composite biomass	
	Wood, %	Admixture, Other fuel, %
1	100	0
2	90	10
3	80	20
4	60	40
5	40	60
6	20	80
7	0	100

Ash content in the samples was determined using the standard method CEN/TS 14775:2004 [25]. The samples were dried at the temperature of 105ºC. They were later placed into crucibles and weighted (Fig. 1).

Fig. 1. Samples analysed to determine the ash content

For combustion of samples the furnace "Nabertherm" was used (Fig. 2).

Fig. 2. The furnace used to determine the ash content

After combustion in the furnace at the temperature of 550ºC the crucibles with ash (Fig. 3) were taken out, cooled and weighted, the respective calculations of ash content were also performed. Each sample was analysed trice, measurement error assessment was also carried out [26].

Fig. 3. Samples after combustion

Highest burning heat value in the samples was determined according to ISO 1928 using the oxygen bomb calorimeter Paar 6772 (Fig. 4).

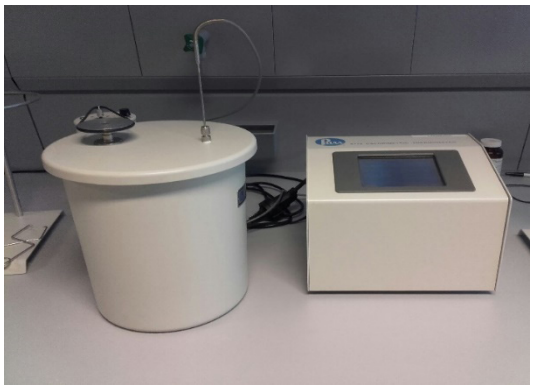

Fig.4. Oxygen bomb calorimeter Paar 6772.

The highest heat of combustion was determined using dry samples. Three parallel measurements were made for each sample and measurement errors were calculated.

III. RESULTS AND DISCUSSION

Within the study, industrially produced wood pellets were used and, by adding different proportions of other fuels, the highest heat of combustion and ash content was analysed. Ash is a by-product of the combustion process, mainly consisting of inorganic substances, predominantly potassium and silica [27], which are left over after the fuel combustion. High ash content in fuel is undesirable as it causes problems with automation of the process of biomass combustion [28].

According to the Standard CEN TS 14961 "Specification of solid biofuels", pellets, basing on their ash content, are divided into several classes. Industrial wood pellets we use correspond to the highest class A 0.7 (ash content below 0.7%); as shown by the results of the analysis, the ash content there was 0.43 ± 0.01% (Figure 5). As revealed by the study, ash content in all other fuels added to the wood is many times higher, e.g. in coal dust it was 8.27 ± 0.39%, in reeds 2.39 ± 0.11%, which was one of the lowest results, while the ash content in flax shives was very high, i.e. 17.76 ± 1.05%. The ash content of the peat used in the study was

4.13 ± 0.21%, the ash content of hay amounted to 7.73 ± 0.01%, for hemp it was 3.78 ± 0.09%. Such results indicate that adding any of these fuels to wood will reduce the quality of the fuel and increase its ash content, which can cause problems with burning such composite fuels in pellet boilers, and generate a large amount of combustion waste.

The research shows that, without reducing the quality class of the fuel below A 0.7, it is possible to mix up to 10% of reed, up to 10% of peat, up to 10% of hay and up to 10% of hemp. In case 10% of flax shives and coal dust is used, the ash content will exceed the class A 0.7, and is therefore only applicable to granules of lower classes. The use of flax shives in the production of composite fuels is not recommended at all, as their ash content is very high (17.76 ± 1.05%), which rapidly increases the ash content of the respective composite fuel and can cause problems with the combustion of such pellets.

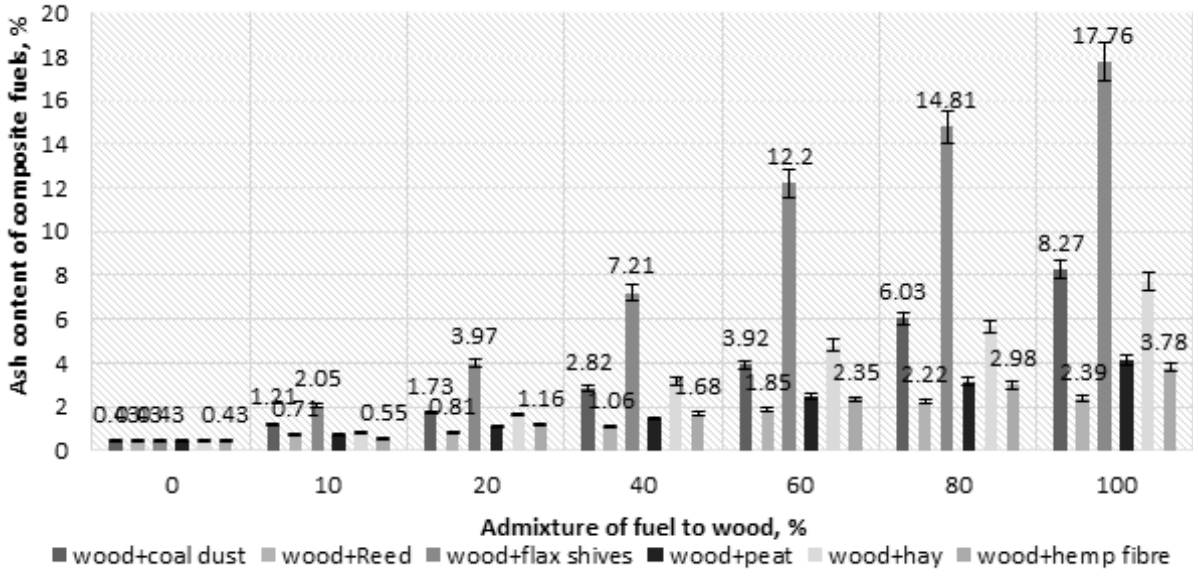

Fig.5. Ash content of composite biomas fuels

Increasing the amount of another plant biomass added to the wood reduces the quality of the fuel because the heat of its combustion decreases (see Figure 6). This can be explained by the comparatively high ash content of different types of biomass and their elemental composition, which was not studied in this research.

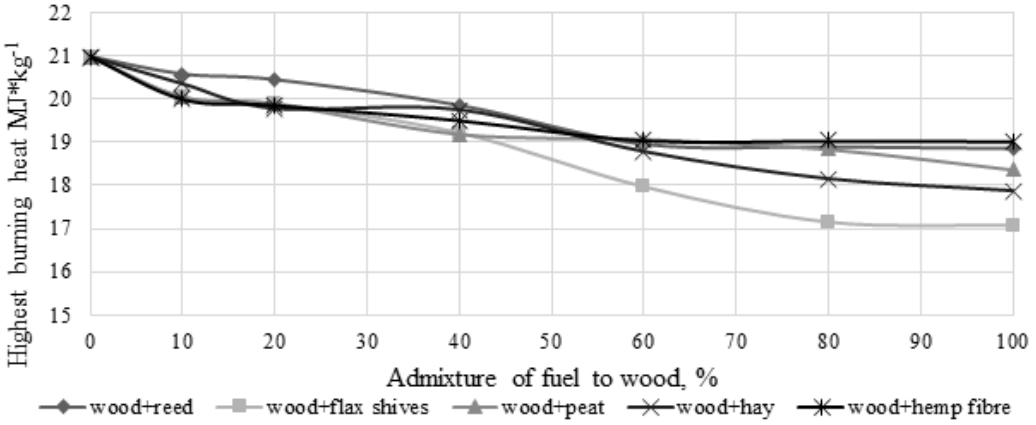

Fig. 6. Highest burning heat of composite biomas fuels

It was found that the heat of combustion of the wood was 21 ± 1 MJ*kg^{-1}, which corresponds to the values indicated on the labels of industrial pellets.

Among different types of biomass whose highest heat of combustion was determined, the lowest value was that of flax shives (17 ± 1.6 MJ*kg^{-1}). Given that flax shives also have a high ash content, it can be concluded that their use in composite fuels is not recommended. Other biomass types had similar values of highest combustion heat: reeds 18.9 ± 1.1 MJ*kg^{-1}, (similar results were found in another study [27]), peat 18.4 ± 1.7 MJ*kg^{-1}, hay 17.9 ± 0.8 MJ*kg^{-1}, and hemp 19.1 ± 0.3 MJ*kg^{-1}. According to the results of studies of ash content and highest heat of combustion, it can be concluded that primary biomass resources to be used in the production of composite fuels are hemp, peat and reed. Hemp's value of combustion heat is lower compared to other types of biomass, therefore its use is not recommended.

An opposite situation can be seen when adding coal dust to composite fuels. The highest heat of combustion raises rapidly when the amount added to the composite fuel increases (see Figure 7).

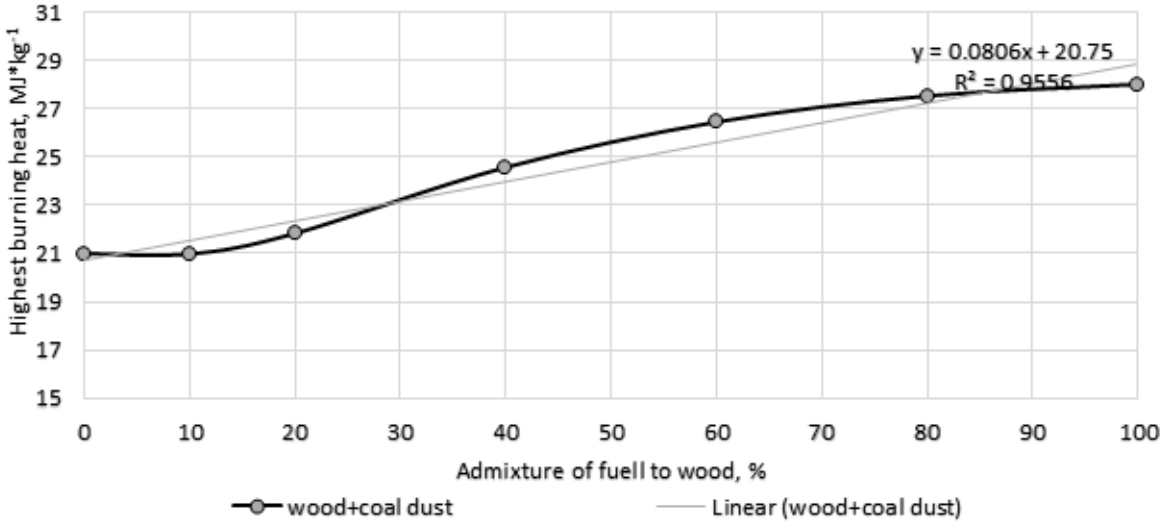

Fig.7. Highest burning heat of composit biomas fuel, wood+coal dust.

The linear equation found for the composite fuel "wood + coal dust" (Equation 1) can be used to predict the highest value of combustion heat depending on the amount of coal dust added.

$$Q=0{,}0806 \quad m+20{,}75 \qquad (1)$$

Where: Q- highest burning heat value, $MJ*kg^{-1}$
m- Admixture of coal dust to wood, %

Coal dust is produced as a by-product of coal handling and transportation and can be successfully used in composite fuels, increasing their value of combustion heat.

Conclusions

1. Production of composite fuels by adding different types of biomass typical in Latvia's conditions to the wood reduces their quality, i.e. increases ash content and reduces the value of combustion heat.
2. Flax shives have high ash content and a relatively low value of combustion heat, their use in composite fuels is therefore not recommended.
3. Without reducing the quality class of the fuel below A0.7 (evaluation based on the ash content), it is possible to add up to 10% of reed, up to 10% of peat, up to 10% of hay and up to 10% of hemp to the wood.
4. Adding coal dust to composite biomass fuels raises their calorific value; the highest value of combustion heat raises rapidly when the amount of coal dust added to the composite fuel increases.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 44-47

Lifestyle Businesses in Rezekne Municipality

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***Abstract*—In regional economy, creation of a system for development of small enterprises and lifestyle businesses is one of the strategies to promote entrepreneurship and targeted use of the local economic resources thus reducing the burden on public and local budgets. Lifestyle businesses are mainly established and maintained with the aim of providing a certain level of income, performing additional activities or developing the owner's hobby, and effectively using the local resources. The aim of the research is to explore the theoretical foundations of lifestyle businesses and potential for their creation and development, using lifestyle businesses of Rezekne municipality as a case. The following tasks were set for achieving the aim: to provide theoretical rationale for lifestyle businesses; to identify lifestyle businesses in Rezekne municipality; to study and analyse the motivation of lifestyle business owners to establish and develop business in Rezekne municipality.**

***Keywords*—lifestyle business, local resources, Rezekne municipality.**

I. Introduction

Latvia's economic growth in 2017 and 2018 has been considerably faster than in previous years. Exports, investments, private and public consumption are steadily growing. Export volumes have reached the highest level so far. Almost all sectors of the economy are experiencing growth. Overall, in the three quarters of 2018, gross domestic product (GDP) has increased by 4.7%, which is even faster than in 2017, when GDP grew by 4.6%. The goal of the Ministry of Economics is to ensure that Latvia becomes the choice for startups in the Baltic countries and to promote lifestyle entrepreneurship in Latvia. (Goal: 1 000 new entrepreneurs) The main task suggested by these goals is to create preconditions for the smallest entrepreneurs to be able to carry out their economic activities without placing a significant burden on the public and municipal social budgets (e.g. provision of benefits to the socially disadvantaged persons) [6]. Specific support programs for this type of entrepreneurs are being implemented [7]. Currently, the solutions for business start-ups, including drawing up the regulation for small business ecosystem and start-ups, are being developed, while the discussion on regulation for lifestyle business is still ongoing.

The vision of the Ministry of Economics envisages promoting lifestyle entrepreneurship in Latvia stipulating that the lifestyle entrepreneurs are those having up to 3 employees and 12 thousand euros in turnover. The Ministry of Economics expects that 1 000 new lifestyles companies will be created in Latvia and the new companies will pay 1.8 million euros contributions to the state budget until 2020. [8]

The aim of the research is to explore the theoretical foundations of lifestyle business and potential for their creation and development, analysing the case of lifestyle businesses of Rezekne municipality.

The following tasks were set to achieve the aim:

- to provide theoretical rationale for lifestyle businesses;
- to identify lifestyle businesses in Rezekne municipality;
- to study and analyse the motivation of lifestyle business owners to establish and develop business in Rezekne municipality.

II. MATERIALS AND METHODS

This article summarizes the results of the authors' research on the motivation for the creation and development of lifestyle businesses in Rezekne municipality.

The methods applied in the research: logical and constructive methods, scientific induction method, synthesis, monographic method and graphic method, sociological research method (survey).

Object of the research: lifestyle businesses.

Subject of the research: motivation for establishment and development of lifestyle businesses.

III. Results and discussion

The authors have chosen the research of lifestyle businesses for several reasons. Small businesses provide satisfaction of personal and family needs; they are more likely to succeed in realizing the initial idea; the opportunity to make a profit right away; working from any location, business can be kept going and moving forward managing it in distance; becoming owner of personal time resource, free planning of the individual daily schedule [9].

Collins English Dictionary defines *lifestyle business* as a small business in which the owner is more anxious to pursue interests that reflect his/her lifestyle than to make more than a comfortable living [10].

Marckettti, Niehm and Fuloria regarding lifestyle entrepreneurs note that they are "neither wealth seekers nor financially independent people who can do their hobby. These are individuals who own business and are

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4111

keen on doing business in close accordance with their personal values, beliefs, interests and hobbies" [5].

Some authors define lifestyle entrepreneurs as individuals who own and operate business closely aligned with their personal values, beliefs, and interests [11], [4]. This definition includes individual values and motivation to start a business.

Business with a limited growth potential is often considered a lifestyle company, and the founder's resources and borrowings are often sufficient to develop it. Lifestyle businesses are companies that are largely dependent on the founder's skills, personality, energy and contacts. Often, their founders express their business through personal talents, skills, flexible schedules, work with other family members, and work in the desired geographical location [3].

A lifestyle company is a company that is created and led by its founders, mainly for the purpose of maintaining a certain level of income and no more or establishing a foundation for enjoying a particular lifestyle.

A lifestyle business is one that focuses on supporting the owner's income and personal requirements rather than maximizing income.

The goal of a lifestyle business is to create a sustainable and pleasant work-life balance. The company must be profitable enough to allow the lifestyle that the owner wants without sacrificing personal life. Type of business can also be chosen based on personal interests, so that working hours are enjoyable [12].

Lifestyle entrepreneurs are often referred to as entrepreneurs engaged in their own hobby, so their business has a personalized approach [13].

Morris uses an entry and exit system approach to distinguish an individual entrepreneur, who may also be a lifestyle entrepreneur, from an interactive business process. Individual and organizational contexts, resources, environmental opportunities and unique business concepts are prerequisites for starting a lifestyle business. Possible outcomes of business processes – permanent job, value creation, innovations (products, services, processes and technologies), profit or personal benefit, employment, business growth and success. Morris [2], Deacon and Firebaugh [1] have studied the link between general systems theory and business processes and have obtained an integrative input-output system model in a result (Fig.1).

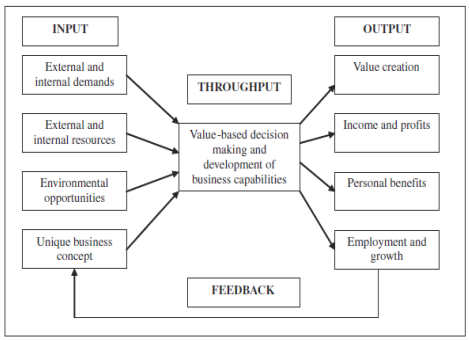

Fig 1. Conceptual model: The relationship of general systems theory to entrepreneurship [12], [13].

Largely, the middle class, especially in the regions, is the result of development of family businesses, which are often lifestyle businesses. These companies operate in a wide range of areas – service, trade, manufacturing, and others [14]. Intended support of the Ministry of Economics to the "lifestyle businesses" could mostly refer to the regional companies producing, for example, candles, sauna accessories, etc. However, there is a growing belief that lifestyle businesses should not be supported.

In the tourism sector in the regions, micro- and small-sized enterprises prevail. For these entities, tourism often is a lifestyle type of business, an additional activity, or a hobby. At the same time, the requirements imposed on such companies do not differ from those imposed on large companies. In the survey conducted by the State Education Development Agency, entrepreneurs have indicated the following significant external factors affecting the overall performance of companies in the tourism sector: amendments in the regulatory enactments (72.3%), improvements in the marketing strategy at national level (68.9%), the wide-ranging tourism advertising campaign in the country (68.6%), as well as changes in tourist demand for services (66.9%) [15].

To find out the number of lifestyle businesses in Rezekne city, Rezekne municipality, and Vilani municipality, the authors have used several statistical sources. The database of the Food and Veterinary Service (hereinafter – FVS) on registered domestic producers was used (FVS registry code 45 – production at home) (see Table 1).

TABLE 1. NUMBER OF ENTERPRISES MANUFACTURING AT HOME IN REZEKNE CITY, REZEKNE MUNICIPALITY AND VILANI MUNICIPALITY ON 28 JANUARY 2019 (COMPILED BY THE AUTHORS BASED ON [16])

Code	Rezekne muni-ci-pality	Vilani muni-ci-pality	Rezekne city
45.2. Production of meat products at home	5	0	5
45.3. Production of dairy products at home	2	1	0
45.4. Processing of fishery products at home	3	0	2
45.5. Production of vegeta-ble oils and fats at home	0	0	0
45.7. Processing of plant products at home	12	1	9
45.8. Production of bread and flour products at home	4	2	3
45.9. Production of egg products at home	0	0	0
45.10. Production of spe-cific food of animal origin at home	0	0	0
45.11. Production of soft drinks and ice at home	1	0	1
45.12. Catering at home	2	1	3
45.13. Production of api-culture products at home	0	0	0
45.14. Production of food supplements and other products of specific plant or mixed origin at home	0	0	0
Total	28	5	23

Some of companies operate in several areas, for example, providing both homemade meat products and home cooking. Therefore the numbers in Table 1 differ from the total number of companies. Overall, in Rezekne city there are 19, in Rēzekne municipality – 26, in Vilani municipality – 5 companies manufacturing at home.

However, it should be noted that the FVS data provides only information on food producers working at home, still, there are many lifestyle companies engaged in crafts, ceramics, and other activities. The authors had access to information on companies registered in LEARN (Rezekne Municipality Foundation for Local Economic Development) database. This database contains information not only about Rezekne municipality, but also about lifestyle businesses in Rezekne city and Vilani municipality (see Table 2).

TABLE2. NUMBER OF COMPANIES IN REZEKNE CITY, REZEKNE MUNICIPALITY AND VILANI MUNICIPALITY REGISTERED BY "LEARN" ON 28 JANUARY 2019 (COMPILED BY THE AUTHORS BASED ON [17])

Type of activity	Number
Meat production	7
Vegetable production	7
Processing of dairy products	3
Herbal teas/ seasonings	4
Egg production	3
Fruit production	15
Bakery	2
Production of honey and apiculture products	10
Fish production	2
Confectionery	7
Sushi	1
Manufacture and sale of alcoholic beverages	2
Handicrafts	33
Ceramics	13
Craftsmen	20
Buckwheat production	1
Total	130

Table 2 shows that there are 130 companies operating in the area under study. However, some of them operate in several fields, resulting in a numerical figure of 125.

For the pilot survey, 13 companies operating in different fields were selected to determine what motivation of the entrepreneurs to operate businesses is and whether home producers/ self-employed persons/ one-person-owned companies, farms, commercial entities can be considered as lifestyle businesses. The authors intend to conduct an in-depth study in this area.

TABLE 3. CHARACTERISTICS OF THE RESPONDENTS BY DURATION OF OPERATIONS AND TYPE OF ACTIVITY (COMPILED BY THE AUTHORS BASED ON THE SURVEY)

Duration of operation		Type of activity	
Answers	%	Answers	%
Up to 1 year	23.08	Production	38.46
1-3 years	30.77	Services	30.77
3-5 years	15.38	Both production and services	30.77
Over 5 years	30.77		

The breakdown of respondents by duration of operation and type of activity is equivalent to all response groups. 46.15% of respondents operate in the food sector and 53.85% – in the non-food sector. (Compiled by the authors based on the survey)

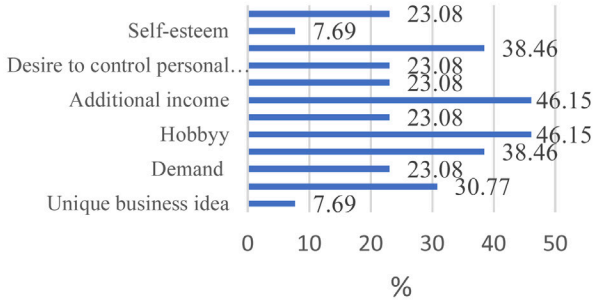

Fig.2. Motivation of respondents to start own business (Compiled by the authors based on the survey)
* Respondents could select multiple answers

Hobby (46.15%) and an additional source of income (46.15%) are the main motivations to start a business. In fact, the opportunity to earn with one's hobby already confirms the lifestyle. The desire to express oneself (38.46%) and use of the environmental advantages (38.46%) are other driving forces to start a business. It should be noted that Rezekne municipality has created tourism objects (Luznava Manor; Tourism and Water Recreation Centre *Baka*, etc.), thus promoting the attractiveness of the environment and enabling the nearby residents to create their own business offer. Other reasons are also important for the respondents.

Fig. 3. The respondents' business result/ satisfaction (Compiled by the authors based on the survey)
* Respondents could select multiple answers

Figure 3 shows that, in opinion of the respondents, it is important to create value (46.15%), receive personal benefits (38.46%), and ensure incomes and profit (38.46%). In fact, it can be concluded that for the people, who engage starting a business, it is important to create the values.

Respondents were also offered to answer questions about their plans. Most of the respondents plan to expand their activities. This indicates that their operations are successful and the people feel demand, satisfaction, and income that motivates them to continue working.

III. CONCLUSIONS

Creating and developing lifestyle businesses around the world involves development of hobbies, satisfaction of personal and family needs, the desire to realize individual intentions, manage own time, earn extra income. In a result of the operations of lifestyle enterprises, the local resources, environmental opportunities are effectively used, and new and innovative products are created. In Rezekne municipality, Rezekne city, and Vilani municipality, lifestyle companies operate in various sectors – both in services and home production, as well as in crafts. Creating and developing their own small lifestyle businesses, the entrepreneurs have their long-term goals and plan to expand their operations in future. For the development of lifestyle businesses, it is often enough with the personal money of founders. In Latgale region, lifestyle entrepreneurs are people who turn their hobby into business and do business in close accordance with their personal desires and values, beliefs, interests. There are many people in Rezekne county who have interesting hobbies and who could create their own lifestyle companies, thus contributing to the economic development of Latgale region.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 48-53

The Modern Status of the Velikaya River Delta on the State of Primary Producers

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***Abstract*—Primary producers are an integral part of freshwater ecosystems. Phytoplankton forms the basis of the trophic pyramid, participates in the formation of water quality and acts as a sensitive indicator of the state of the reservoir. The ability of macrophytes to accumulate mineral and organic substances makes them active participants in the self-purification of natural waters. Higher aquatic plants are characterized by conservatism to short-term changes in the environment, but changes in vegetation over the years may indicate anthropogenic transformation of ecosystems.**

The contribution to maintaining the stability of the functioning and biodiversity of the ecosystem makes phytoplankton and macrophytes compulsory research objects aimed at studying the state of water bodies.

The aim of the work was the study of primary producers as bioindicators of the ecological status of the Velikaya river delta in the summer of 2018.

As a result, 127 phytoplankton taxa from 8 phylums were found: Chlorophyta, Bacillariophyta, Cyanobacteria, Euglenophyta, Chrysophyta, Dinophyta, Cryptophyta, Charophyta. The species richness was dominated by the Chlorophyta (42.5%), Bacillariophyta (25.2%), Cyanobacteria (11.1%). According to the ecological and geographical analysis of the delta algaflora, cosmopolitan, freshwater, planktonic forms of microalgae dominate, preferring neutral and weakly alkaline waters. Water quality assessment revealed the beta-mesosaprobic nature of the waters, which indicates moderate pollution of the water area.

In the composition of macrophytes, 43 species from 3 phylums were identified: Magnoliophyta, Equisetophyta, Chlorophyta. By species composition, angiosperms dominated (95.3%), of which 46.3% were dicotyledons and 53.7% - monocotyledons. Hygrophytes (34.9%) and hydrophytes (32.6%) prevailed in terms of ecological structure. The leading role in the overgrowing of the delta belonged to high-grass helophytes and rooting hydrophytes with leaves floating on the water. A total of 37 saprobiont flora were found. The total index of saprobity was 277 points.

***Keywords*—algae, ecological assessment, ecological monitoring, phytoplankton, macrophyte, primary producer, Velikaya river delta.**

I. Introduction

All ecosystems exist under conditions of constant maintenance of the balance of matter and energy, which are the basis of their long-term existence [1]; [2]; [3]. On an ecosystem scale, most of the energy is provided by the producers in the process of photosynthesis, after which it is used by organisms of next trophic levels. Therefore, regardless of the complexity of the ecosystem, an accurate assessment of the production speed of organic matter is needed so we can understand ecosystems functioning and they thermodynamic behavior [4]; [5].

Aquatic ecosystems are a unique position in the general structure of ecosystems, since they are characterized by a high rate of substance renewal and closer integration of all biotic components. For that reason they are characterized by a quick response to any external disturbances, which allows them to be used as objects for long-term environmental monitoring.

Freshwater ecosystems are characterized by a smaller scale compared to marine ones, enabling them to be used for regional and local environmental monitoring, and the field data help develop predictive ecological models of higher quality. The two most important groups of primary producers of freshwater ecosystems are planktonic algae and macrophytes. They make the greatest contribution to the primary production of aquatic ecosystems and are characterized by specific responses to dynamic processes occurring in the environment. Some authors have suggested, that up to 60-70% of the primary production in freshwaters of the North-West falls on phytoplankton. The productivity value of phytoplankton determines the abundance of next links in the food chain [6]; [7]. Macrophytes creates a favorable habitat and breeding for many hydrobionts and form heterogeneous habitat conditions, which contributes to an increase in the biodiversity of water bodies.

External factors such as features of the movement of water masses, mineralization, organic pollution, temperature, oxygen concentration and pH have a

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4086

significant impact on the long-term and seasonal dynamics of primary producers and contribute to the formation of specific responses that can be used to study the state of natural water bodies.

Ecotone ecosystems contain the largest reserves of organic matter, since, apart from their own primary production, they are closely related to the continental ecosystems, from which they receive additional organic matter in the form of effluent, which significantly increases their productivity [8]; [9]; [10]. As a result, ecotone ecosystems function as biogeochemical reactors that supply large areas of waterbodies of organic matter.

The Velikaya river delta (Pskov Region, Russia) is a typical ecotone ecosystem with a high diversity of communities of primary producers. In recent years, the delta is characterized by its increased dynamics of overgrowing by macrophytes, which indicates an abundance of nutrients, in particular phosphorus [11]. This may be due to both external causes and the natural processes in the waterbody. The structure of phytoplankton communities is subject to seasonal and spatial changes, the nature of which is not fully studied [10]; [12]. In this regard, it is necessary to clarify the regional forecasts of the reactions of primary producers to a set of external factors, including those associated with global climate change processes.

The purpose of this work is to study the primary producers of the Velikaya river delta as bioindicators of the ecological state of the water body.

II. Matherials and methods

Hydrobiological samples were collected out in the summer period of 2018 in the Velikaya river delta. The results of measuring the parameters of the water showed that the average temperature at the time of sampling was 25.5 ° C and the pH of the medium was 8.03.

Phytoplankton samples were collected from the surface horizon at five sampling stations (Fig. 1). They are fixed with 40% formalin and concentrated by the sedimentary method. The samples were processed in a laboratory by standard methods [13].

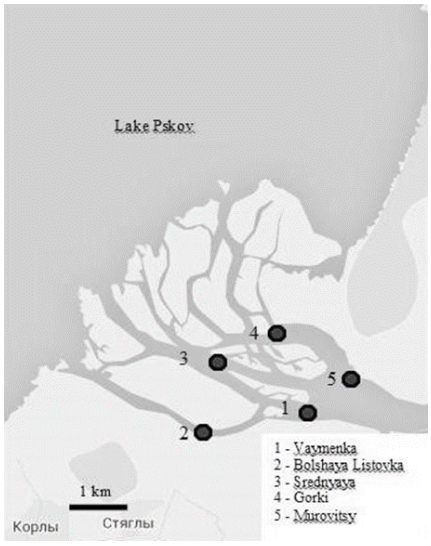

Fig. 1. The sampling stations in the Velikaya river Delta

Phytoplankton taxonomic identification was performed in the laboratory of Pskov State University using a Carl Zeiss Axio Lab A1 microscope. A number of reference books were used to identify taxones [10]. In the allocation and location of the algae divisions, the system used in the "Algae Handbook" [14] was used. The abundance of phytoplankton was calculated using standard methods [10]. Algae biomass was determined by a standard methods [15]. To clarify the ecological data of algae, a number of monographs were used [16], [17], [18]. The saprobic index was calculated by the method of Pantle and Buck [19]. Water class quality was determined by phytoplankton biomass [20].

Macrophytes were studied using the generally accepted method of geobotanical studies of aquatic vegetation [21]; [22]. Systematic and ecological-geographical analyzes of flora were carried out according to the methods described in a number of articles [23]; [9]. In ecological analysis of flora used classification V. G. Papchenkova [9]. As one of the characteristics of the ecological structure, the hydrofit index of flora proposed by B. F. Sviridenko [24] was used:

$$I_{hd} = \left(\frac{2A}{B}\right) \quad 1,$$

where: A - number of aquatic species; B - number of all species of the considered flora.

When describing vegetation, the ecological-phytocenotic classification of plant communities was used [25]. When forming the names of associations, we were guided by the works of IM Raspopov [26] and VG Papchenkov [9].

The main structural indicators (shoot height, shoot diameter, above-ground biomass) of the main edificator of the delta vegetation cover - *Phragmites australis* (Cav.) Trin. ex. Stend.

The trophic regime of the studied ecotone was established using a list of indicator species of aquatic macrophytes [16]. To assess the trophicity of the aquatic environment, the Tsyganov index (IZ) was calculated in points [27]. This index was calculated by the method of finding the average score based on a list of vascular plant species, in which the averaged tolerance amplitude scores with respect to the generalized salt regime of the soil (trofomorphs) are indicated.

As the source material for the analysis of overgrowth of the Pskov Lake, satellite images of Landsat 5, 7, 8 of different years with minimal cloudiness reflecting the state of coastal aquatic vegetation in the water body were used.

A series of multispectral images of Landsat 5, 7, and 8 satellites was obtained from the data catalog of the US Geological Survey (USGS) for the period from 1988 to 2018 for the area of Pskov Lake. All stages of the preparation of remote sensing data and their processing were carried out in the QGIS 3.4.

As a basic tool for the classification procedure of remote sensing data the SCP module (Semi-Automatic Classification Plugin) for QGIS was used. After selecting the most successful classification and correction option,

all the images were translated into a vector format, and using the field calculator tool in QGIS, we calculated the area of overgrowth by macrophytes.

III. Results and discussion

As a result of a qualitative analysis of phytoplankton in the Velikaya river delta 127 taxa from 7 phylums, 11 classes, 18 orders, 38 families and 76 genera were found.

General analysis of data from all research stations showed that the basis of the flora was 3 phylums: Chlorophyta - 54 (42.5% of the total number of species), Bacillariophyta - 32 taxons (25.2%) and Cyanobacteria - 14 taxons (11.1%) (Table 1).

In total, these departments accounted for 77.8% of phylums, 86.8% of families and 82.9% of genera of the total number of detected microalgae taxa. The species richest families were the Scenedesmaceae and Selenastraceae from the green algae, the Naviculaceae and the Fragilariaceae from the diatoms, and the Merismopediaceae from the cyanobacteria.

TABLE 1.
TAXONOMIC COMPOSITION OF PHYTOPLANCTON OF THE VELIKAYA RIVER DELTA (SUMMER, 2018)

Phylums	Number of species (pc.)	Sample stations				
		Vaymenka	Bolshaya Listovka	Srednaya	Gorki	Murovitsy
Chlorophyta	54	39	29	32	28	37
Bacillariophyta	32	15	24	15	16	15
Cyanobacteria	14	12	11	10	6	6
Chrysophyta	8	7	7	7	7	6
Euglenophyta	7	5	6	5	3	2
Dinophyta	7	4	4	6	3	2
Cryptophyta	4	4	3	4	2	3
Итого	**127**	**86**	**84**	**79**	**65**	**71**

The remaining phylums are represented by a small number of species: Chrysophyta - 8 (6.3%), Euglenophyta - 7 (5.5%), Dinophyta - 7 (5.5%), Cryptophyta - 4 (3.1%) (Table 1).

Thus, the taxonomic composition of summer phytoplankton of the Velikaya river delta in 2018 was characterized as green-diatom-cyanobacterial. A similar situation was observed in the summer period of 2015. In the summer season of 2016 and 2017 the first place by the number of taxa were diatoms.

An analysis of the phytoplankton species richness in the sampling stations showed that the largest number of taxa was noted at the stations "Vaymenka" and "Bolshaya Listovka" (86 and 84 taxa, respectively), and the smallest - at the "Gorki" (62). At the stations "Vaymenka" "Bolshaya Listovka" and "Srednaya" green algae, diatoms and cyanobacteria were dominated, at the "Murovitcy" third place in the number of taxa was divided by Cyanobacteria and Chrysophyta, and in the "Gorki" Cyanobacteria dropped out of the dominant complex and gave way to Chrysophyta (Table 1).

The number of phytoplankton varied from 2.7 million cells/l ("Gorki") to 9.9 million cells/l ("Bolshaya Listovka") (Table 2). The average abundance for all sampling stations was 6.1 million cells/l, of which Cyanobacteria accounted for about 2.8 million cells/l (45.9% of the total algae population). The dominant species were representatives of the genera *Aphanocapsa* Näg., *Aphanothece* Näg., *Merismopedia* Meyen., *Snowella* Kütz. Green algae accounted for 2.2 million cells per liter (36.1%). At the same time, it should be noted that *Binuclearia lauterbornii* (Schmidle) at some stations was dominated (10.8-16.2% of the total). The remaining 18.0% accounted for the number of representatives of other phylums.

The biomass of planktonic algae ranged from 0.6–1.8 mg/l (Bav = 1.2 mg/l). The minimum values of the total biomass are noted at the stations "Gorki" and "Murovytsy", the maximum - at the station. "Vaymenka" (Table 2).

TABLE 2
QUANTITY PARAMETRS OF PHYTOPLANKTON OF THE VELIKAYA RIVER DELTA (SUMMER 2018)

Parameters	Sample stations					Mean
	1	2	3	4	5	
Abundance, million cell/l	7.3	9.9	7.5	2.7	3.1	6.1±1.4
Biomass, mg./l	1.8	1.3	1.4	0.6	0.7	1.2±0.2

According to phytoplankton biomass, the Velikaya river delta in the summer period of 2018 belonged to the 3rd class of water quality - the water of satisfactory cleanliness.

Ecological-geographical analysis of phytoplankton showed that the most of the 127 species were the most cosmopolitan by distribution - 88 taxons (69.3%) (Table 3).

TABLE 3
ECOLOGICAL-GEOGRAPHICAL CHARACTERISTIC OF PHYTOPLANKTON OF THE VELIKAYA RIVER DELTA

Parameters	Number of species	Percentage of total number species
Distribution		
cosmopolitans	88	69.3
boreal	6	4.7
galarctic	5	3.9
arctic	1	0.8
no data	27	21.3
Habitat		
planctonic	75	59.1
lanktonic-benthic	39	30.6
benthic	10	7.9
epiphyton	3	2.4
Halobility		
Indifferent	70	55.1
Halophyles	13	10.2
Oligogalobs	6	4.7
Halophobs	3	2.4
no data	35	27.6
Related to pH		
Indifferent	37	29.1
Alcaliphile	21	16.5

Acidophile	5	3.9
Alcalibionts	2	1.6
no data	62	48.9
Saprobity		
β- mezosaprobionts	49	48.6
o-β, β-o- saprobionts	16	15.8
o-α- mezosaprobionts	11	10.9
α-β, β-α- mezosapro-bionts	9	8.9
oligosaprobionts	9	8.9
α - mezosaprobionts	5	5.0
χ-β- mezosaprobionts	1	1.0
β-polisaprobionts	1	1.0
Mean Pantle-Bukk index	2.0	

By the habitat was dominated by plankton taxa - 75 (59.1%). Plankton-benthic forms were represented by 39 taxa (30.6%). A small number of benthic forms and epiphytonic forms were encountered.

In relation to the halobility, all phytoplankton species were freshwater, of which 70 taxa (55.1%) - indifferent, 13 species (10.2%) - halophiles, 3 taxons (2.4%) -halophobes.

In relation to the acidity factor, indifferent species prevailed (29.1%), in second place were alkaliphils - 21 taxa (16.5%). The other forms accounted for a small percentage. Almost half of the microalgae did not have information about this factor.

A total of 101 saprobity indicator species were found. Most of them were β-mezosaprobes - 49 (48.6%). Species preferring pure waters, as well as species preferring polluted waters, accounted for 26 taxa each (Table 3).

According to the results obtained no significant changes in the values of the saprobity index have been observed in comparison with results of 1992. (Table 4). The waters of the Velikaya river delta belong to the third quality class - moderately polluted.

TABLE 4
VALUES OF PANTLE-BUKK INDEX IN THE VELIKAYA RIVER DELTA IN DIFFERENT YEARS

Years	Pantle-Bukk Index value
1992	1.9 – 2.2
2000	1.7 – 2.2
2001	2.3 – 3.5
2016	2.0 – 2.2
2018	1.8 – 2.1

The highest value of the Pantle-Bukk index was noted at "Murovitsy" station - 2.1, the smallest - at "Bolshaya Listovka" station - 1.8. The obtained index values at the research stations are close, which characterizes the delta as a relatively homogeneous territory in terms of organic pollutants concentration in the water.

As a result of studying the flora of vascular aquatic vegetation of the Velikaya river delta in the summer of 2018, 43 species belonging to 3 phylums, 23 families and 36 genera were identified (Table 5).

TABLE 5
TAXA COMPOSITION OF MACROPHYTES OF THE VELIKAYA RIVER DELTA (SUMMER, 2018)

Taxa	Number			% of all species
	Families	Genera	Species	
Chlorophyta	1	1	1	2.3
Equisetophyta	1	1	1	2.3
Magnoliophyta	21	34	41	95.3
Liliopsida	11	20	22	53.7
Magnoliopsida	10	14	19	46.3

The species composition was dominated by the Magnoliophyta. The dicotyledonous plants accounted for 46.3% of the total number of angiosperms, for monocots - 53.7%. Chlorophyta and Equisetophyta did not contribute significantly to the species richness - 2.3% each. Among the families prevailing in the number of species were the following: Ranunculaceae (5 species), Poaceae, Hydrocharitaceae, Cyperaceae, Lemnaceae, Nymphaeaceae (3 species each).

According to geographical analysis, the flora of the Velikaya river delta were represented by four regional and five zonal types of areals (Table 6).

TABLE 6
NUMBER SPECIES WITH DIFFERENT TYPES OF AREALS IN THE FLORA OF THE VELIKAYA RIVER DELTA

Regional areal type	Zonal areal types				
	p	asm	bm	bsm	Total
Pl	10	-	-	-	10
H	10	1	2	-	13
EA	6	-	7	1	14
ES	-	1	1	4	6
Total	26	2	10	5	43

Pl – pluriregional, H – Holarctic, EA – Euro-Asia, ES – Euro-Seberia; p – plurizonal, asm – arctic-submeridian, bm – boreal-meridian, bsm – boreal-submeridional.

The most numerous were the macrophytes of four types of areas: the pluriregional pluurizonal, the holarctic plurizonal - 10 species (23%), the Eurasian boreal-meridional - 7 species (16%) and the Eurasian plurizonal - 6 species (14%).

Thus, the flora of the ecotone was dominated by species widely distributed in different zones and regions - Plurizonal, Holarctic, and Eurasian.

The ecological structure of the flora of the Velikaya river delta was represented by four ecotypes: hygrophytes, hydrophytes, helophytes and hygrohelophytes. Coastal (near-water) plants and hydrophytes - real aquatic plants (32.6%) prevailed.

The following ecological groups dominated among hydrophytes: 1 - hydrophytes freely floating in the water column (*Lemna* spp., *Stratiotes aloides* L.); 2 - submerged rooting hydrophytes (all *Potamogeton* species, *Batrachium circinatum* (Sibth.) Spach, *Elodea Canadensis* Michaux, etc.), 3 - rooting hydrophytes with floating leaves (*Nuphar lutea* (L.) Smith and *N. pumila* (Timm) DC, *Nymphaea candida* JC Presl.).

Helophytes, or air-aquatic plants (23.3%), are equally represented by tall grass plants - *Phragmites australis* (Cav). Trin. ExSteud, *Typha angustifolia* L., *Glyceria*

mixima (Hartm.) Holmb, *Scirpus lacustris* (L.) Palla and others, and low-grass plants - *Butomus umbellatus* L., *Equisetum fluviatile* L., *Sagittaria sagittifolia* L. and others.

Hygrogelophytes (near-water plants) accounted for 9.3% of the total number of macrophyte.

In general, the diversity of the water flora is slightly lower than the coastal waters flora, which is also indicated by the hydrophyte index equal to –0.35.

Analysis of the taxonomic structure of communities indicated a wide variety of macrophyte communities in the Velikaya river delta. In total, 26 associations belonging to three classes of formations, five groups of formations and 16 formations were identified.

Aquatic vegetation (Aquiphytosa genuine) is represented by three groups of formations and eight associations. The communities of rooting hydrophytes with leaves floating on the surface of the water prevailed (three formations).

In the group of classes coastal aquatic vegetation (Aquiherbosa vadosa) was dominated by a group of high-grass helophyte – formations (Aquiherbosa helophyta procera) - 38% of the total number of associations. The main ecosystem engineer species this type were *Phragmites australis*, *Scirpus lacustris* L. and *Typha angustifolia* L.

Leading role in the overgrowing of the Velikaya river delta was belonged to the high-grass helophytes and the rooted hydrophytes with floating leaves. Helophytes formed mono- and multi-component communities that located on coasts of numerous islands in the delta. In this they formed a strip from 2 to 20 m wide. The river channels between the islands were overgrown with groups of *Nuphar lutea*, *N. pumila*, *Nymphaea candida*.

Reed beds were spread along the entire coastline, and were surround numerous islands and well as common in the form of separate spots in channels of the delta.

The most common in the lake are clean (one-species) reed beds.

The average height of the reed was 259.7 ± 5.30 cm, stem diameter 0.78 ± 0.04 cm. The aboveground biomass varied between 954.0-1877.0 g / m².

According to saprobiological analysis, 24 saprobiont of the flora were found (55.8% of the total number of species). B-mesosaprobes were dominated - 37.5%. The share of oligosaprobes and β-α, α-β- saprobionts were accounted for 12% each.

Whole 37 trofomorphs with a known trophic score in the composition of the flora of the Velikaya river delta were revealed. Species with a high trophic index (8-10 score) - 21 (57%). According to the Tsyganov Index (IZ), the total trophic grade point of the aquatic environment was 277 score.

IV. Conclusions

Thus, the species composition of phytoplankton of the Velikaya river delta in summer of 2018 as green-diatom-cyanobacterial was characterized.

The average phytoplankton abundance was 6.1 million cells/l., mean biomass - 1.2 mg/l.

According to the ecological and geographical analysis in the Velikaya river delta freshwater, widespread, planktonic microalgae, preferring slightly alkaline waters were prevailed.

According to the saprobiological analysis of the delta's waters to the 3rd class of quality were classified. The average index of saprobity in Pantle-Bucca was 2.0.

In the aquatic vascular vegetation of the delta, 26 associations belonging to 3 classes of formations, 5 groups of formations and 16 formations were identified.

In the flora by the Magnoliophyta was dominated. Plurizonal, holarctic and eurasian geographical elements were prevailed. The hydrophilic core of the flora (hydrophytes, helophytes and hygrohelophytes) was 65%.

Main role in the overgrowing of the Velikaya river delta to the high-grass helophytes was belonged. Phragmites australis was the main ecosystem engineer.

Among the 37 saprobionts of the flora, β-mesosaprobes - indicators of moderate water pollution were dominated.

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Proceedings of the 12th International Scientific and Practical Conference. Volume I, 54-58

State of the Population Disclosure Systems in the Changing Radiation Situation in Bulgaria

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***Abstract*— In February and March 2017, I conducted a survey among 3 population groups and 392 participants on the state of the population monitoring and disclosure systems so that the information received was up to date. The resulting and aggregated information should not be considered as a constant because the situation changes dynamically, both in terms of the political situation in the region and the intentions of our neighbours regarding the sites that represent both the radiation risk and the meteorological elements that affect any radioactive contamination. Especially dynamic is the development of meteorological elements, which should be analyzed very thoroughly in the event of a nuclear accident or incident. The results of the study are presented, diagrams and analyzes and guidelines for follow-up are presented..**

Keywords — danger, disclosure systems, population, radioactive background

I. Introduction

The topic of radiation safety is very painful for society. Despite its timeliness, its relevance has not diminished over the past 30 years. In order to increase the monitoring of the radioactive situation, the nuclear accidents in Chernobyl in 1986 and in Fukushima in 2011 played a major role. Simultaneously with the use of the atom for peaceful purposes, over the past 2 years, there has been an increase in the development of new and advanced nuclear weapons. Even in recent months, there has been intense talk about ending the operation of the Nuclear Weapons Convention by leading world powers [1,5,8].

Bulgaria is at the forefront of Europe, Asia and Africa where people, technology, weapons, and smuggling are being deployed. This, along with the increased terrorist activity in Europe and the banging of weapons around Bulgaria leads to a concern in part of society [2]. We can not be indifferent to what kind of world we live in and what happens around us.

All of this has led me to make a survey of the population to what extent it is aware of the problems of radiation safety and what each of us should do in the event of a radiation accident in Bulgaria or near Bulgaria which will lead to an increase of the natural radioactive background [9]. The extent to which the public is aware of the procedures and actions to be taken in changing the radioactive situation should be increased. As a purpose, I set myself to explore the real state of public awareness and analyzing information to identify awareness-raising measures. I segmented the community to get more reliable information to summarize and analyze. In order to achieve the purpose I set up a questionnaire with specific questions and I made a preliminary study of the problem [5].

II. Materials and methods

In Bulgaria, such a survey has not been done over the past 15 years, and there is no evidence of such a study being made before. After a year's familiarization with the state of the problem, the structure of the organizations in the direction and the current legislation in Bulgaria and the European Union formulated the main directions of the future study. Based on the studies, aggregation of information and analysis of the results, I made a questionnaire containing 20 questions, which represented the problem in a wide range. [8, 10]. The inquiry included issues that covered the overall vision of radiative background monitoring systems, population disclosure, action by competent authorities and bodies and their interaction. Together with these basic radiation protection values, the respondents also expressed their opinion on the main factors that could lead to a radiation accident and the manner of distribution of the radioactive particles, isotopes and rays in terms of the meteorological elements that influence them. The volume of survey questions was chosen so that it could fully cover the research problem from all the relevant points of view, and in the same time, not being boring for the survey participants. With the number of questions raised, there is a danger that respondents will not pay enough attention to the issues raised and those who I am at the end of the poll will not give a credible answer. That's why 20 questions were selected for the survey [3, 7]. If it goes to the other extreme and there are too few questions, then we will not get the amount of information we need for the scientific

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4152

analysis of the problem and its subsequent findings.

The survey was conducted in February and March 2017 so that the information received is current at the time [8]. The resulting and aggregated information should not be considered as a constant because the situation changes dynamically, both in terms of the political situation in the region and the intentions of our neighbours regarding the sites that represent both the radiation risk and the meteorological elements that affect any radioactive contamination. Especially dynamic is the development of the meteorological elements and most of the wind, which should be analyzed very thoroughly in the event of a nuclear accident or incident.

III. Results and discussion

To obtain an objective picture of the survey, the respondents were divided into three large groups. The first group consisted of radiation protection and nuclear physics specialists, who have a deeper understanding of the problems, and their opinion has a greater weight. Due to the specificity of the problem, people from different institutions working in this or near area were involved, but considering the research problem, their circle was not large - 38 people responded to the survey. In the selection of these specialists, I endeavoured to cover a wider range of institutions - Kozloduy NPP, BAS, MI, POHD, RIA to BAS and others, but due to the specificity of the problem, the circle of institutions was small. Due to the avoidance of subjective opinion, in the survey did not participate employees working in or being close to ”Vassil Levski” National Military University.

The second group included randomly selected people from different age groups, educational qualifications, gender and religion from the whole country, randomly selected. In this category, the questionnaire was answered by 196 people.

I also made a study among the trainee students in the first course at the “Vasil Levski” Military University and the results were also processed and analyzed independently. Here were 158 students who had received initial training in nuclear, chemical and biological protection, and had some basic knowledge of nuclear accidents and their actions.

In summarizing the results, the views of the three categories of people are considered separately, making only a comparison, but not a general presentation of the problem, because these issues are specific and some knowledge in the field of radiation protection is needed in order to be able to respond competently. For some of the questions that do not require in-depth knowledge, the results are close, but where more knowledge is needed, there is already a greater difference in responses.

After the survey was completed among all learning categories, the results obtained were processed by me and summarized in tabular form. Based on aggregated data, we can make several statements.

1. According to the results of the study, the state of radiation protection in Bulgaria has gaps and the experts give a higher assessment of reality than the other 2 groups.

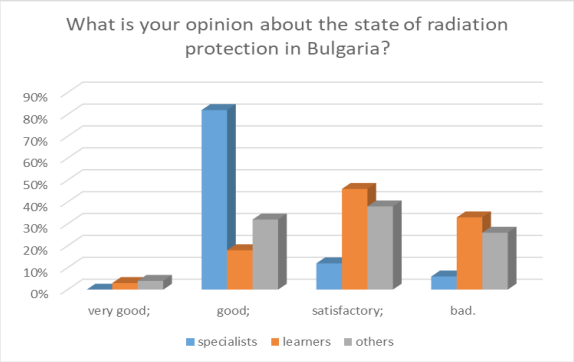

Fig. 1. Answer a question „What is your opinion about the state of radiation protection in Bulgaria?“

The group of learners and people, selected randomly, gives a lower score, as the lack of information influences this. People with higher education also give higher marks than people with secondary and lower education (Figure 1).

2. The population at all is not aware of the measures, that need to be taken by the competent state, municipal and voluntary bodies in the event of a radiological emergency. This potential problem is seen with great disregard and disinterest by the majority of the population, regardless of gender, age, ethnicity, education. Such an event is seen as something unrealistic, fictitious, and as impossible happen in Bulgaria. Older people are more concerned about the problem than young people [5]. In responding, respondents with a higher level of education are more interested in the affected aspects of everyday life and are at least partially aware of the problems related to radiation protection, while those with secondary and lower education are ignorant and uninterested in the discussion in the consultation. Hence, the fact that the majority of respondents are not satisfied with the state policy, regarding the actions and measures taken in case of a radiation accident (Figure 2).

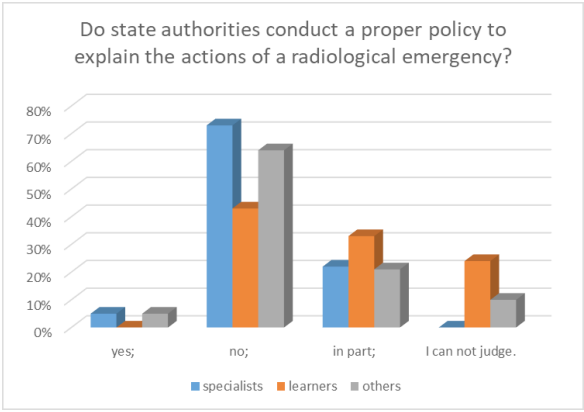

Fig. 2. Answer a question „Do state authorities conduct a proper policy to explain the actions of a radiological emergency?“

3. In general, it can be made a report that people do not know the National Automated System for Continuous Control of the Background Radiation Range. The far more professional than the problem an interviewee is,

the smaller his knowledge is . The same can be said of the educational level of the participants - people with higher education have a better idea of the system. In terms of gender, religion and age, the distribution is even and no response can be drawn. People who do not express an opinion are below 10% and are equally distributed among the different groups (Figure 3). In the consultation, a comment was often made that it is not my direct duties and I do not care.

The percentage of people familiar with the systems varied between 2% and 26%, which is a very low percentage. On this basis, a high percentage of people who have responded positively to the effectiveness of these systems can not be expected. More than half can not assess the degree of coordination between organizations that monitor the radiation situation and manage the activity of managing a situation with increased radioactive background and take measures to reduce and limit the negative impact on people and the environment.

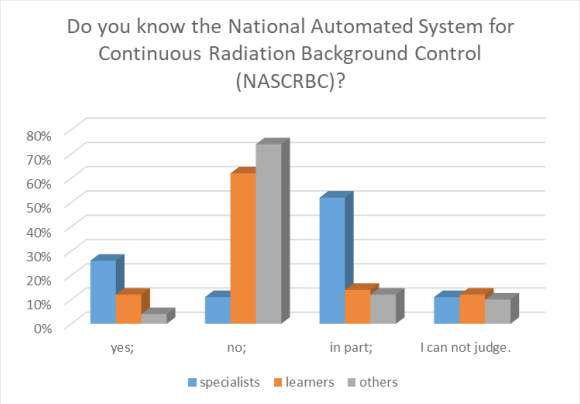

Fig. 3. Answer a question „Do you know the National Automated System for Continuous Radiation Background Control (NASCRBC)?“

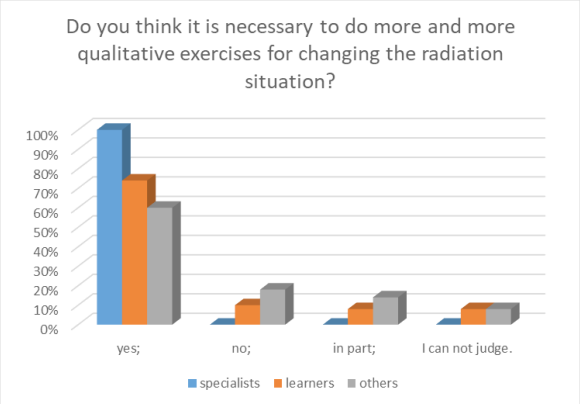

Fig. 4. Answer a question „Do you think it is necessary to do more and more qualitative exercises for changing the radiation situation?“

4. There is a concentration of responses to the need to conduct regular and up-to-date exercises for changing the radiation situation. Although much of the teachings are pre-directed, it is necessary to run regularly. An example here may be the teachings of Kozloduy NPP and other enterprises [5, 8]. Good examples can also be taken from other countries with well-established structures such as Russia, France, Japan and others. It is a good impression that such exercises take place in some schools such as Emilian Stanev Secondary School, University of Sofia, „Professor Assen Zlatarov“ Professional Lenguage School in Veliko Tarnovo and others. In conducting such exercises the respondents expressed the wish to participate more experts from the control bodies (Figure 4).

5. To a large extent, respondents have expressed the view that it is necessary for people who are professionally engaged in this to periodically increase their qualifications and to monitor changes in the field of radiation protection. It is necessary to issue documents with a fixed term to the workers, after which they have to undergo refresher training. This will maintain a higher level of competence for those working in the field. Here the answers are unambiguous and it is necessary to legislate the requirements. There is no deviation from any group in this question and the answers can be summarized for all respondents at all.

6. The sum of responses to the issues of coordination of the responsible authorities and agencies gives us a real picture of the population‘s interest in the real radiation situation, how it is monitored and what actions should be taken to reduce the negative impact. In this respect, the competent state authorities must necessarily improve their work among the population and their coordination among themselves. Only in this way would they weigh in their place, raise their authority, and the population would have greater faith in their actions.

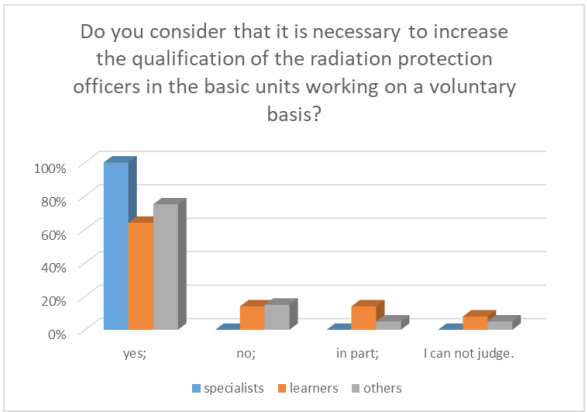

Fig. 5. Answer a question „Do you consider that it is necessary to increase the qualification of the radiation protection officers in the basic units working on a voluntary basis?“

Here, also, the predominant is „I can not judge“ again, which is indicative of the fact that a large part of even the experts can not judge the real picture of the state of coordination among the most important authorities in the field of radiation protection. It is imperative for these important units for the state to become professionals and not leading to a continuous changing of structures and performers, depending on the political situation. For example, Italy may be given a position where, despite frequent political changes and elections, the Secretary of the Ministry of Foreign Affairs has headed for more than 30 years, and this creates the security of the institution he represents.

Figure 6 shows the assessment of the coordination

between the responsible radiation monitoring institutions, according to the respondents.

All the inquiries about the need of more and better quality exercises and annual training of the staff responsible for monitoring the radiological situation and especially for government, local authorities and other non-governmental or voluntary organizations are all categorical.

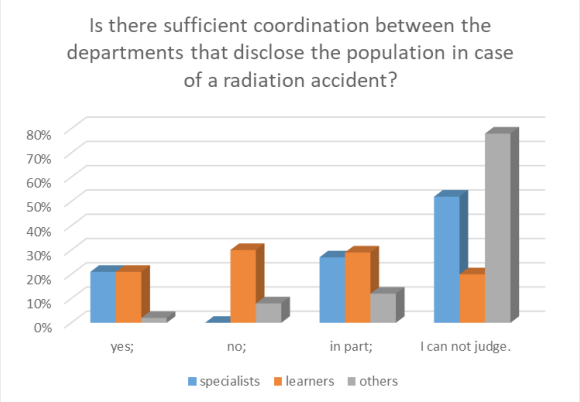

Fig. 6. Answer a question „Is there sufficient coordination between the departments that disclose the population in case of a radiation accident?“

When examining in detail the main sites where nuclear facilities are or could be located, there is also a different degree of the suspected danger, the most serious being, according to all respondents from Turkey, where specialists give 37% and the other participants give 57 - 64%. The other possible answers are given in roughly the same range regardless of the type of category. It is quite clear that the Kozloduy NPP is the most reliable nuclear site in the region and is unlikely to have radioactive contamination (Figure 7).

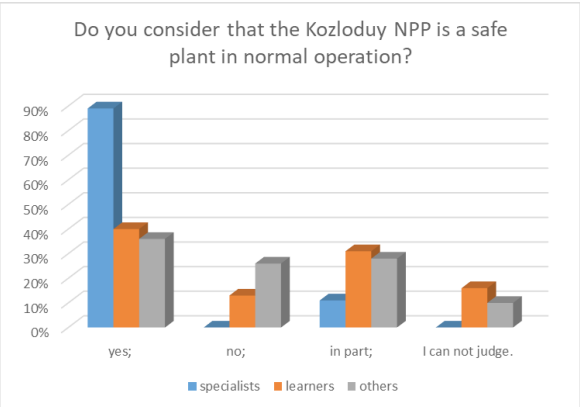

Fig. 7. Answer a question „Do you consider that the Kozloduy NPP is a safe plant in normal operation?“

When reading the survey data, it is clear that a large part can not judge whether the sites in Romania are potentially dangerous because of the lack of the necessary information. This leads us to the conclusion that a large part of the population in Bulgaria is not familiar with our neighbouring countries and we are not interested in enriching the knowledge about our safe living not only in terms of radiation safety but also in terms of other potential dangers and risks.

Although a referendum was recently held in Bulgaria on whether to develop nuclear power by building new capacities in the consultation, I included such a question. The predominant response was to Belene NPP, with approval of 80% for nuclear and safety specialists, while for the random respondents the positive response was 54%. Accordingly, the disapproval was highest in the last category - 46%, and in the experts it was only 20%. With a ready-made one and almost ready-made second reactor, it is most reasonable to install them on the approved site and put into operation and Bulgaria to regain its dominant position in the energy exporter region, otherwise, in the near future, we may become extremely energetic dependent.

8. The majority of respondents from the second and third groups did not make suggestions, but there are also very reasonable and reasoned ones. Together with the suggestions of the employees in this field, we can bring them to the following summarized suggestions:
   - The need of more quality annual exercises of all responsible institutions;
   - Improving interaction between follow-up and disclosure organizations;
   - Conducting seminars and refreshing effective staff training;
   - To have up-to-date and accessible information on the radiation situation by explaining to the competent authorities and the media where and how the population will receive it;
   - In the current development of the technique, the publicity should include, in addition to national television and radio and other electronic media and mobile operators, this being legislatively regulated;
   - Increase the control points for monitoring the radiation background, taking into account the research and analysis [11].

IV. Conclusions

1. The data from NASCRPF are used by the competent state authorities for preventive measures and for the organization of measures aimed at limiting the impact on human and the environment of radioactive particles, rays and isotopes;
2. The lowest radioactive background in Veliko Tarnovo is the lowest.
3. The awareness of both professionals and voluntary formations and the population itself is low, as shown by the survey data;
4. It is necessary to carry out an explanatory work among the population in order to improve its awareness. It is also necessary to carry out exercises for changing the radioactive situation.
5. The radiation gamma background of the neighbouring atmospheric layer is within the boundary of the country's background values without significant deviations over the last 20 years. Surface water currents and basins are in good radiological state and are controlled by the control bodies of the EEA in accordance with the applicable regulations. As far as the radiation status of the soils is concerned, no values

are found above the backgrounds of the periodic and extraordinary measurements made during the last 15 years;

6. A clear program has been developed and implemented in terms of nuclear safety with the participation of all levels of state and local government [9]. A National Strategy for the Safe Management of Spent Nuclear Fuel and Radioactive Waste has been developed and the necessary control has been introduced on these activities. It is a weakness that changes the position of the bodies involved in this activity, there is an outflow of specialists and the thread between the state and municipal authorities and the voluntary organizations is broken.
7. Government documents were adopted to solve the problems with the consequences of priority liquidated sites of uranium mining and uranium processing. There are still weaknesses and under-reclaimed sites and unsealed former mines where environmental pollution from leakages and soils containing uranium and other radioactive isotopes may occur.
8. Research shows that specialists responsible for radiation protection at secondary and lower levels are not sufficiently theoretically and practically prepared and the exercises conducted are not effective. It is necessary for these specialists to undergo refresher courses every year for both radiation and accidents and other accidents. This would help to increase their knowledge, skills and competencies. The management of NASCRGF is carried out professionally, according to the requirements of the international organizations and according to the domestic and international legislation. An extension is needed from the team of specialists working to monitor the radiation background in Bulgaria, as well as improving their financial and resource security [8].

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Use of Drilling Muds

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***Abstract*—Drilling of wells is accompanied by pollution of all environmental components with drilling and process waste. With drilling operations carried out, terrain and soil mass disturbance occur first. Waste generated during the drilling process includes drilling muds, return drilling muds, drilling wastewater. The contaminating ability of drilling waste is determined by the use of chemical reagents and components involved in the preparation and processing of drilling muds. The use of additives and reagents is necessary to make sure the solution displays certain properties that ensure effective well drilling. The resulting waste is usually disposed of at landfills or is buried at the site of formation in mud pits, ensuring minimal environmental impact. The use of drill muds in other spheres is hindered by the complex composition of oily waste.**

The composition of liquid and solid fractions of drilling muds from several deposits were studied in laboratory setting. Waste samples were analyzed for moisture content, organic substances, oil products and other substances. According to the results of the research, measures for improving the properties of drilling muds were developed and proposed. For this purpose, an introduction of high sorption substances to the waste is proposed.

The most effective should be the use of a sorbent capable of retaining organic matters and heavy metals. The resulting homogeneous soil-like mixture can be used for land reclamation in the city areas and other settlements, when performing planning works at the initial and final stages of construction, as well as at landscaping residential areas.

Keywords—drilling mud, laboratory tests, land reclamation, waste disposal.

I. Introduction

Oil production exists and is developing in different countries of the world for more than 110-140 years. Since then, oil and gas production has increased more than 40 times. Now the new generation of drilling rigs are fully automated, equipped with robots that minimize manual labor, performing monotonous and dangerous types of work on the rig [1] – [5].

However, if the equipment, procedures and drilling technology have evolved over the years, then such by-products of well drilling, like drilling muds, have been placed and accumulated in mud pits of the drilling sites for many years [5] – [7]. The importance of the problem lies not only in the increasing amount of waste, but also in their negative impact on all components of the natural environment [8]. Wastes significantly change the natural state of the geo-ecological environment, decrease natural resistance of groundwater, activate geochemical and geomechanical processes, and alter the natural microbiocenosis [9] – [11].

Due to the complex component composition of oily waste, the choice of its processing method is difficult. In the oil industry, research and development is carried out on the separate processing of drilling wastes, depending on the conditions of their formation, their depth and shelf life in mud pits [12] – [14]. Such an approach makes way for the rational use of wastes as secondary material resources.

Waste generated during the drilling process includes drilling muds, return drilling muds, drilling wastewater. The contaminating capacity of these wastes depends on the type of chemical reagent and the components used in the preparation and processing of drilling fluids in order to provide the solution with certain properties that contribute to more efficient drilling [15] – [17].

Most oil companies place drilling muds in mud pits on their well pads to investigate ways to convert the muds into fuel, fertilizers, and construction soil [16] – [20].

Simple backfilling of mud pits with soil after disposal, without reclamation measures, leads to an increase in anthropogenic load on the utilized area.

II. Materials and methods

The first goal of scientific research was to determine the composition of drilling muds formed on the territory of the Orenburg region. Material for studies was collected on the territory of the Tsarichansky-Filatovsky deposit of the Orenburg region, namely at the construction sites of production wells No. 526 and No. 419. This deposit is the largest discovered in the Orenburg region in recent years and one of the most problematic in terms of geology in the world. For such a challenging oil production, drilling of high-tech wells with multi-stage hydraulic fracturing is performed.

Constantly circulating drilling fluid, present in the process of drilling, brings to the surface cuttings which are later sent for temporary storage in a two-section mud pit (Fig.1). The solid fraction of the waste is separated and precipitated in the first receiving section, and the liquid components flow through the overflow pipe into the second section of the pit and are involved in the process of recycling for repetitive use of the solution.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4101

Fig. 1. The two-section mud pit.

Table 1 and 2 present the estimated volumes and masses of drilling waste generated during well construction.

TABLE I. ESTIMATED MASS AND VOLUME OF WASTE FROM DRILLING WELL NO. 419

Parameters	Type of waste		
	Drilling muds	***Drilling fluids***	***Wastewater***
volume, m3	357	751	1500
mass, tonne	643	788	1516

TABLE II. ESTIMATED MASS AND VOLUME OF WASTE FROM DRILLING WELL NO. 526

Parameters	Type of waste		
	Drilling muds	***Drilling fluids***	***Wastewater***
volume, m3	361	755	1511
mass, tonne	651	793	1526

Study

To determine the physical and chemical composition of the resulting waste muds, liquid and solid fractions of drilling waste were taken as samples. The samples were collected in several parts of the mud pit, meeting the following conditions:

- first sampling took place before the drilling mud was exposed to the atmosphere,
- second sampling took place directly in the first compartment of the mud pit, where the solid components had precipitated,
- third sampling was carried out in the second compartment of the pit where the liquid fraction had accumulated.

The solid fraction before the study and after the elimination of water and components soluble in organic solvents is presented in Fig. 2 and 3 respectively. The liquid fraction of the sample is presented in Fig. 4

Fig. 2. The sample to conduct research.

Fig. 3. The sample after the elimination of water and components soluble in organic solvents.

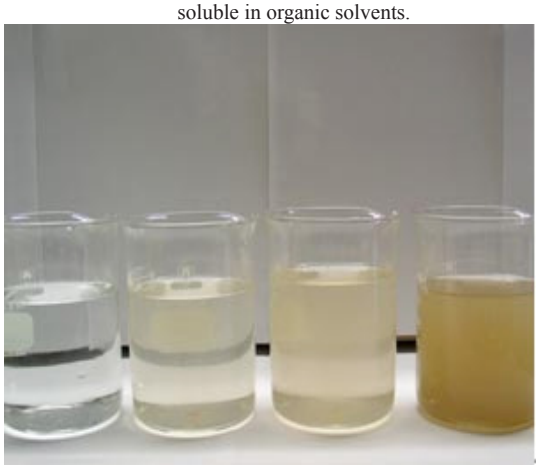

Fig. 4. The sample of liquid fraction.

III. RESULTS AND DISCUSSION

The results of chemical analysis are presented in the diagram (Fig. 5).

Based on the data obtained, the hazard class 4 of drilling waste was determined. The results of the study also showed similarity of drilling muds and surface rocks that belong to soil-forming rocks.

Therefore, the resulting drilling fluid that has undergone four-stage cleaning can be used as a feedstock for the final decontamination and formation of artificial soil.

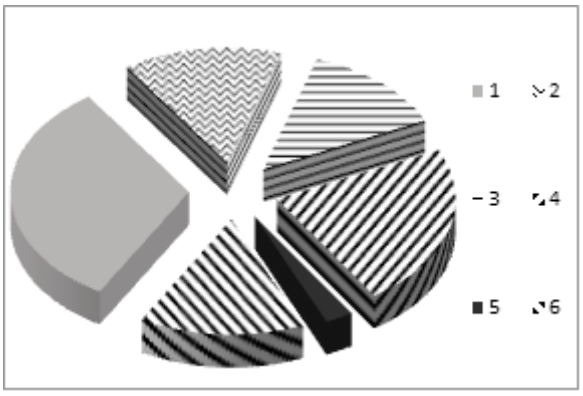

Fig. 1. The percentage of pollutants in the sample of the solid fraction of drilling muds (%): 1 - clay, 2 - calcium chloride, 3 - magnesium chloride, 4 - calcium carbonate, 5 - magnesium carbonate, 6 - iron oxide

The utilization of such soils is possible only in the case of their transformation and decontamination by the additives that have no negative impact on the

environment. Such substances include sorbents with high sorption capacity.

There are currently several such sorbents utilized for the disposal of drilling muds. Each has its own advantages. The comparative analysis of groups of sorbents showed that a destructive sorbent, which consists of carbon and silicon dioxide, is the most effective for the considered drilling waste. That is, the sorbent must exhibit the properties of coal and silicate adsorbents. Such a sorbent will be closest to the soil in its composition, and will allow the fixation of organic substances and heavy metals.

For these purposes, the destructive sorbent СД-1 was analyzed. It has no artificial biodestructive microorganisms in its composition. The oxidative activity of the sorbent helps to improve the conditions for the development of the local natural community of biodestructive species.

To apply the recommended method of disposal of drilling wastes, we advise to analyze the possibility of building a drill hole (at the preparatory stage) to determine the feasibility of using this treatment technology. The next recommendation is to provide a compartment directly in the mud pit for further mixing of the drilling fluid with the reagent. At the final stage of drilling waste treatment, it is recommended to conduct intermediate monitoring of the condition and composition of the obtained soil. After all the necessary decontamination processes have taken place, a fertile layer of 10-20 cm thick is created on the reclaimed surface.

IV. Conclusions

To develop measures to reduce the negative impact of drilling wastes on the environment, to decrease the utilized volumes of drilling fluids, studies were conducted on the composition of the liquid and solid fractions of the resulting drilling wastes at several drilling sites in the Orenburg region.

Based on the presented research results, possible options for drilling waste disposal were analyzed to determine the most optimal solution.

The recommendation is to use a sorbent, which allows both to decontaminate drilling fluids and decrease their hazardousness from class 4 to class 5, and also to obtain artificial soil without hazardous properties.

The resulting soil mixture can serve as a mineral base for the fertile layer when carrying out biological reclamation, as a backfill at construction sites, in the course of construction and finishing of field roadways and field sites, as well as for reclaiming and backfilling of open pits, trenches and other types of works that make use of traditional soil.

Since, while being processed, the hazard class of drilling muds goes down to 5, and the muds have no negative impact on the environment, the resulting soil may be used in the planning of construction sites of settlements, as well as in land reclamation.

The economic effect from the use of sorbent (data calculated for one well) is approximately 5 million rubles.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 62-64

Minimization of Soil Pollution in the Urban Environment

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***Abstract*—The development of all spheres of human activity is associated with an increase in anthropogenic pressure on environment. Metropolitan areas and large cities are experiencing the greatest pressure. Both the development of new areas adjacent to built-up areas, as well as operating existing industrial and residential complexes suffer the influences. The article presents the results of a soil study conducted in the city of Novokuibyshevsk to determine the prospects for future growth of the city. Soil samples were taken throughout the city. When choosing the place of sampling, the locations of highways, industrial zones and residential buildings were taken into account. Soil testing was carried out to obtain data on the concentrations of heavy metals (lead, zinc, copper, cadmium, nickel, manganese, etc.), as well as sulfates and nitrates. The results were analyzed and contrasted with the standards and results of previous years.**

Based on the study of the current state of the soil, the authors assessed the degree of pollution of urban soils in an industrial city. In their study they proposed and developed measures to improve the condition of the soil, namely, analyzed the efficiency of using phytoremediation to reduce soil contamination in residential areas of the city.

Keywords*—land reclamation, soil contamination, phytoremediation, soil examination, urban areas.

I. Introduction

Heavy metals today belong to the group of the most dangerous toxic pollutants. The ingress of metals into ecosystems leads to irreversible changes and disruption of vital functions in many living organisms.

The main advantages of urbanized areas lie in their suitability for ornamental plants, the ability to absorb pollutants in depth and keep them from penetrating into the soil and groundwater. When first heavy metals get

into the depth of soddy-podzolic soil, they gradually come into contact with a layer of litter [1] – [3].

These contacts manifest themselves in different ways. On the one hand, litter layer acts as a trap for heavy metals, and on the other hand, the acquired saturation with water-soluble organic elements leads to the transformation of metals into a more migratory-active form.

Moreover, the predominance of heavy metals within the ecosystem leads to their increased accumulation by plant organisms [4] – [5]. As a result, we face changes in the mass and composition of tree waste, in the nature of its decomposition, and in the transformation of the humus state of the soil. Changes in the properties of the soil cause changes in soil processes and states, secondary pollution of the urban area soil layer. The degree of soil contamination, in turn, affects the attractiveness of residential areas. It is no surprise that areas with a high level of pollution are less attractive for the working population [6] – [9].

The objective of this study is to assess the degree of urban soil pollution and to investigate the effectiveness of using phytoremediation to reduce soil contamination [10] – [12]. Phytoremediation is a highly efficient technology for the decontamination from a number of organic and inorganic pollutants. The potential of phytoremediation for treating the areas contaminated with toxic agents causes great interest in the sturdy of further restoration of the environment by plants. In recent years, this technology has gained great popularity, which is directly related to its low cost [13] – [18].

II. Materials and methods

To determine the degree of soil contamination, samples were taken in each area of the industrial city (Fig. 1). Soil samples were also collected around the Petrochemical complex within a radius of 5-6 km.

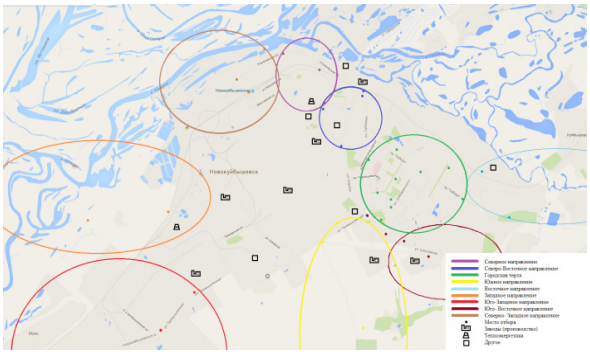

Fig. 1. Soil study areas.

Soil samples were collected according to the following wind rose directions: north, south, west, east, south-west and south-east, at a distance of 0 to 6 km from the source of pollution. A test site of 100*100 m, completely reflecting the soil structure of the study area, was

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4102

selected near the fixed points. Sampling was carried out according to the "envelope" method of the test site: four additional test pits were dug round each of the five points. A monolith measuring 10*10*20 cm was cut from a pit with a soil knife.

Of the twenty-five individual samples of approximately equal mass, a mixed sample was made up, from which remains of vegetation, stones, etc., had been removed. The soil was ground, mixed, then packed in a cloth bag or paper box to be delievered to the laboratory.

Analysis of the samples taken is carried out in the laboratory of the Center for Monitoring Environmental Pollution. The measurements were taken using calibrated instruments. Harmful substances were determined according to the approved methods. The soil samples were examined for heavy metals: cadmium, manganese, copper, nickel, lead, zinc, aluminium.

In case there were not any agreed upon MPC values for a specific element, the values obtained were compared with the APC values. The findings were then set against the background reference levels for pollutants in the soils of Samara region (i.e. regional concentration clarkes) to determine the degree of soil contamination in Novokuybyshevsk.

The next stage of research was to determine the effectiveness of phytoremediation in the urban environment. For this, petunia seeds were used.

Soil for conducting experiments on the composition and degree of contamination was taken similar to that obtained in the first part of the research. The focus was on pollutants such as zinc and copper.

III. Results and Discussion

The results of soil contamination study are presented in Fig. 2. Following the retrieval, the Quantum-Z atomic absorption spectrometer was used to test the samples for the presence of the main pollutants: aluminum (Al), cadmium (Cd), manganese (Mn), copper (Cu), nickel (Ni), lead (Pb), zinc (Zn). This method is based on the phenomenon of selective absorption of optical radiation (light) by free atoms of chemical elements.

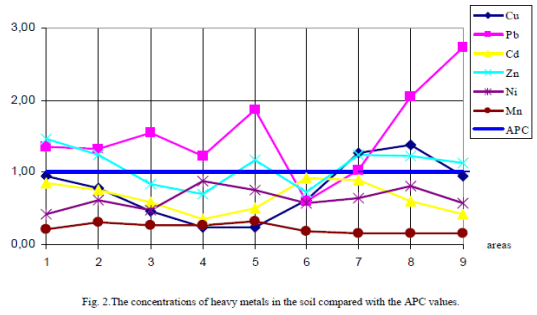

Fig. 2.The concentrations of heavy metals in the soil compared with the APC values.

Fig. 2. The results of the analysis of soil contamination.

In the soils of the city, the average Cu content was 15.3 mg/kg. The study proved that in two soil samples (areas No. 7, 8), the Cu content exceeded the regional background and ranged from 25.5 to 27.7 mg/kg. However, in two areas the values obtained exceeded those of the regional concentration clarke (20 mg/kg) by 27.5% (Group 7 - south-west) and by 39% (group 8).

Analysis of the total Pb content in sample soils showed that its concentrations exceeded the background level across the board. The concentration of lead ranged from 6 to 27 mg/kg, with the average at 15.26 mg/kg, which did not exceed the MPC value (32 mg/kg), but was 53% higher than the background reference level (10mg/kg). The maximum value reached 1.8 MAC. The average lead content in the city was 0.5 MAC. The values of the regional concentration clarke were exceeded in seven areas out of nine.

The analysis of data on the content of Cd in soils showed that its content in samples taken from the northern, western and southwestern areas was much closer to the regional value The average and maximum content of cadmium in the soil of the city was observed at the level of 0.2-0.4 of a permissible value.

The content of Zn in all soil samples was lower than the existing MAC, although in some cases the number of total forms of Zn in the soil was at the level of its background. The following zinc concentration values were obtained: the maximum value at 73.5 mg/kg, the minimum value at 36.3 mg/kg and the average value at 54 mg/kg. As the MPC value for zinc is 220 mg/kg, these values were within permissible limits. However, when set againstthe background reference levels (50 mg/kg), the values obtained exceeded the background values by 13-47% in six areas.

The maximum nickel concentration at 35.35 mg/kg did not exceed neither the MPC value (80 mg/kg), nor the regional concentration clarke (40 mg/kg) in any of the areas. Similar results were obtained for nickel and manganese.

The average aluminum content in the soil of the city was observed at the level of 6224 mg/kg (5.4 of background values), the maximum – 7936 mg/kg (6.9 of background).

For planting, averaged concentrations of pollutants were taken (Table 1). Petunia seeds were planted in two containers.

TABLE I. Contaminants In Soil Before Planting

Container No.	Heavy metals in container soil, mg/kg	
	Zinc	*Copper*
1	46.5	15.3
2	532.8	343.5

Intensive care (watering, extra light) provided the first shoots after 15 days. Figure 3 shows that the plant in tank No. 1 (controlled) noticeably predominates in development than the plant in tank No. 2.

Fig. 3. The first shoots of petunias.

The stem of both plants is dense. The leaves are green, with no visible changes (Fig.4). Petunia in container No. 2 develops more slowly, without visible negative changes. Figure 5 shows that the petunia planted in container No. 2 is still lagging behind in development.

Despite the soil contaminated with heavy metals (Zn and Cu), petunia seedlings showed satisfactory development. At the same time there was a significant decrease in the concentration of pollutants in the soil. For example, the concentration of copper decreased by 3 times, and the concentration of zinc by 1.5 times. From this we can conclude that the plant absorbs zinc in smaller quantities.

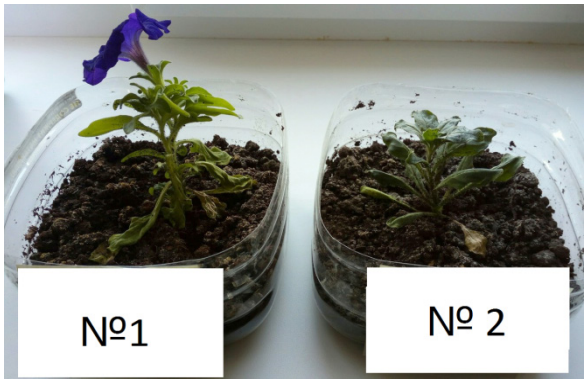

Fig. 4. Plants after 38 days.

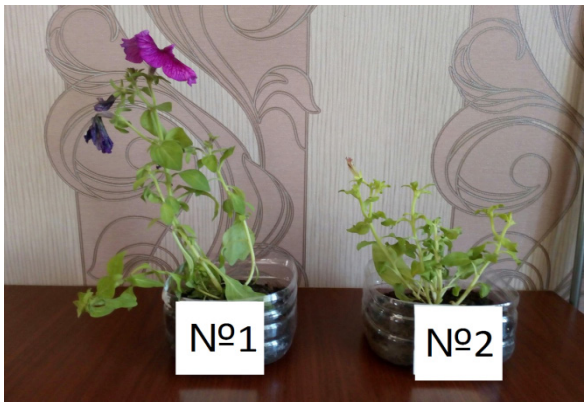

Fig. 5. Plants after 60 days.

Taking into account that in the laboratory experiment seedlings of petunia were grown in an artificial environment and did not reach their maximum biomass, when growing a flower crop under natural conditions, the values are expected to be higher. We can draw the conclusion about the prospects for further research of this plant in order to use it for phytoremediation of contaminated urbanized soils with copper and zinc pollution reaching the value of 5 MAC.

IV. Conclusions

The proposed measure to minimize soil pollution in the city of Novokuybyshevsk should reduce the negative impact of anthropogenic sources on the environment. Moreover, the measure decreases the pollution of the atmosphere, soil and water, as well as reduces damage to the animal and plant world, which leads to a more beneficial state of the environment.

A separate and equally important area of research is the in-depth consideration of the issue of utilization of contaminated plant biomass in order to prevent re-contamination of various ecosystem components with their subsequent entry into food chains.

As an example, for the concentration of heavy metals the following can be done:

1) burning plants with coal in the furnace of a thermal power station

2) composting (using plant biomass as intermediate layers of a landfill).

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 65-69

Downstream Transformation of the Flood-Flow Characteristics within the River-Floodplain System of the Middle Daugava

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***Abstract*—A series of 11 experimental hydrological field surveys of the Daugava's flood-flows has been conducted within the river-floodplain system of the Middle Daugava by the Department of Geography and Chemistry, Daugavpils University, in 2007-2017. The field surveys were conducted in a form of real-time Lagrangian drift experiments, which were focused on a continuous tracking and monitoring of pre-selected flood water masses moving along the Middle Daugava River from Krauja to Dunava at the peak of the spring floods. The real-time tracking and monitoring of the selected flood water masses was conducted by applying a manned drifting research platform. It was equipped with a GPS receiver and an echo-sounding device for repeated measurements of the average drift velocity, the channel's depth and geographical position of the platform in relation to its initial location. During the drift experiments, instrumental measurements were performed repeatedly, each 30-60 minutes. The obtained records were then used to analyze downstream changes in main hydraulic characteristics of the surveyed flood-flows. Main results of 9 real-time Lagrangian drift experiments conducted within the Middle Daugava river-floodplain system in 2007-2017 are analyzed and discussed in this paper. Application of the Lagrangian reference frame for the obtained data records revealed the unsteady, spatially varied nature of the surveyed flood-flows and highlighted an overall downstream reduction of their average drift velocities and depths, as they leaved the Baltic Moraine Uplands and entered the East Latvian Lowland downstream from Daugavpils. The Spearman's correlation revealed the strong effect of inter-annual variation of the peak flood discharge and longitudinal gradient of the water surface on the main hydraulic characteristics of the flood-flows. Application of the well-known Chézy equation to the obtained data records also revealed its inadequacy for research purposes of this natural river-floodplain system, but also highlighted the importance of other factors (such as the active cross-section area and hydraulic interaction between the river and its floodplain) on the site-by-site variation of the current velocity within the main channel during the floods.**

***Keywords*— Daugava, flood-flow, Lagrangian study.**

1. Introduction

The river-floodplain system of the Middle-Daugava is the largest natural floodplain area inundated annually by the floodwaters of the Daugava River, not only in Latvia but also along its entire length [1]. It is located in upper part the *Naujenes-Jēkabpils stretch* [2] between Daugavpils and Jersika. In this stretch, the Daugava River leaves the Baltic Moraine Upland area (i.e. the Augšzemes and Latgales Uplands) and enters the East Latvian Lowland (i.e. the Jersika Plain). The downstream shift in fluvial geomorphology results in significant reduction of the riverbed's longitudinal gradient in summer (from about 0,1 to 0,05 m km^{-1}). Along with that gradient change, the average depth of the Daugava's valley decreases from 10-15 m at Daugavpils to 4-6 m at Dunava, while the width of the valley proportionally increases – from approximately 1 km at Naujene to 2-4 km at the Berezovka (Dviete) inlet [2].

These important geomorphological changes significantly affect also the downstream propagation of the flood-flows that enter the complex river-floodplain system of the Middle Daugava downstream from Daugavpils. During the average spring floods, the relative heights of the flood waves decreases from 6,6 m at Daugavpils to 3,9 m at Jēkabpils [2].

The peak flood discharges are usually observed in the Daugava River at Daugavpils in late March – mid-April [3]. Significant part of the Daugava's flood discharge is transferred then to the adjacent floodplain areas, which covers more than 200 km^2 and are able to temporarily accumulate more than 0,6 km^3 of water for a significant period of time, up to three months [1], [4]. Therefore, this river-floodplain system is a natural flood control mechanism that provides important ecosystem services for the downstream towns and municipalities like Līvani, Jēkabpils and Pļaviņas by diminishing the overall flood risks and preventing more frequent and potentially more catastrophic inundation at spring [4].

Since 2007, a series of 11 real-time Lagrangian drift

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4150

experiments has been conducted within the Middle Daugava's river-floodplain system during the spring floods in order to develop an empirical model that describes downstream propagation and transformation of the flood-flows under different hydrological conditions. The so-called Lagrangian reference frame and/or research method (continuous tracking and monitoring of a selected water mass or 'parcel' during its downstream transport [5]), has been systematically applied for the first time in the history of hydrological research in Latvia [6]. Its application allowed conducting the first real-time monitoring surveys of the moving floodwater masses down the Daugava's valley, helped to overcome the logistic constrains related to the field studies of a large inundated river-floodplain area at the peak of the floods, as well as to avoid the scarcity of hydrological stations located in this particular stretch of the Daugava [7].

This study summarises main results of nine real-time Lagrangian drift experiments conducted by the Department of Geography and Chemistry, Daugavpils University, in 2007-2017, highlights and analyses the observed downstream variation of the average drift velocities and the channel's depths of the surveyed flood-flows, and discusses their relation to the peak flood discharges, longitudinal gradients of the water surface, carrying capacity or roughness of the riverbed and other factors.

The main aim of this study was to test empirically the well-known rule (hypothesis) in river hydraulics that the average current velocity depends mainly on the roughness of the riverbed, the average depth of the channel and longitudinal gradient of the water surface [8], [9]. It was also aimed to answer the intriguing question – is it possible to adequately describe the site-by-site variation of the average current velocity of the particular flood-flow within the Middle Daugava river-floodplain system by applying this general model?

2. Materials and Methods

The nine real-time Lagrangian drift experiments mentioned in Introduction were conducted on the Middle Daugava River in 2007, 2010, 2011, 2012, 2013, 2014, 2015, 2016 and 2017, respectively, at different hydrological phases (Table 1). Each drift experiment was conducted shortly before or after the peak of the spring floods (usually in mid-April) at different water level and peak flood discharge of the Daugava River at Daugavpils (Fig. 1).

All nine drift experiments were conducted by applying the manned drifting research platform "Aventura" designed at Daugavpils University in 2007 and made of a maritime life-raft and an inflatable boat attached to each other [6]. The drifting research platform was equipped with two floating anchors, an echo-sounding device, a GPS receiver and other field survey equipment, essential for safe and uninterrupted tracking and monitoring of the selected flood water masses down the river during daytime. During most drift experiments, the average drift velocity of the research platform and total drifted distance was measured each 30 minutes by the built-in GPS receiver of the HACH DS-5 multiprobe [6], [10]. It was recorded also manually by using the GARMIN 76 maritime GPS receiver.

The depth of the main channel of the Daugava River at the particular sites was measured also manually by an echo-sounding device "Plastimo ECHOTEST". The depth soundings were performed each 30-60 minutes [6], [10].

The peak flood discharge values in the Daugava River at Daugavpils during the particular drift experiments were obtained from a stage-discharge relationship curve constructed for the hydrological station "Daugava-Daugavpils" (Fig. 2). It was based on the empirical data records of the water level heights and corresponding instant discharges available at the hydrological data archive of the Latvian Environment, Geology and Meteorology Centre (LVĢMC). The water level heights at Daugavpils in March, April and May were also obtained from the online information retrieval system of the LVĢMC (Fig. 1).

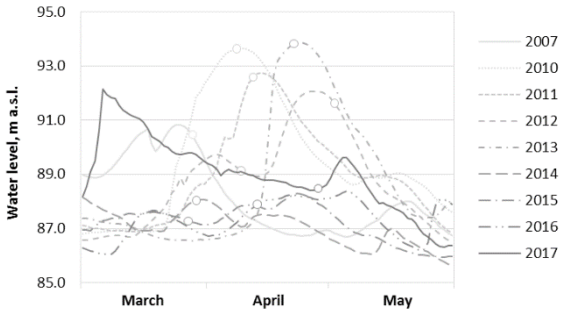

Fig. 1. Fluctuation of water levels in the Daugava River at Daugavpils during the spring floods of 2007-2017 (dates of the drift experiments are marked as empty curves; data source: LVĢMC).

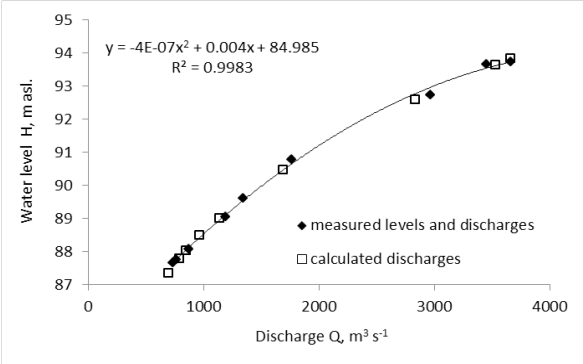

Fig. 2. The stage-discharge relationship curve for the Daugava River at Daugavpils for the spring floods of 2007-2017 (main data source: LVĢMC).

To test the hypothesis mentioned in Introduction, the average current velocities were calculated for each site used for instrumental measurements during the relatively moderate spring floods of 2014, 2015, and 2016 (Table 1). These drift experiments were selected by assuming that during realatively low spring floods the flood-flows of the Daugava River are concentrated mainly within its main channel, and the water mass exchange with the adjacent floodplain downstream from Daugavpils is minimal.

The average current velocities at particular sites (v_{av}) for these moderate flood-flows were calculated by applying the well-known Chézy equation [8]:

$$v_{av} = C\sqrt{R\,I} \quad (1)$$

where

C – the Chézy's coefficient;

R – hydraulic radius of the river channel (m);

I – longitudinal gradient of water surface (m km^{-1}).

The Chézy's coefficients (C) were calculated by applying the Manning's equation [8]:

$$C = R^{1/6}/n \quad (2)$$

where

n – roughness coefficient of the riverbed that, in this case, was equal to 0,033 [7].

The hydraulic radius (R), which is roughly equal to the average depth of the river [8], was substituted by the actual depth of the main channel recorded *in situ*. The longitudinal gradients of the water surface (I) were assumed to be constant for the entire length of the drift distance and were calculated as differences per distance (m km^{-1}) between the water level heights at the nearby hydrological stations (i.e. "Daugavpils" and "Vaikuļāni" located 20 km from each other) on the particular days, which in turn were obtained from the LVĢMC online data archive.

The calculated average current velocity values were then compared to the actually recorded average drift velocities by applying the linear correlation analysis method [8]. The Pearson's correlation coefficients were calculated also between the average velocities and depths of the surveyed flood-flows and the peak flood water discharges and longitudinal water level gradients of the Daugava River at Daugavpils.

3. Results and discussion

In total, more than 160 series of instrumental data records were obtained *in situ*, and main hydraulic characteristics of the surveyed flood-flows thus were obtained (Table 1). The correlation analysis revealed strong linear positive correlations of the average drift velocities and the main channel's depths to the inter-annual variation of the peak flood discharges in the Daugava River at Daugavpils (Fig. 3), as well as to the longitudinal water surface gradients between the nearby hydrological stations during the particular drift experiments (Fig. 4).

Graphical analyis of the recorded data records plotted on the distance axis showed that the flood-flows of the Daugava River must be classified as *unsteady, turbulent and spatially varied flows* [9], since their average velocity and depth changes abruptly from site to site over a relatively short distance (Fig. 5, 6). There are also certain downstream trends visible, especially during the relatively large spring floods of 2010, 2011 and 2013 – i.e. a gradual decrease of the recorded average drift velocity and the channel's depth *en route*. Such trends have been stated and described already after the second real-time Lagrangian drift experiment on the Middle Daugava River conducted on April 8, 2010 [10].

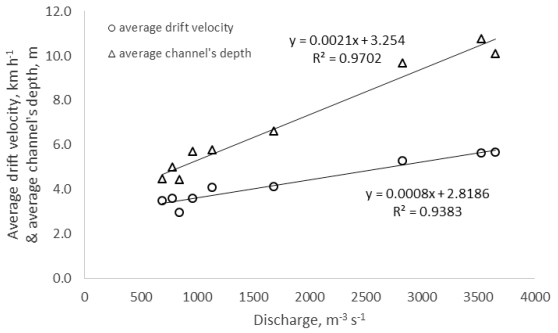

Fig. 3. Correlation of the average drift velocities and depths to the peak flood discharges of the Daugava River at Daugavpils.

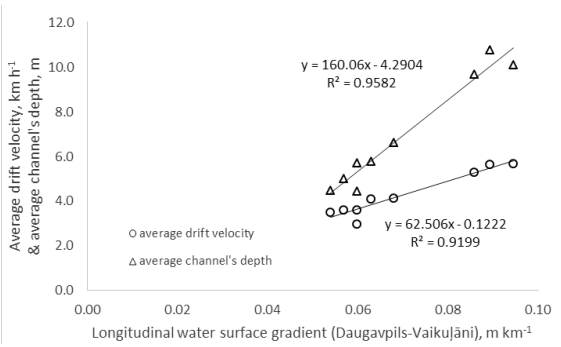

Fig. 4. Correlation of the average drift velocities and depths to the longitudinal water surface gradients of the Daugava River between Daugavpils and Vaikuļāni.

However, in the case of the particular flood-flows, there were no significant correlations stated between the average drift velocities and actual channel's depths, except for some rare cases, like on March 28, 2007 (Table 1). This lack of correlation obviously indicates that the observed downstream variation of the average drift velocity for this particular stretch of the Daugava River is controlled by some other factors instead of the depth of the main channel.

Correlation analyis revealed also a large gap between the actually recorded average drift velocities obtained during the relatively low or moderate spring floods of 2014, 2015 and 2016, and the theoretically calculated average current velocities for these cases (Fig. 7).

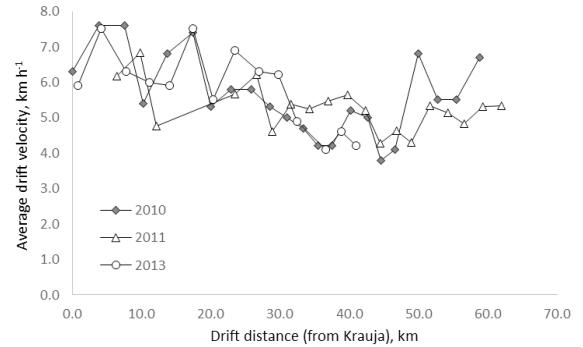

Fig. 5. Variation of the average drift velocity in the Daugava River downstream from Krauja during the spring floods of 2010, 2011 and 2013.

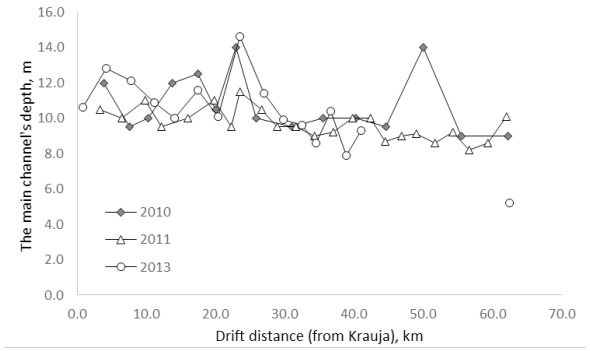

Fig. 6. Variation of the main channel's depth in the Daugava River downstream from Krauja during the spring floods of 2010, 2011 and 2013.

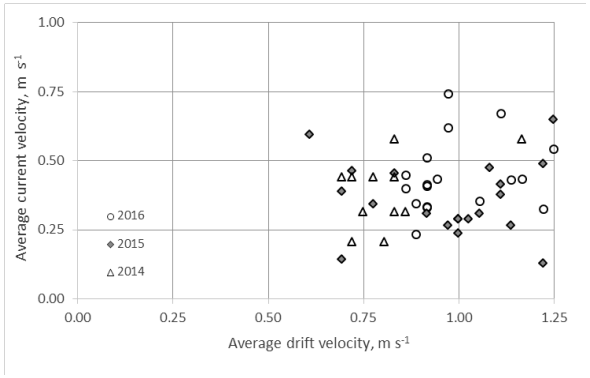

Fig. 7. Correlation between the calculated average current velocities and the recorded drift velocities during the spring floods of 2014, 2015 and 2016.

Even by taking into account an assumption that the recorded drift velocities represent the maximum velocities of the surveyed flood-flows (and therefore must be multiplied by 0,6 in order to obtain the corresponding average current velocity values [8]), they are nevertheless about 30 % higher than those calculated theoretically by applying the Chézy equation (Fig. 7). Such discrepancy probably indicates that actual carrying capacities of the Middle Daugava's main channel during the spring floods are at least 30% higher than those calculated theoretically.

On the other hand, there was almost no correlation found between these two velocity characteristics (Fig. 7). Obviously, it must be attributed to the actual depth data soundings which were used in this study to substitute the average depth (hydraulic radius) of the river channel in the classic Chézy's and Manning's equations. Therefore, the Lagrangian data records of the actual depths could not be directly used with these formulas to adequately describe site-by-site variation of the average current velocities within the main channel of the Middle Daugava river-floodplain system. Similar conclusions have been drawn from other experimental studies of the river-floodplain systems, too [11].

Therefore, the average current velocities of the surveyed flood-flows and their site-by site variation within the Middle Daugava river-floodplain system during the moderate floods could not be explained by an impact of a single driving factor, such as the depth of the main channel. Other factors included in the Chézy's equation should be analysed also.

The first driving factor – the carrying capacity or roughness of the riverbed at the particular site, is physically related to the morphology of the riverbed, its roughness or smoothness and/or sizes and shapes of underwater obstacles [8], as well as to the channel's active cross-section area [9].

In the case of the low-to-moderate flood-flows, which are constricted mostly to the main channel of the Daugava River, the principle of *continuity* must be in force if the discharge remains constant [9]. In other words, if the velocity goes down, the size of the cross-section area goes up, and *vice versa*. The active cross-section area in turn depends on the average depth and width of the channel. In our case, the actual depths of the main channel slightly decreased during the drift experiments in 2014 and 2015, or remained almost constant in 2016 (D. Gruberts, unpublished data). Therefore, it is right to assume that the width of the Daugava's main channel and the active cross-section area of the flood-flows simultaneously increased in order to compensate overall reduction of the drift velocities and the channel's depths down the river (Fig. 5, 6).

Possible impact of the second factor (i.e. the site-by-site variation of the longitudinal gradient) could not be verified jet because of the lack of detailed information regarding the heights of the water surface at particular sites along the main channel of the Middle Daugava on the particular days. In theory, the current velocity must decrease along with reduction of the longitudinal gradient of the water surface. It must be true also in this case because the longitudinal gradient of the riverbed of the Daugava River at summer gradually decreases downstream from Daugavpils (J. Soms, unpublished data). To some extent such reduction could also be stated from the historic flood water level data records obtained at corresponding hydrological stations, i.e. "Krāslava", "Daugavpils", "Vaikuļāni" and "Jersika" [7]. These hydrological stations are too few and located too far from each other, however, in order to use their actual daily data records for calculation of the longitudinal gradients at particular sites along the river channel.

In the case of relatively large spring floods such as those recorded in 2010, 2011 and 2013, there is another very important driving factor not mentioned before – an active *hydraulic interaction* between the main channel and the adjacent floodplain. The hydraulic interaction between the river and its floodplain, as well as its physical impact on spatial variation of the average current velocity, is still poorly understood due to the lack of direct observations *in situ*. In general, four main stages of such interaction and their hydrological effects have been identified by laboratory experiments [11]:

(a) actively interacting, sub-parallel flood-flows within the river and the adjacent floodplain – the average current velocity within the main channel decreases by 8-10 % when compared to laterally isolated flood-flows;

(b) active movement of the floodwaters from the river to the floodplain – the current velocity within the main channel increases by 10-20 %;

(c) active movement of the floodwaters from the floodplain back to the river – the current velocity within the main channel decreases significantly due to turbulent mixing (by >40 %);

(d) the dynamic axis of the flood-flows crosses at wide angle (>10°) – the water carrying capacity of the main channel and the average current velocity within it de-

creases drastically, and even negative velocity values could be observed.

Since during the spring floods the riverbed and adjacent floodplain of the Middle Daugava River do actually interact with each other by exchanging large volumes of water at particular sites, especially at the Berezovka (Dviete) River inlet [12], this factor must have also a profound effect on the site-by-site variation of the average current velocities within the main channel. Its role and action could be best analysed by applying the geospatial methods (such as the ArcGIS tools) to the obtained Lagrangian data records, which is outside the scope of this study, however. Geospatial analysis of these hydrological processes and their effects is the next logical step in hydrological research of this large lowland river-floodplain system.

4. Conclusions

Application of the Lagrangian research method in annual hydrological field surveys of the largest river-floodplain system in Latvia provided first insight into the real-time processes of downstream transformation of the main hydraulic characteristics of the Daugava's flood-flows that are specific to this stretch of the river, and highlighted the complex nature of their inter-annual and site-by-site variation.

In general, the average current velocities and actual depths of the surveyed flood-flows of the Daugava River are dictated by the inter-annual variation in the peak flood discharge and longitudinal gradient of the water surface downstream from Daugavpils.

In this stretch of the Daugava River valley, where it enters the East Latvian Lowland, the average current velocities and actual depths of the flood-flows are gradually reduced downstream, most probably, due to the corresponding significant increase of the active cross-section area (in the case of moderate spring floods) and/or active hydraulic interaction between the main channel and the adjacent floodplain (in the case of relatively large spring floods).

The well-known Chézy's equation could not be successfully appied along with the Largrangian experimental data records to calculate the average current velocities even for the moderate flood-flows, since the actual depth soundings do not represent the average depths of the main channel at the particular sites. Therefore, it is not possible to adequately describe the observed site-by-site variation of the average drift velocity of the particular flood-flow within the Middle Daugava river-floodplain system by applying this general model, and geospatial analysis methods must be applied instead.

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12. L. I. Glazacheva, *Ledovoj i termicheskij pezhim rek i ozer Latvijskoj SSR.* Uchenye zapisi. Geograficheskije nauki. Tom 65. Riga: Zinatne, str. 118, 1965 (in Russian)Table 1. Summary of the main results of the 9 real-time Lagrangian drift experiments conducted on the Middle Daugava River in 2007-2017

Date of the drift experiment (dd/mm/yyyy)	28/03/2007	08/04/2010	12/04/2011	10/04/2012	22/04/2013	29/03/2014	26/03/2015	12/04/2016	28/04/2017
Hydrological phase	drainage	filling	filling	drainage	filling	filling	drainage	filling	drainage
Water level of the Daugava River at Daugavpils, m a.s.l.	90.5	93.6	92.6	89.0	93.8	88.0	87.4	87.8	88.5
Discharge in the Daugava River at Daugavpils, $m^3 s^{-1}$	1688	3530	2831	1137	3659	845	696	787	965
Total drifted distance, km	51.3	62.2	61.9	44.9	62.4	24.2	35.5	32.3	41.2
Total drift time, hh:mm	12:00	11:00	11:00	10:30	11:00	08:30	10:00	09:00	10:00
Average drift velocity, km h^{-1}	4.1	5.6	5.3	4.1	5.7	2.9	3.5	3.6	3.6
Average depth of the main channel, m	6.6	10.8	9.7	5.8	10.1	4.4	4.5	5.0	5.7
Average longitudinal gradient of the flood water level (Daugavpils-Vaikuļāni), m km^{-1}	0.07	0.09	0.09	0.06	0.09	0.06	0.05	0.06	0.06
Pearson's correlation coefficient between the average drift velocity and the main channel's depth, r	0.96	0.50	0.66	0.54	0.74	0.45	-0.03	0.22	0.55

Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 70-74

Mass Transfer Management and Deposition of Contaminants within Car Road Zones

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***Abstract*—The present study determined that the essential factor of technogenic influence on the roadside landscapes is a motor complex that leads to the alienation of large territories, destabilizing of the natural ecosystems, the disarticulation of landscapes and an irreversible transformation of nature and territorial complexes in general. The significant influence of motor transport is the exhaust emissions with Carbon (II) oxide, Nitrogen oxides, hydrocarbons, aldehydes, soot (technical carbon), mineral dust, heavy metals, etc., that influence not only on the environment, but also on the health of the population. The migration and deposition of the pollutants that are produced by vehicle flows are caused by many factors of different genesis. In particular, this landscape topographic characteristics and the geochemical territory activity of natural and technogenic geo-ecosystems, structure of biocoenoses, presence of geochemical barriers (including artificially created), density, construction, transport, physical and geographical, social and economic features of transport network infrastructure, the intensity of transport flows, etc. Therefore, to ensure the environmentally safe operation of "car – road – environment" system should include a systematic approach to the development concept of the transport complex within the specific natural and man-made geo-ecosystems with developed automobile and communication networks that would provide not only its economic and transport feasibility, but also minimizing the anthropogenic transformation of natural and territorial complexes in general. To reduce eco-destructive impact we recommend to apply the developed design of forest of gas and dustproof lane road that substantially reduce the dangerous zone of influence.**

Keywords*— *environmental security, model forest of gas and dustproof strips, road pollution.

I. Introduction

The establishment and operation of a national network of international transport corridors in Ukraine provide significant reduction of negative influence of transport complex on the roadside territories by creating environmental conditions on the highways, because the arterial and separate infrastructure roads refer to objects that make up an increased ecological danger [1, 2].

In general, the density of roads in Ukraine is in 6.6 times lower than in France (0.28 and 1.84 km of highways per 1 square km of the country area). The length of expressway roads in Ukraine is ~ 0.3 thousand km. By contrast, in Germany – 12.5 thousand km, in France – 7.1 thousand km, but the level of funding per 1 kilometer of roads in Ukraine, respectively, in 5.5 – 6.0 times smaller than in these countries [3]. The roads of the first category with high-speed multirow movement are absent on the territory of Ukraine. Most of them pass through the cities and don't meet the requirements of international transport corridors, and this fact leads to speed restriction and increase the danger level, including the environmental danger. The length of expressway roads in Ukraine of the European model is only 280 km. It should be mentioned that the dynamic growth of the vehicle and the annual 5-percent growth of cars in Ukraine, leads to an increase in traffic intensity on the main roads up to 20%. The transport and operational status of motorways is also unsatisfactory: 51.1% did not meet the equality requirements, and 39.2% - the durability requirements. Such low road transport and operational speed indicators of roads determine the low operational speed of vehicles that is in the 2-3 times lower on the roads of Ukraine than in Western European countries. In addition, these indicators lead to the rising of fuel and lubricant costs that are 30% larger than the similar indicators in European countries [4].

Therefore, the increase in the motorization level and vehicle intensity on the highways leads to increasing their eco-destructive influence on a large scale. Therefore, to ensure the environment safe operation of transport complex a systematic approach to the state concept of

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4145

"car – road – environment" development that will provide a high transport performance, convenience and safety of vehicles, the preservation of the natural characteristics and properties of the roadside landscape should be applied.

The purpose of the research is to increase the level of environmental safety of natural and man-made geo eco-systems with high density of road network on the basis of artificially created geochemical barriers such as forest gas and dust-proofing zones that limit the migration and exhaust fumes emission caused by motor transport activity.

II. Materials and methods

The main results of the thesis were obtained on the basis of the system analysis and generalization of multivariate information about the dynamics of technological transformation of natural and man-made geo eco-system with developed vehicle networks (ecological optimization of the road network infrastructure, the development of scientific and methodological fundamentals of ecological safety of "car – road – environment"), the laws of thermodynamics, energy transfer and aerodynamics (the research on the processes of the vehicles gas and dust emission migration, landscape and spatial distribution of polluting ingredient deposition, the environmental effectiveness of protective road infrastructure) simulation modelling methods according to physical and dynamical analogy method (ecological and transport optimization of reference frame of transport network and the optimization of structural parameters of profile in cross-section reserve and technology automobile lanes). Analytical studies are performed on the basis of fractal geometry method (the study of the processes of dust aerosol adhesion on the landscape surfaces, compliance with environmental landscape safety that have been transformed road network).

III. Results and discussion

The transformation of natural processes is identified, primarily, in terms of motorway influence through the roadside contamination by the following polluters: Carbon (II) oxide, Nitrogen oxides, hydrocarbons, aldehydes, soot (technical carbon), mineral dust, heavy metals, etc., that cause significant influence both on the environment and the health of the population.

The regression equation (often the third order) is widely used to calculate gas and fuel emissions, as well as the specific fuel costs of motor flow:

$$Y_i=A_4\cdot q^3_{an}+A_3\cdot q^2_{an}+A_2\cdot q_{an}+A_1 \quad (1)$$

where Y_i [kg] is the specific weight of a certain exhaust fumes ingredient, or specific fuel consumption by car flow;

A_i – empirical coefficients

q_{an} [1/s] is the intensity of transport stream.

In this case:

$$A_i=f(S_i,S_j) \quad (2)$$

where S_i, S_j is the share of motor vehicles equipped with diesel engines and the share of motor vehicles for passenger transportation in the total number of motor vehicles.

However, the current method for determining the balance of emissions that are produced by vehicle flow, in the full extent ignores such important transport operational signs of road network as geo-morphological nature of road, its technical condition, transport capacity and weather and climate conditions (road and climate zoning) natural and technogenic geo-ecosystems, the operational status of the vehicles in the motor transport flows and a number of other important indicators that significantly affect the level of technological transformation and environmental safety of natural territorial complex [5, 6].

That is why the generalized concept of maximum saturation of natural and technogenic geo-ecosystems by vehicle and road infrastructure is formed on the basis of the evaluation of the territory transport capacity i.e. the ability of the landscape of natural and territorial complex to ensure transport needs (in the areas for the location of stationary and moving objects in a motor complex, natural objects and recreational resources) without violation of the ecological balance. Transport capacity D_{max} is expressed in the form of maximum density of the road network and transport infrastructure within the natural territorial complex as [1, 6]:

$$D_1^{\text{т}} = \frac{Y_{\text{а}}\,\Pi_{\text{н}}\,S_{\text{а}}}{S_{\text{т}}} \le [D_{max}]$$

$$D_{max} = \frac{Y_{\text{а}}^{max}\,\Pi_{\text{н}}^{max}\,S_{\text{а}}}{S_{\text{т}}} \quad (3)$$

where $Y_{\text{а}}$ is the level of motorization in the region, person/car;

$\Pi_{\text{н}}$ is population density, person./km^2;

$S_{\text{а}}$ is given (taking into account the objects of the transport infrastructure) area for units of rolling stock vehicles, m^2/car;

$S_{\text{т}}$ is the total area of nature and territorial complex km^2;

$Y_{\text{а}}^{max}$ is maximum (on the basis of securing the transport needs of a region) level of motorization, person/car (varies within the 0.45-0.5 person/car

$\Pi_{\text{н}}^{max}$ is population density, which provides favorable conditions, person/km^2, take 30-50 person/km^2.

The ability of natural and technogenic geo-ecosystems to maintain the properties of the natural territorial complex within some environmentally safe amplitude is determined by the reproductive ability of the territory on the following basic indicators: atmospheric oxygen recovery, reproduction of surface water resources, soil and vegetative cover, restore tree and shrub plantings (, , ,) i.e. [6]. According to the values of the reproductive capacity of the area of the natural territorial complex through the generalized index of I_p reproductions you can set the limit scope of the transport development of natural and technogenic geo eco-systems under each of the component and to determine the relevant indicators of the reproductive capacity of the area of the natural territorial complex to the indicators of the actual and future consumption of major biotic and abiotic components of the ecosphere in the result of trucking activity.

Therefore, to implement the objectives of transport and environmental rationalization of transport network of natural and man-made geo ecosystems it is more advisable to use function that would be connected not only with the structure of the fleet of vehicles, and to a specific area of nature and territorial complex. Objective function in this case, will look like:

$$f_{C\leq[\text{ГДК}_j]} = \frac{S_{C\leq[\text{ГДК}_j]}}{S} \rightarrow 100\% \qquad (4)$$

Where is the total area of nature and territorial complex, km;

is the area of nature and territorial complex, where the concentration *j* of harmful substances that is produced by car flow in ground layers of atmospheric air does not exceed the value of the maximum allowable concentration.

In this case, the generalized evaluation of ecological safety in construction (reconstruction), repair and maintenance during the operation of the road can be used as a criterion for cumulative index (K), which is calculated for the "car – road – environment" giving the "weight" of the individual parameters of a state and territorial complex [10, 11]:

$$K = \frac{S_1 \quad \alpha_1 + S_2 \quad \alpha_2 + \quad + S_n \quad \alpha_n}{\alpha_1 + \alpha_2 + \quad + \alpha_n} \qquad (5)$$

where is the value of compliance degree of individual influence parameters on the objects of nature and territorial complex and regulatory requirements;

is the influence coefficient of "weight" and i-parameter on the objects of nature and territorial complex at certain stages of its operation.

The integrated index (K) determines the level of ecological safety of "car – road – environment" system and is the basis for the development of strategies for ensuring the reduction of the anthropogenic influence of road network on the objects of nature and territorial complex [7]. Carrying out such a complex assessment of natural and technogenic geo eco-system with advanced motor transport network the risk factors should be taken into account and that arise in the operation of "car – road – environment" infrastructure systems. This level of operational security complex "car – road – environment" is defined by the formula:

$$R = \sum_{i=1}^{m} P_i \quad \lambda_i \quad G_i \qquad (6)$$

Where is probability (frequency) of the development of i situation;

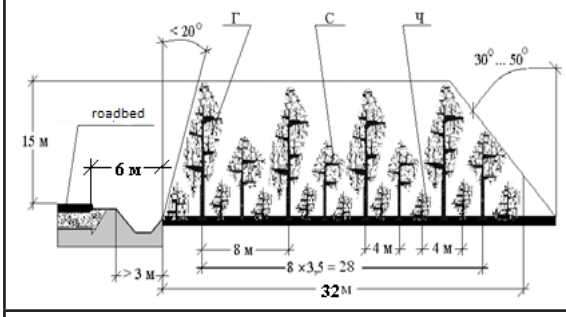
is probability (frequency) of development of i situation to some ultimate situation, which is characterized by the formation of the unacceptable situation for some negative impact;

is the level of the effects caused by i situation to the infrastructure objects of man-made geo eco-system.

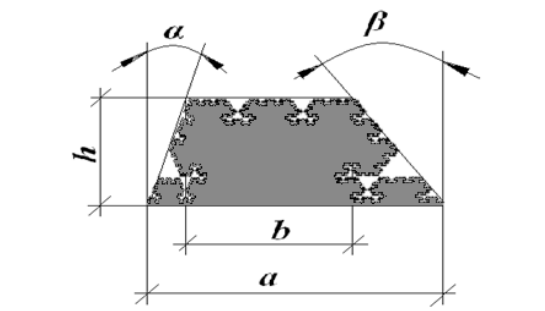
The results of the research. Therefore, the main task of the protection of the natural and man-made geo-ecosystem with developed vehicle networks from the influence of transport flow emissions is to develop such structures of transport infrastructure that would provide the intensification of exhaust fumes deposition at reserve and technology driving lanes (taking into account meteorological, weather and climatic conditions of nature and territorial complex) and would narrow the total width of the influence lanes of transport network.

In its turn, the lack of transport network protection leads to uncontrolled contamination of natural and technogenic geo ecosystem that depends on the contaminant migration, that produce the vehicle flows, the levels the chemical activity of these substances, weather, climate and meteorological conditions in the region, the characteristics of landscape and the underlaid surfaces of his objects, etc. [1, 3].

In that context, on the basis of analysis the parameters were scientifically proved and the design constructions of the forest, gas and dustproof zones for their practical realization were developed. These constructions consider such factors as: road of category, intensity of transport flow, weather and climate, landscape characteristics of the territory and limit the impact of transport on the environment and provide sufficient level of ecological safety of the territory with developed road network. 1 [7].



Fractal and invariant model of forest gas dustproof zones of road network



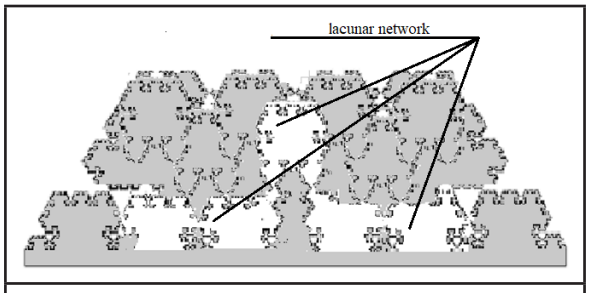
Geometric parameters of the profile of transversal junction of gas and dustproof road zones

Fig.1. A model of forest, gas and dustproof road zones.

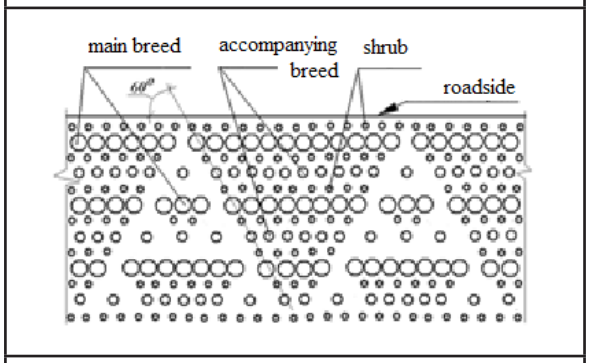
A characteristic feature of tree and bush type forest, gas and dustproof zone construction is trapezoid profile of its cross-section with different discharge angles of

the avers (inverse to carriageway road) and reverse side surfaces. In this case, the angle of inclination α of avers forest belt surface is 1.5-2.5 times smaller than the β angle of inclination of its reverse surface. Such geometry parameters of the cross-section of protective insulating type forest belt as a result of specific aerodynamic conditions of stripes wrap by air flows cause "the aerodynamic shadow" on its reverse side. The forest belt gas and dustproof zone construction is very effective in terms of protecting roadside areas with advanced road network from gaseous emissions that are produced by vehicle flow, and provide the decrease of pollution index of the atmosphere on the reverse side of the zone in comparison with its avers side for such ingredients as CO, N_xO_y, SO_2 is in ~ 10.7 times and the level of oxygen recovery of car flow is in 39-47%.

To improve the dustproof properties of the gas and dustproof forest belt constructions the derivative constructions with thin planting of trees or with lacunar network in plant formation structure of forest belt can be applied (fig. 2) [8].



The model of forest gas and dustproof zones with lacunar network



Forest, gas and dustproof zone of 1-a, 1-b categories (the example of separation of tree and bush for creating lacunar network*)*

Fig. 2. The model of gas and dustproof road zones with lacunar network

Types and aerodynamic characteristics of fractal and lacunar model cross-section of gas and dustproof forest belt shown in Fig. 2 are defined, first of all, by its percolation (from the Latin percolare – "to flow") properties.

The intensity of the filtration properties of the forest belt will depend, in this case, on its percolation parameters and will be determined by some boundary value L_{gr}, that identifies the lack of percolation in fractal under the condition of $L < L_{gr}$. The following inequality describes the basic aerodynamic property of forest gas and filter type dustproof road stripe road that is defined as subpolar (from Latin "sub-colare" – almost "to leak") (fig. 3).

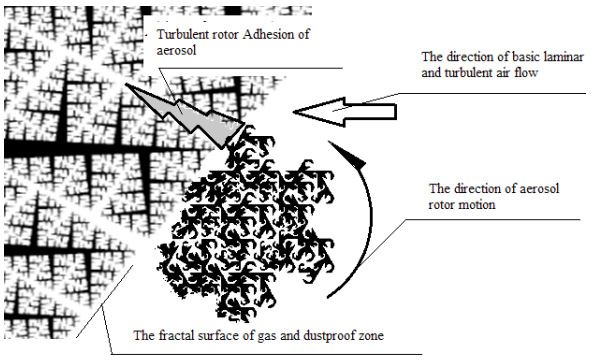


Fig. 3. Mineral dust adhesion of aerosol gas and dust clouds ejection with the surface of the obverse side of the gas and dustproof forest belt (adhesion process consists of a regular fractals)

The constructive integrity of a fractal invariance of artificially created lacunar cavities for such gas and dustproof forest belt to the original design ensures keeping its performance including indicators of gaseous pollutants (CO, CO_2, SO_2, N_xO_y), that is produced by vehicle flows [7, 9].

It has been found that the design of gas and dustproof zones with a maze of lacunar cavities provides full deposition of mineral dust particles within the forest belt with factions > 150 microns. Disperse particles of mineral dust from factions < 150 microns only partly deposited within forest belt, and can remain disperse in the air aerosols. However, the mass fraction of not deposited dust pollutants does not exceed 0.04% in summer and 0.12% in winter from the general mass of mineral dust that is produced by car flow [7, 8].

The evaluation findings of developed constructions for each road category, performed according to lacunar degree as the expected value of the second-order ratio of "massive" area indicators of transverse section model of forest belt to the square of lacunar cavities are listed in Table 1. by the formula:

$$R = \frac{n}{\left(\frac{k}{(k_{thinning})} \quad 1\right)} \qquad (7)$$

Where k is the total number of woody and shrubby plants on one step in all ranks of the forest belt;

$K_{thinning}$ is the total number of misses in planting of woody and shrubby plants in lacunar cavities on one step in all ranks of the forest belt landing;

TABLE I. FEASIBILITY STUDY OF USING R – LACUNAR CONSTRUCTION FOREST AND DUSTPROOF LANE FOR AUTOMOBILE ROADS OF RELEVANT CATEGORIES

Category of road	**1a**	**1б**	**2**	**3**	**4**	**5**
The intensity of the motor traffic flow, car/hour	15000	7000	2000	1000	500	200
Planting lane of forest belt	≥17	17	13	9	5	3
Calculation of R	7,08>>1	7,08>>1	4,19>1	2,19>1	0,81<1	0,25<1

Conclusions

The results of the research make it possible to conclude that exhaust fumes transfer is determined by the design characteristics of the protective road zones. The analysis of feasibility study on using forest gas and dustproof car zones of lacunar construction demonstrates their feasibility for roads of 1a, 1b, 2 and 3 categories. At the same time for roads of categories 4 and 5 forest gas and dustproof zones of general construction with planting lane of trees and bushes.

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Simulation of Spatial Distribution of Rare Species in Protected Natural Areas (on the Example of the Central Forest Reserve, Russia)

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***Abstract*—An important task of modern ecology is the modeling of the spatial distribution of organisms. Of particular relevance is the modeling of the distribution of rare species in protected natural areas. The paper discusses the main stages and presents the results of modeling the habitat suitability of the Central Forest State Nature Biosphere Reserve (Russia, Tver region) for the red vole. This species is a rare and relict for the center of the Caspian-Baltic watershed. In the modelling the maximum entropy method (MaxEnt) was used. The basis for building the model was the field sampling of the authors, performed in July-August 2010-2014. Each year, trapping were carried out at 745 sampling points each of which has geographical referencing in the WGS 84. A total of 12238 trap-days were worked out and 141 red vole individuals were caught. In the process of modeling, the contribution to the species distribution of certain integral characteristics of habitats (relief, vegetation type and three vegetation spectral indices) was determined. A map model of habitat suitability for the red vole on the territory of the Reserve was built, which allowed to describe the spatial structure of the population groups of the species. The total areas of the most favorable sites for the habitat of the red vole on the reserve's territory were calculated.**

Keywords*—modelling, maximum entropy habitat, GIS analysis, MaxEnt, rare species, protected natural areas, red vole.

I. Introduction

Important challenge of modern ecology is the modeling of the spatial distribution of organisms. To build good-quality models, it is necessary to take into account a large number of ecological factors and peculiarities of their influence on organisms. Simulation of the spatial distribution will have a probabilistic nature, since ecosystems are non-equilibrium thermodynamic systems, the parameters of which change [1; 2; 3]. Of particular relevance is the modeling of the spatial distribution of organisms due to climate change, the natural dynamics and the anthropogenic transformation of natural systems [4; 5]. These studies are important for research of the distribution of rare and invasive species, the historical aspects of the formation of biodiversity, the organization of environmental monitoring and conservation measures [6; 7; 8].

The priority role in the conservation of biodiversity, including rare species, belongs to protected natural areas. The Central Forest State Nature Biosphere Reserve (Russia, Tver region) is very important in preserving biodiversity in the Caspian-Baltic watershed. Eastern Palaearctic species of small mammals belong to the relict species and are extremely rare for this region.

This paper discusses the main stages and presents the results of modeling the habitat suitability the core of the Central Forest Reserve for example of one of the relict species of rodents.

II. Materials and methods

The object of the study was the red vole (Myodes rutilus Pall.) is a typical species of the Eastern Palaearctic. The red vole currently has an extensive range. The species is spread in Fennoscandia, in the north of the European part of Russia, Siberia, the Far East, Kamchatka, and Sakhalin Island [9; 10; 11]. In the Central Forest Reserve, the species is located on the southwestern periphery of the range and is distributed sporadically [12].

The territory of the Reserve is a moraine plain of the Valdai glaciation with altitudes of 230-310 m above sea level. The region belongs to the southern taiga subzone. The soil cover is characterized by complexity and differentiation [13]. The vegetation cover is mainly represented by southern taiga spruce forests and secondary forests [14]. Boreal spruce forests are found on poorly dissected watersheds. Well-drained slopes of watersheds are occupied by nemoral spruce forests. Spruce forests nemoral-boreal are spread on weakly drained slopes.

In this work, the maximum entropy method to simulate the spatial distribution of the species was used [3; 6], successfully implemented in the program MaxEnt 3.4.1. For the application of the method, only the presence of the species at a point of observation is sufficient. The result of the study is a spase model of habitat suitability with predicted probabilities of the presence of the species

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4098

in each cell of the raster map.

The basis for the construction of the model were the author's field materials, performed in July-August 2010-2014. Trapping of small mammals was carried out on a transect of 2280 m in length, which crossed various types of ecosystems of the reserve [15]. There are 114 central points on the transect, the distance between them is 20 meters. The points have detailed geobotanical descriptions on areas of 20 × 20 and 5 × 5 meters. Five traps were placed crosswise at each central point with a distance of 5 m from each other. In addition, data from seven standard counting traps lines (25 traps, 125 m) were added. They located in various types of spruce forests of nemoral and boreal genesis. Thus, annually catches were carried out at 745 sampling points each of which has geographical referencing in the WGS 84 coordinate system. A total of 12238 trap-days were worked out and 141 red vole were caught.

Preparation and processing of raster data was carried out in the QGIS 3.4. Were used: a vegetation type classification file resulting from classification of the Sentinel-2 satellite image and integral habitat characteristics: relief and vegetation spectral indices (NDVI - Normalized DifferenceVegetation Index, reflecting the amount of photosynthetically active biomass; LAI - Leaf Area Index, characterizing the degree of leaf cover ; GRVI - Green-Red Vegetation Index, reflect the change of vegetation types). The vegetation indices were calculated using the raster calculator tool in QGIS. The quality of the classification of vegetation types was checked by the field descriptions of transects for the corresponding points.

The MaxEnt program requires that all environmental geodata have single geographic characteristics (coordinate system, pixel cell size, and extent). To solve the problem of heterogeneity of the source data (digital elevation model, classification file with the main types of vegetation, vegetation indices), a regular vector grid with a cell size of 20 x 20 m over the whole study area was created. Further, all the initial data were converted to raster format, and then using the QGIS "zonal statistics" tool were recorded into the attribute table of the polygonal grid layer. On this basis, thematic roasters were created which were converted to the ASCII format and were loaded into Maxent along with the species presence points.

Verification of models quality were carried out on a test samples. For this purpose, 25% of the initial sample points of the red vole were used, randomly selected from the original sample. The obtained AUC values were evaluated on an expert scale [3].

III. Result and discussion

The modelling shows that the best results are obtained by using the bootstrap method with 500 iterations, at which AUC values = 0.94, and the standard deviation does not exceed 0.003 (Fig. 1). This quality of the model, according to the expert scale, is characterized as excellent.

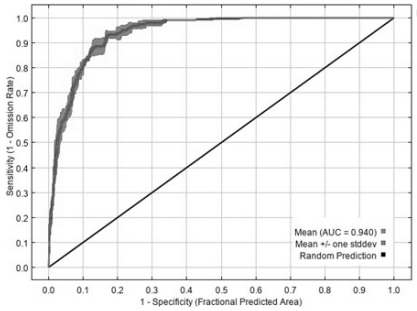

Fig. 1. ROC-curve for model of habitat suitability for M. rutilus

One of the tasks of spatial ecological modeling is the answer to the question of which environmental variables make the greatest contribution to the description of the spatial distribution of the species [1, 2]. The average values of the contributions of the characteristics of the environment to the spatial distribution model of the red vole are showed in Table 1.

TABLE 1.
CONTRIBUTION OF ENVIRONMENTAL CHARACTERISTICS TO THE MODEL OF THE SPATIAL DISTRIBUTION OF THE RED VOLE

Variable	Percent contribution
Relief	55,0
Type of vegetation	34,5
NDVI	6,9
GRVI	3,1
LAI	0,4

The relief is the first contributor to the space distribution of the red vole. The second most important factor is the type of vegetation. The impact of the NDVI index is noticeable, which serves as an indicator of the "productivity" of the habitat.

Taking into account all said environment parameters on the territory of the Central Forest Reserve, a cartographic model of habitat suitability for the red vole was constructed (Fig. 2). The model predicts the presence in the reserve of five relatively large areas with good habitat suitability for the red vole. Each of these areas has spots with a very high probability of presence of the species, which can be considered the "core" of population groups. A certain similarity in the configuration of the areas attracts attention. They have a continuous tape character, which can provide the specifics of the most likely movement of individuals throughout the Reserve area.

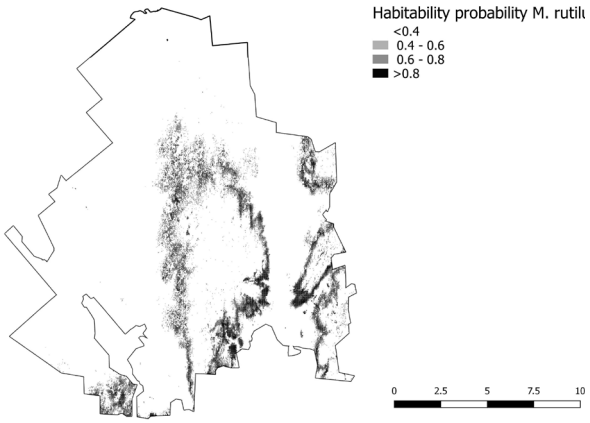

Fig. 2. Map model of habitat suitability for the red vole in the Central Forest Biosphere Reserve

On the basis of the constructed model, the total areas for different types of suitability in the reserve were estimated (Table 2).

TABLE 2.
RATIO OF DIFFERENT CLASSES OF THE HABITAT SUITABILITY FOR THE RED FIELD IN THE CENTRAL FOREST RESERVE

Class (probability of suitability)	Area, ha	Percentage, %
<0,4	20677,2	88,3%
0,4–0,6	1347,2	5,8%
0,6–0,8	889,0	3,8%
> 0,8	488,8	2,1%

The total area of the most favorable habitats for the red vole is relatively small and amounts to about 6% of the Reserve's core territory. Same area is occupied by sites with an average degree of habitat suitable for the red vole.

IV. Conclusions

Modern methods of statistical and GIS-analysis allow us to build multi-scale and high-quality models of spatial distribution of species. Built on the basis of the integral characteristics of the environment, the model is possible to determine the location and describe the size of most suitable areas for the habitat of the species. The results can be used to determine the ecological carrying capacity and to plan more detailed case population studies of of relict species in the Central Forest Biosphere Reserve.

In general, a similar identification of localized potential habitats of rare species may serve as a basis for developing measures for the biodiversity conservation and the creation of new protected areas.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 78-80

Development of a Technological Chain for a Background Streamflow Forecasting System in Russia

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***Abstract*—The hydrological forecasting methods that have been used for many years in Russia require precision input data, which are difficult to obtain. Until now, none of forecasting systems, developed by Russian hydrologists, has been officially implemented in practice. In the face of an increasing number of catastrophic and destructive hydrometeorological hazards, the development of a modern automated system for operational flash floods forecasting is highly relevant in Russia. In this paper, a new technological chain for background streamflow forecasting is presented. The authors have attempted to create such a chain under the conditions of the country's poor hydrometeorological network and difficulties in obtaining data and their assimilation. The chain presents a joined logistic scheme, which was developed based on analytical elaboration of scientific works of key Russian hydrologists. The paper also includes the analysis of the most efficient use of the hydrometeorological data available through the national observation network. This seems to be assimilation of satellite and radar data, in situ observations, numerical weather prediction models and catchment models outputs.**

Keywords—data assimilation, hydrological forecasting, radar and satellite data, surface observation network.

I. Introduction

In the Russian Federation, there are about 2.6 million streams, the vast majority of which are not studied hydrologically and are called "ungaged". About one third of the country's population lives in such catchments. Therefore, timely hydrological forecasting of hydrological hazards will always remain an important practical task for the entire hydrometeorological science of the country. In last few years, there were many destructive flash floods in the Far East and Krasnodar krai: the number of such phenomena has increased. To prevent negative consequences, it is necessary to have a modern forecasting operating system that enables making minimum lead time forecasts. Such a system can be developed based on background forecasts, since they do not require high accuracy and much input data. So far, there has not been an effective system for background streamflow forecasting, uniting all links of the forecasting process in a joined chain at all stages of the process, from data obtaining to presenting forecast production to the public and stakeholders.

The first block of the technological chain is the system for receiving and assimilation of observed hydrometeorological data. The surface observation network in our country, operated by the Ministry of Natural Resources and Ecology of the RF (Roshydromet), has a number of specific features. Let us focus on several important aspects in the context of operational streamflow forecasting.

First of all, the surface hydrometeorological observation network is characterised relatively low spatio-temporal resolution. There are only 2644 hydrological stations and 1915 meteorological observation points in Russia. Their characteristics are presented in Table I [1].

Table I. Characteristics Of The Hydrometeorological Observation Network In Russia [1]

Hydrological network	Meteorological network
2644 stations, 708 of them are equipped with Automatic Hydrological Complex (AHC) (27%) and 160 (6%) have automatic discharge indicators.	1915 observation points, 1808 of them are equipped with Automatic Meteorological Complex (AMC) (94%).
Only 340 of the stations are working in operational regime (high time resolution data).	316 observation points with data time resolution of 10-minutes.
216 (8%) stations are equipped with snow and rain gauges.	52% of meteorological data is transmitted immediately.
Advanced offices are in the North-Western, Irkutsk and Central branches of Roshydromet.	Advanced offices are in Bashkortostan, Tatarstan and Primorsky branches of Roshydromet.
One operational hydrometeorological station for 9440 km^2: the observational network density is three times lower than recommended by the World Meteorological Organization (WMO).	
Spatial heterogeneity: the observation network density in European Russia is quite good, but it is insufficient in the Asian part.	

Low spatio-temporal data resolution, insufficient equipment quality and staff qualification affect forecasting. For this research, these issues play an important role, limiting application of some techniques for assimilation data and forecasting models calibration and validation, which could be used in the case of a denser and better equipped observation network [2].

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4194

Since 2012, the network has been under modernization, and some progress was made that can enhance forecasting. For example, modern operational development centers and software for them were established (AIS Duty Officer and Programming Complex ARM of Hydrologist [3]), which are included in the final chain.

Radar data is quite limited in the Asian part of Russia but it is easier available in the European part (Fig. 1). There are only 33 remote-sensing instruments in the country: 10 of them are in the Asian part and seven more are at the border with Belarus and the Ukraine. Seventeen radars are working with low time resolution (more than two hours) [4]. In general, the use of radar data allows enhancing the spatio-temporal discreteness of precipitation observations, what makes it possible to predict the development of floods based on distributed conceptual hydrological models.

Satellite data can serve as a good basis for floods forecasting, especially in poorly gauged areas. To forecast flood occurrence, data on the moisture content in the upper soil layer (2-5 cm from the surface) is in high demand, since it is required to correct the initial conditions while runoff modeling.

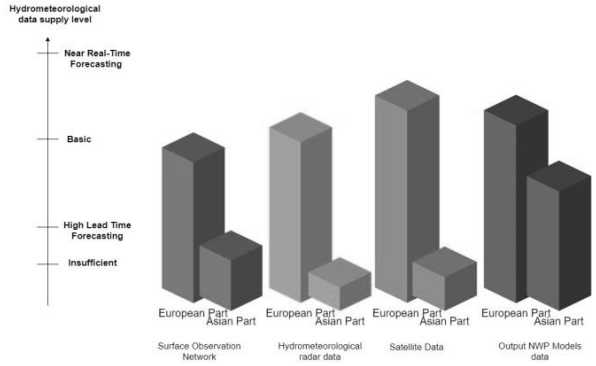

Fig. 1. Comparison of hydrometeorological data supply in the European and Asian parts of Russia (designed with [10]).

Besides, various snow cover characteristics are needed when predicting the development of spring floods of snowmelt genesis and mixed genesis floods.

For 2019, not a single meteorological satellite remains out of eight satellites that previously existed in Russia. In some areas, mostly in the European part of the country, it is possible to obtain data from foreign satellites. Other options are to use small low-orbit or general-purpose satellites as carriers of hydrometeorological sensors.

There is some progress in the development of the space data collection and transmission system (DATS), designed to "ensure the transfer of alphanumeric information from the estimate documentation of the Roshydromet network to the data collection and processing centre (Moscow) in real time" [5]. At the same time, nature-resource satellite financing has definitely decreased in recent years.

Using data from mesoscale weather patterns allows increasing the lead time of background streamflow forecasts up to 3-5 days. In the Hydrometeorological Centre of Russia, the Weather Research and Forecasting Model (WRF model) has been adapted for these purposes. It should be noted that the volume of information transmitted by such models is extremely high. For this reason, Global Ring Network for Advanced Application Development (GLORIAD) technology was developed – a global high-speed network infrastructure designed for telecommunication support of advanced scientific projects [6]. It is also used for international data exchange.

Summarizing, in Russia satellite data and mesoscale weather models outputs are considered to be the most suitable for streamflow forecasting. Other data sources require enhancing.

The sequence of the main technological steps, from obtaining data to receiving a forecast, is presented in Fig. 2. The system enables permanent forecasting: in background (qualitative) mode until there is no potential danger. As soon as flood risk appears, the system allows more accurate forecasting.

The next block of the technological chain is a technology for different genesis background streamflow forecasting. In this case, first of all, the type of flow, the available data set, and the lead time of the forecast matter.

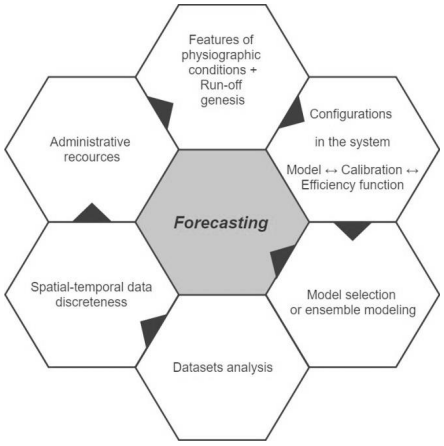

Fig. 2. Visualization of technological steps of streamflow forecasting (designed with [10]).

Considering the issues of applying the entire technological chain for particular genesis streamflow forecasting, the authors have come to the following conclusions, which seem to be actual for hydrological practices in the country:

1. Hydrologiska Byråns Vattenbalansavdelning Light (HBV Light) model is often used by key experts in hydrological forecasts and can be used in the technological chain in the case of rainfall floods genesis. The input data for models calibration usually include precipitation, runoff and soil moisture, which could be obtained from two main sources, described above [7].
2. Machine learning algorithms for model calibration are gaining popularity now (IHE Delft Institute for Water Education projects). Methods of machine learning are being introduced, so this is already present hydrometeorological forecasting.

3. Getting reliable forecasts is crucial, but it is also necessary to transfer them to clients for competent use as soon as possible. An automatic forecasting system is perfect for this task. This system involves a consistent prediction, at the beginning of the background streamflow forecasting, and then, in the case of potential danger, the specified.
4. Best results of the system operation are achieved by selecting for each specific catchment its own set of optimal configuration, including a suitable model, calibration method and objective function.

This configuration is selected for each catchment separately, depending on its size, physical and geographical conditions, climate, type of feeding and other features.

5. For Russia, using Multi-layer conceptual model 3 (MLCM3) and HBV Light is convenient because these models require input data that can be obtained from radars and satellites, but not from the surface observation network, which rarely provide operational data.
6. Additional parameters in the flood forecasting when refining forecasts can be added (for example, snowmelt characteristics), but this will increase the timing of the forecast and impose requirements on the source of these additional parameters. This is quite feasible for each specific user, if one needs it.

Connections between data-obtaining and forecasting procedures should be provided by the operational forecasting centres (and corresponding software) in the near real-time mode and data transfer and processing should be done based on top GIS technologies.

Management decisions must be made in accordance with the Predefined Decision system [8], in close cooperation with the country's special services (The Ministry of the Russian Federation for Civil Defence, Emergencies and Elimination of Consequences of Natural Disasters.). Risks should be compensated in the framework of a well-designed flood risk insurance system (analogue of The National Flood Insurance Program).

The technological chain includes three types of forecasts visualization: a discharge hydrograph with marked danger zones (probabilistic forecasting), flood zones visualization, dynamic interactive maps of the prognostic situation (nowcasting). All of them are possible to realize using abilities of [3].

The final version of the technological chain is presented in Fig. 3. The given technological chain is considered to be highly relevant in the conditions of growing climatic risks, an increase in the number of extreme hydrometeorological phenomena, including destructive floods [9], as well as the absence of an effective system of background forecasting of runoff in the country at the moment. This chain is an integral reflection of the experience gained in the country and also includes suitable internationally applyied approaches.

Such analytical surveys are designed to reduce the negative impact of high floods, including flash floods, for which this scheme provides mechanisms for possibile minimizing the forecast lead time.

It is worth noting, the existing restrictions on the implementation of this chain are: low spatial and temporal discreteness of data, insufficience of ground-based observation network for calibration and validation of models, poorly developed hardware and administrative complex and limited state funding provided to Roshydromet.

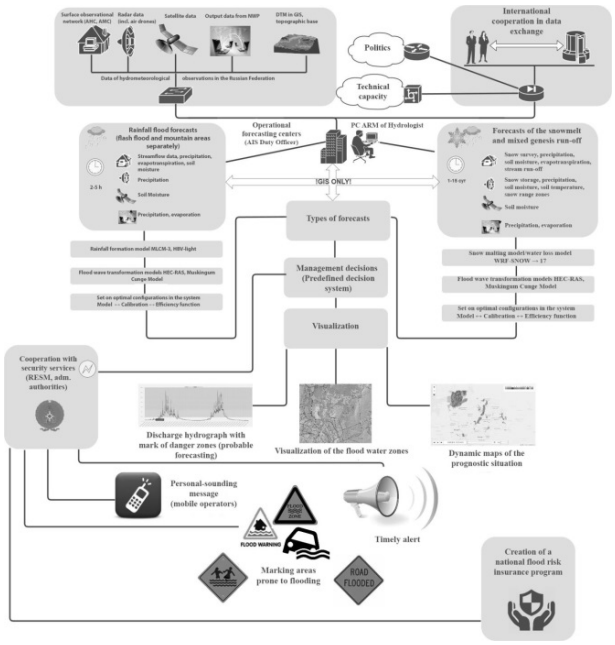

Fig. 3. Technological chain for a background streamflow forecasting system in Russia (designed with [10]).

Acknowledgements

In memory of Vadim A. Kuzmin, Doctor of Technical Sciences, former Director of the State Hydrological Institute, Russia.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 81-85

Financial Instruments to Increase the Ecological Safety

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***Abstract*—This article justifies, that questions of environmental protection, protection of natural resources, ecological safety are the most actual for effective development of economic systems. In the modern economic situation, coherence and administrative leverage in total with ecological taxation and insurance are forceful instruments to move towards the model of «green» economy.**

The main goal is to consult the theoretical and practical experience of formation the ecological safety under the paradigm of «green» economy of European countries and the Republic of Belarus based on analysis of main financial instruments of the state ecological policy.

The main tasks are: identifying mechanism of formation of ecological safety in conditions of green economy in European countries and in the Republic of Belarus; identify and systematization of main financial instruments for state ecological policy; justification of necessity and directions for improvement the ecological taxation and insurance.

Methodology of the study is based on the principles of the system analysis, formal logic and interdisciplinary scientific approach to the problem. Monographic and descriptive method, method of analysis and synthesis, statistical data analysis method were used to complete the tasks of research.

Novelty of this research is that systematization of theoretical practical foundations of state management of ecological safety through financial instruments of green economy can increase the effectiveness of the stable development of the economic system.

***Keywords*—Financial mechanism, insurance, leverage, methods, policy, security, structure, tools, taxes.**

I. Introduction

The problems of the environmental protection occupy a more prominent position in the system of the world priorities. At present, we can note the great international attention to improving the efficiency of environmental activities, especially in developed countries and large regional economic blocs, in which environmental values are actively embodied in economic development strategies, which makes it possible to very successfully solve environmental safety problems.Many countries use a wide arsenal of funds, both legislative and economic measures, including financial ones, when carrying out environmental protection policies.In this regard, it is particularly relevant to study the financial mechanism for ensuring environmental safety.

II. Materials and Methods

Research methodologies for environmental-economic interactions emerged in the second half of the 20th century as a result of a sharp exacerbation of environmental problems. A significant contribution to the study of these problems was made by the works of scientists of the Rome Club, such as D. Meadows, A. Peccei and J. Forrester [1]. The works of the outstanding Russian scientist V.I. Vernadsky [2] served as the starting point of many global environmental studies.

Based on documents UN, UNEP, OECD [3-5] and other international organizations, the main way to protect the environment and meet the growing resource needs is to adopt a model of sustainable development. Most developed countries have come to realize the fact that the formation of a balanced environmentally oriented model of economic development is the main condition and the main component of the transition to sustainable development.

In the Republic of Belarus, the National Action Plan for the Development of a Green Economy until 2020, the National Strategy for Socio-Economic Development until 2030 take fully into account the current global environmental problems and determine the priority areas of a green economy and sustainable development [6, 7].

III. Results and Discussion

An effective environmental and economic policy requires a wide range of measures. However, when addressing issues of ensuring the environmental safety of the state, issues of efficient use of financial resources are particularly relevant. They should be solved with the help of an active financial policy and an appropriate mechanism for the accumulation, distribution and use of funds.

The financial mechanism for ensuring environmental safety is designed to ensure the implementation of the targeted functions of a social state, which consist in solving a set of social and protective tasks, creating conditions for the development of civil society, in shaping a healthy social and environmentally safe climate, which will eventually lead to a dynamic and sustainable economic

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4062

development of the country. Using only direct methods of influencing users of nature based on relations of power and subordination is not always effective. Accordingly, it becomes necessary to use financial instruments and levers based on material interest, i.e., on indirect state management of environmental safety.

The purpose of the financial mechanism to ensure environmental safety and environmental protection is to harmonize the financial and environmental interests of social production.

According to the authors, extremely insufficient attention has been paid to the nature and content of the financial mechanism for ensuring environmental safety. In addition, financial and economic mechanisms are considered in the aggregate, not highlighting the individual categories. The authors of this study propose to consider the financial and economic systems as relatively independent phenomena, which is caused by the need to use the functional capabilities of the financial mechanism in solving environmental safety issues.

The authors adhere to the point of view that the financial mechanism for ensuring environmental safety should be viewed as an interconnected and interdependent financial management system through financial methods, levers and instruments of public administration in the field of ecology, based on regulatory and informational support.

Based on the study of points of view of domestic and foreign scientists [8-10], the authors have identified approaches to the content and components of state policy in the field of environmental safety. This allowed, based on the research Esina E. [11], systematize the structure of the financial mechanism for ensuring the environmental safety of the state and highlight the main elements in it. The following components of the mechanism under study differ from the approaches that previously existed in the scientific community with a clear structure and depth of detail. This allows us to consider the situation in the field of financial instruments of environmental safety in a comprehensive and systematic way.

I –financial methods, including:

- financial planning and forecasting;
- financial control and audit;
- financing of environmental activities;
- financial normsandregulations;
- financial incentives for environmental activities of business entities;
- financial responsibility for violation of nature conservation legislation;
- environmental taxation;
- environmental insurance;
- leasing of environmentally friendly industrial technologies and environmental protection equipment.

II – financial leverage and instruments, including:

- types and forms of financial plans and forecasts for the implementation of environmental programs;
- budget subsidies;
- use of resources from targeted extra-budgetary environmental funds;
- attraction of extra-budgetary funds;
- investment in the development of environmentally friendly industries;
- environmental taxes, fees and charges;
- taxbreaks;
- accelerated depreciation of fixed assets for environmental purposes;
- financial sanctions for violation of environmental legislation;
- charges and fines for the placement of environmentally harmful substances;
- administrative fees for licensing and others;
- increased rates of payments for violation of environmental standards.

III – financial management:

- statelegislatures;
- financial authorities;
- revenue administrators of the budget system;
- external financial control and budget audit agencies;
- credit managers;
- insurance companies;
- financial departments of enterprises, organizations;
- leasing companies;
- the apparatus of non-profit organizations implementing environmental programs.

IV– organizational support, including:

- legal (legislative acts, decrees of the President, government decrees, orders and letters of ministries and departments and other legal documents);
- regulatory (instructions, guidelines, other regulatory documentation);
- informational.

The effective operation of the financial mechanism is possible only in conditions of the relationship and interdependence of its structural elements. In turn, all the component parts of the control mechanism under consideration contain specific types of impact on users of nature, that is, they themselves are systems.

The practical implementation of a financial mechanism for ensuring environmental safety, including "green" investment, involves the use of various financing instruments, which are presented in Table 1 [12].

The material which is presented in Table 1 allows us to conclude that financial instruments for ensuring environmental safety are not fully implemented in the Republic of Belarus: there is no ecological insurance, a system for trade in pollution rights, leasing of safe industrial technologies and environmental protection equipment, and others. The system of environmental taxation and financial incentives

for the environmental activities of economic entities require improvement.

Table 1 – Green Investment Financing Tools

Country	*Ecological charges*	*Ecological taxes*	*Subsidies*	*Pollution Rights Trading System*	*Mortgage system*	*Payments for non-compliance with environmental requirements*	*Commitments implementation*	*Payments related to liability for damage*
Australia	+		+	+	+		+	
Austria	+	+	+		+			
Belgium	+	+						
GreatBritain	+	+			+			+
Hungary	+	+			+	+		
Germany	+	+						+
Greece	+		+			+		
Denmark	+	+	+	+	+			+
Iceland	+	+			+			
Italy	+				+			
Canada	+		+	+	+	+	+	+
Korea	+				+	+		
Mexico	+	+			+			
Netherlands	+	+	+		+			
Norway	+	+	+		+	+		
Poland	+	+	+	+	+	+		
USA	+	+	+	+	+		+	+
Turkey	+		+		+	+		+
Finland	+	+	+		+			+
France	+		+	+				
CzechRepublic	+	+	+		+	+		
Switzerland	+	+	+	+				
Sweden	+	+	+		+	+		+
Japan	+	+	+					+
Russia	+	+	+					
Armenia	+	+	+					
Belarus	+	+	+					
Kazakhstan	+	+	+					
Kyrgyzstan	+	+	+					

According to the authors, one of the possible ways to efficiently use financial resources to ensure the environmental safety of the state could be the creation of a system of incentives for enterprises whose high revenues coincide with a small amount of harmful emissions. Thus, according to the proposed approach, when calculating environmental payments, it is necessary to take into account both the emissions of pollutants and the company's revenue. Such a ranking of enterprises for two productive factors allows you to create an acceptable set of options and, on their basis, to develop preferential coefficients on environmental tax.

When developing a system of preferential coafficients, the principle of fairness must be taken into account: an enterprise that has the greatest impact on the environment will be subject to a higher tax than before, which should stimulate this organization to revise its environmental policy.

Ecological tax is included in the calculation of the cost of production, so reducing its amount ultimately affects the decrease in the selling price of products. Accordingly, the goods offered by such organizations will become more accessible to the consumer. Moreover, the legislator has the right to provide for a reduction in payments to the budget of the environmental tax amounts, provided that the payer uses these saved resources for environmental protection measures (for example, the introduction of new technologies, developments and equipment). In addition, the option of not charging an environmental tax on enterprises during the period of updating the main technological equipment is possible.

According to the authors, in addition to improving the overall efficiency of the system of using resources for the greening of the economy, the proposed approach will provide the state with a new information resource regarding the volume of organizations participating in environmental pollution.

Further in the publication we will consider the experience of European countries in levying an environmental tax on mobile emission sources and the possibilities of its use for the Republic of Belarus.

The relevance of considering this financial instrument is extremely high. According to the European Environment Agency's indicators [13], automobiles account for almost three quarters of all harmful emissions into the atmosphere. Ecological harm of motor transport is expressed in emissions of exhaust gases, noise emissions, deterioration of landscapes.

In Europe, apply environmental tax on motor vehicles. In France, it is levied on all vehicles registered domestically or abroad, if the permissible total weight of the vehicle exceeds 3.5 tons and driving along the 15,000 km long taxable national and regional network of France [14].

The payment is calculated in depending on the distance traveled by the taxable network of highways. The sum is calculated on the basis of the collection rate per kilometer, which is determined by the category of car and may vary depending on the level of pollutants in the vehicle exhaust gases (exhaust emission class (European standard), geographical area (remoteness principle: a reduced rate is provided for a number of regions) and road congestion levels [14].

In Germany, issues of environmental hazards of transport are manifested through a tax on car ownership. Only wheelchair users are exempted from its payment. The amount charged depends on the engine size, the type of fuel and the amount of CO2 emitted into the

atmosphere. Each 100 cm3 cylinder volume will cost the owner of a vehicle that consumes gasoline at € 2 per year. For diesel engines, the tax is much higher - 9.5 € per 100 cm3. But this is if the diesel engine is equipped with a particulate filter. Without it, the tax is even more: 10.7 € per 100 cm3 [15].

The second component of the tax is determined depending on the weight of carbon dioxide emitted into the atmosphere per 100 kilometers. Here, each gram will cost another € 2 per year [15].

Within the tax under consideration, motor vehicles should be understood as automobiles and trailers. It is possible not to consider vehicles that are used to clean the streets as it is done in other European countries, for example, France and Germany, as objects of taxation.

According to the State Automobile Inspectorate of the Republic of Belarus, every third resident of the country is the owner of a motor vehicle.

For the fairness of charging, it is necessary to establish tax rates for different types of fuel, taking into account the uneven impact of their emissions on the environment (for example, taking the tax rates in Germany as a basis and adjusting them for the income of the population of the Republic of Belarus). Further, it is necessary to introduce different coefficients to the tax rate for different engine volumes, since the amount of fuel consumed by the vehicle depends on it. This will encourage owners to buy newer vehicles, emissions from which do not exceed the norm. Imagine the possible correction factors to tax rates in table 2.

Table 2 - Possible Correction Factors for Tax Rates

Vehicleweight *Up to 1,1*		**Engine Capacity, In Liters**			
		1,2-1,5	***1,6-3,5***	***Over 3.5***	
up to 3.5 tons	Passenger cars	0,5	0,75	1,25	1,5
	Freight	0,75	1	1,5	1,75
over 3.5 tons		2			

According to the authors, a reduction factor should be introduced for vehicles using the safest types of fuel - 0.2.

Taxation of mobile sources will encourage taxpayers to use machines with the lowest fuel consumption, in order to reduce harmful emissions. If the taxpayer chooses a car with high fuel consumption, then such a decision will have to pay a more substantial amount of environmental tax. As in the case of the tax from stationary sources, the approach to which we considered above, the principle of justice also works here. An entity that has a significant environmental impact will pay more than a taxpayer with micro or small cars.

The introduction of a motor transport tax in the Republic of Belarus will in many ways stimulate the development of public transport and the development of systems for effective purification of exhaust gases, the use of which in the future will improve the quality of life of the population of the Republic of Belarus.

Ecological insurance is recognized as an independent element of financial support for the mechanism of environmental protection, which makes it possible to define it as one of the effective ways to ensure the environmental safety of the state.

At the moment, the Republic of Belarus is far behind European countries in the use of this financial instrument. However, the systematic introduction of European conceptual directions of ensuring environmental safety into the practice of the state policy of the Republic of Belarus will make it possible to radically change the situation. To this end, it seems necessary to fix a clear definition of the concept of "environmental insurance" in the Law of the Republic of Belarus "On Environmental Protection". Further, at the legislative level, determine the place of environmental insurance in the system of insurance relations of the Republic of Belarus as an independent type of liability insurance for harm. It is possible to implement this task by making appropriate amendments to the provision "On insurance activities in the Republic of Belarus", approved by decree of the President of the Republic of Belarus of August 25, 2006 No. 530. This will serve the Republic of Belarus as a significant step towards the development and adoption of a package of regulatory legal acts regulating a special sphere of public relations in the field of liability insurance for harm caused by harmful effects on the environment.

IV. Conclusions

From the above materials of the article it can be concluded that at the present stage of socio-economic reforms carried out throughout the world, one of the key problems of further development of the national economy is the fundamental problem of the imbalance between sustainable economic growth and the preservation of natural capital. This situation leads to the actualization of the use of the most progressive financial instruments to ensure the environmental safety of the state.

The systematization of theoretical and practical materials carried out by the authors of the article made it possible to identify the main elements of the financial mechanism for ensuring environmental safety. Analysis of the use of individual financial instruments of the mechanism under study, both in European countries and in the Republic of Belarus, allowed the authors to suggest ways to improve their use in practice.

The application of the proposed directions for improving the financial mechanism for ensuring the environmental safety of the state in practice will allow: to ensure an increase in the level of efficiency in the use of collected resources for restoration and protection of the environment; increase the incentive function of the environmental tax; introduce the most progressive experience of foreign countries.

The increasing complexity of economic relations, the development of market relations entail the improvement of the already established, as well as the emergence of new elements of the mechanism aimed at ensuring resource-saving environmental management and environmental protection. These include, for example, the

creation of a market for natural resources, the sale of rights to a certain amount of environmental pollution, a "pledge-return" system that is actively used in some foreign countries.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 86-91

Social Entrepreneurship as One of the Business Development Activities in Rural Areas of Latvia

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Abstract Since 1 of April 2018, it is possible to register social entrepreneurship in Latvia as one of the type of business and to take advantage that is only suitable for this type of business.

The study analyses how coud social entrepreneurship become one of the opportunities to address social problems, directly in rural areas, where today in Latvia is concentrated the largest population of a socially unprotected groups.

This means that, while developing social enterprises and solving social problems in the regions of Latvia, at the same time, also address other issues that are actual today – lack of labour force.

For entrepreneurs in rural areas, the lack of labour is the most significant, and there is no problem in Latvian regions with finding a place of residence. The development of social entrepreneurship would also be a contributory factor in the fact that the new generation would not leave the countryside, but try to build up their business using existing infrastructure, including a rural school, kindergarten – it helps to them continue to work as well.

In the Latvian countryside most are farmers and crafts companies, whose business is most often expressed seasonality. At the rural areas farmers can support with works during sowing and harvesting, and some works during growing period on organic farms.

There is also a growing lack of labour force in the sales companies who support farmers with new technologies, especially in aftersales – service departments.

Social entrepreneurship could be one of the solutions, especially since it is very seasonal for repairs, so that it is possible to focus the work on the season by successfully management with the contingent in the countryside.

There is a great opportunities to make cooperation with local authorities on this issue, the role of the social business in the development and social Affairs of the rural environment should be clarified. As a result of successful cooperation, social enterprises can become an important contribution to local authorities in addressing the societal challenges of the municipality.

The study analyses how important to develop this model of cooperation, as it needs to convince local leaders before work on regional reform begins.

Keywords - social enterprise, social entrepreneurship, , regional reform , rural development.

I INTRODUCTION

The growth of modern economic systems has generated more numerous, complex and urgent social challenges. [2]

Despite the social innovation being defined and interpreted differently, it provides the social benefits for both local community and/or society in general.

Nowadays, social innovations, particularly in the rural areas, focus on successful solution of different social, economic, political and environmental issues. The social benefits, for instance, reduce the threat of climate change ,maintain the biodiversity, ecosystems and landscapes; offer fresh and healthy local food etc., can be provided by the social innovations based on the agricultural production and other rural activities.

The following social innovations (but not all) will be suitable for Latvia:

- sustainable or environment friendly agricultural production;
- local food systems;
- social or care farming;
- social services;
- renewables (e.g. bioenergy);
- ecosystem services (ecotourism) and recreation services;
- cooperation;
- local action groups and financial services. [1] [5] [8]

As a result of technological advances and capital gains, the volume of economic performance generated by the same amount of work-related resources increases from one year to the year. Technological developments are mainly aimed at reducing work resources in the farming process. For one of the most popular politicians slogans have become “Create new jobs”.

In fact- this is wrong, because not a number of jobs, but the result /productivity of work would be important in terms of prosperity. [2]

Technological developments lead to two-fold effects on the rural economy – on the one hand reducing the number of workers needed for entrepreneurs - and, on the other hand, the need for more and more young, well-educated, new-knowledge workers.

It is basically new people – new families who are ready to move to the countryside only if they are equipped with the appropriate infrastructure – living conditions, roads, kindergartens, schools, social services, cultural life.

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Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4165

Published by Rezekne Academy of Technologies.

future of Latvia. For young people it is serious choice - to find themselves in Latvia or to go to another country, when they choose the fields of education, business or make a more serious choice – to leave from native country.

They must first understand whether they can work- in fast food shops, greenhouses, hotels or other low-skilled jobs abroad, in Riga – or to build up their professional life in the countryside of Latvia.

Developing the rural economy is one of the key indicators towards a country's success. Whether it be the need to look after the welfare of the farmers or invest in rural infrastructure. Best way how to improve life in countryside - is to look at "people's participation".

Social entrepreneurship is the ability to draw in innovative solutions by businesses to solve different social problems. From a rural development point of view, social entrepreneurs can work to fill the societal gap, helping in social transformation of the economy.[1]

With planned and innovative attempts, Latvia can work towards combating problems like poverty, inequality, unemployment in countryside. The benefits are double ended – social entrepreneurs can look forward to making profits while the society gains at large.

The problem needs to be addressed both from employees, workers and the public and local authorities, this is a matter of complexity, one of the most important choices, projects and decisions before the Latvian countryside are completely empty, before the schools and nurseries are closed.

It is only through cooperation, with the help of variety of laws and projects, including those European Union funds support, to change the situation in Latvia. This is a question that is often debated, but fully in a systematic, coordinated way, with all the interested parties working together, still not resolved.

From time to time there are some very valuable activities on these issues, but they are usually impulsive without any results in the long term. A social entrepreneurship would be one way for entrepreneurs to develop their business in rural areas, in cooperation with local authorities, in the development of their businesses, while helping the municipality address the social issues with which they are not to be able handle to end, what is one of the reasons that people leave the countryside, thus creating even greater challenges for entrepreneurs to find the necessary staff.

Social enterprises solve problems faced by not one or two people but larger sections of society. These are problems which, suffered by the general public in the long term and have not been solved from state or business sector or non-governmental organisations. [5]

At the end all will have benefits, in addition to have savings in national /state and municipalities budgets, as social enterprises often remove different types of social helps from shoulders of municipalities.

To calculate benefits, we must put an account not only tax income from social enterprises, but also decreasing of costs for social support. [8]

It is often social entrepreneurs, as much as traditional entrepreneurs, who are involved in developing new ideas, new products and activities, and envisioning a future for the rural area.

For young people to find themselves in Latvia or to go to another country if they choose the fields of education, business or make a more serious choice, you must first understand whether you can work in fast food shops, greenhouses, hotels or other low-skilled jobs abroad, in Riga – or to build up their professional life in the countryside of Latvia.

One of very important findings of paper - the problem needs to be addressed both from employees, workers and the public and local authorities, this is a matter of complexity, one of the most pressing at the moment, before the Latvian countryside are completely empty, before the schools and nurseries are closed. It is only through cooperation, with the help of a variety of laws and projects, including European Union funds – financial support, is possible to change the situation .

This is a question that is often debated, but fully in a systematic, coordinated way, with all the interested parties working together, still not resolved. From time to time there are some very valuable activities on these issues, but they are usually impulsive without any results in the long term.

A social entrepreneurship would be one way for entrepreneurs to develop their business in rural areas, in cooperation with local authorities, in the development of their businesses, while helping the municipality address the social issues with which they haven't been able to handle , which is one of the reasons that people leave the countryside, thus creating even greater challenges for entrepreneurs to find the necessary staff. [8]

Social enterprises solve problems faced by not one or two people but larger sections of society. These are problems which, in essence, are suffered by the general public in the long term and have not been solved by state or business sector or non-governmental organisations. [5]

At the end all will have benefits, in addition saving the money for national /state and municipalities budgets, as social enterprises often remove different types of expenditures from the state and municipality, helping to make more effective use of taxpayers ' money over the long term.

Perhaps someone who has long dreamed of being a business can finally implement it through local government and state aid, as well as tax relief.

Social enterprises can operate in a wide range of business areas-the main thing that there is a clear social objective, both an activity sector and a business model.

Of course, the logic of the social enterprise should be excluded obviously the harmful sectors-weapons, cigarettes, drugs, etc. [3] [4]

The new social company Law also mentions a number of other sectors in which social enterprises in Latvia cannot function, but it is more in Latvia's local context than conceptual considerations. A social enterprise can just as well operate in the timber industry, as in food production, as a video hardware rental business, as long as there is a clearly identifiable social objective and positive social impact that the company generates through its work. It can certainly be said that social entrepreneurship

is a future business, as it is already in Europe and in the world, the smarter heads of the big business are looking for new and new social enterprises in different business areas – they involved wide sections of the population.

Investors increasingly also require a strong social impact aspect of traditional businesses, as well as big brands increasingly thinking about how the social impact aspect is to be realised not only by certain charitable form of projects, but in all activities and business processes that take place on a daily basis. [5] [8]

Also in Latvia we see that there is growing interest in both business and customer and consumer, it is increasingly important that not only to rake in money, but we can do something good at the same time, and not only one or two times, but in the long term.

Another element of the high level and potential of the Latvian rural activities is the low scale of the country and borders with its neighbours, Estonia (the road to Finland), direct links with Sweden (ferry to Stockholm), Lithuania, Poland, while the largest advantages is border with Post Soviet countries as Belarus, Ukraine, as well Russia, -there is a big market and our mentalities are very similar. [8]

II RESULTS AND DISCUSSION

In the last twenty years, the business activity in Latvia has evolved very rapidly, big part of the large and successful enterprises mostly located in the big cities, leaving the countryside empty. [1]

In turn, social problems are left to the discretion of the state and local authorities, partly addressing these issues to non-governmental organizations.

In order to investigate the situation, the most valuable information could be obtained in interviews with the authorities in rural regions, entrepreneurs with long experience in business, especially in countryside, with the professional management of technical schools, municipal leaders, social entrepreneurs, Ministry of wellfare, officials and social partners of Ministry of Economy, Chamber of Commerce, leaders of the nongovernmental organizations.

By listening to the various perspectives on the developing process of the social entrepreneurship, the law of Social Entrepreneurship, the need for justification and its implementation in life, as well as an understanding of the impact of social entrepreneurship on rural regional and its place of business, you can do Conclusions, conduct a SWOT analysis and predict the sustainability of social entrepreneurship in regions of Latvia.

The countryside in Latvia remains one of the most ecologically clean environments in Europe, which could become a prerequisite not only for new families in Latvia, but also for new families from other European countries to consider creating their business in the countryside of Latvia.

In addition, a variety of financial instruments of the European Union are still available to help to start a new business, to expand an existing business, and to acquire good quality; additional Education -needed to to every entrepreneur for successful business development.

To respect the diversity of generations, more and more workers are choosing a freelancer type of work, when you can organize your work every time, day, month by yourself. More and more people choose to work from home, which means that rural areas do not need to develop business centers and officies, as previous years, to have a small demand for coworking spaces. It means not need to make investment for premises. [8]

As one of the prospective activities, there is a social enterprise which may become an existing or newly established company, an existing non-governmental organization or association. The status of a social enterprise can be obtained by companies with limited liability, pursuing a creative economic activity with a positive social impact, such as providing social services, forming an inclusive civil society, promoting education, supporting Environmental protection and conservation, ensure the protection of animals or promote cultural diversity. [4]

If we look at industries, there are many different options in Latvian countryside: Fisheries, Forestry, non-agricultural production, services, tourism small-scale food processing, domestic production, social entrepreneurship, etc.

Fisheries: fishing, the cultivation of goods by order, In the use of a pawing of fish stocks, offering farmed fish for fishing in ponds. The pond is a sector that requires a large capital investment, but is a perspective, because it is possible to unite it with tourism, meaning two businesses in one principle. [8]

Forestry : is one of the main business types in Latvia,

45% of Latvian territory is occupied by forests. The Latvian forests have a unique biological diversity. Per capita, Latvia has 1.1 hectares of forest, which ranks fourth in Europe in this index. [1]

Non-agricultural production: continuing forestry business opportunities include woodchip production, one of the most important export products, as well as furniture production, wood production. The Latvian countryside also contains a number of successful sweets producers, clothing etc.

Toy makers, textile manufacturers, manufacturers of various fashion accessories.

One of the important directions for Latvian rural producers is not only production of honey and honey products, but also a variety of treatments and cosmetic products, or their raw materials, not only for the local market, but also for export - soap, tea, herbal teas, masks, creams, treatments.

Services – The development of rural activities, the situation where new families move to live, or, on the contrary, to keep the young generation in the countryside, it is necessary to develop a variety of services that meet today's standards, requirements and the new generation Interests. [8]

Traditions of previous generations – choirs, ensembles, dancing groups are much too less for the younger generation to be interesting to live in the countryside.

Wellness is one of the services that has been requested, which has not been typical for previous generations, as well as sporting activities – gyms, pools, slobs, accountancy and consultancy services, legal

services, IT services and Other modern lifestyles require service types.

Existing services need to be developed in the quality of modern technologies and standards of life, for example, it is necessary to invest in knowledge as well as service equipment.

Many services, including trade, can be carried out remotely, especially the young generation is more likely to have purchased by websites than in shops.

Tourism -A wide range of tourism is available in rural areas, and the basic rule is nature and infrastructure. The main pre-requisites for tourism development is the geographical location.

A rich cultural historical heritage – the different peoples of the world have gone across Latvia, German landlord famous hunting, summer castles still present and many have been refurbished in recent years.

Resort traditions – especially for neighbours from eastern countries, former post Soviet countries – Latvian resorts are popular for them - climate, mentality and language skills.

Reduced nature – still in many places a completely unbroken nature with a natural flora and fauna characteristic for the environment.

Small-scale food processing – Small farms, home manufacturers are able to produce very special unique originals in small quantities with a specific taste-rich food, which realize at larger or smaller trade fairs, whether in their own region or in the big towns and in the Riga market. There is already a popular celebration of different cities, where small producers are actively trading,

Christmas time is an opportunity for these small producers to earn. Traditionally, in particular, local businesses, in cooperation with small producers, produce a wide variety of unique products – which, through their own logo, are complemented by entrepreneurs and donates to their customers and business partners.

Domestic production is always the perfect option for a small but well-performing business, which can be developed and expanded over time.

Social entrepreneurship -is one of the types of business that can be developed in rural areas, in cooperation with local authorities, to address the problems with which the local authority has not been able to cope, while maintaining a living countryside with the necessary services providing other Who find work in local businesses.

Social entrepreneurship essentially includes both business and social and charity different elements, and profits earned are invested in achieving social goals.[5]

Although certain support mechanisms and a few financial instruments for social innovation and employment exist in practice, they are not specifically designed and adapted to the development or support of the social business environment, directly for social enterprises and Development. The concept is intended for the Cabinet of Ministers to identify the priorities to be supported, both in terms of societal challenges and in the support of problem groups. [3]

In a Latvian situation the social enterprise will follow Commercial law An entity (commercial company) that, based on a legal set of criteria, will be assigned a specific social status in a legal order.[3]

Good examples of social entrepreneurship are:

Wooly World – which produces quality natural material for toys, mostly for export. There are blind and partially-sighted workers working in the production of felt bears.

Mammu Ltd – produces high quality and very expensive scarves for export (one scarf cost 70 – 150 EUR). The scarves produce young mothers, regardless of their place of residence, and also take into account the fact that young mothers are not able to work full time in the first year of a child.

Juhu Ltd – produces porcelain and ceramics, with individual designs, producers are people with special needs.[5]

Next to these already smart examples, author want to put the opportunity in rural areas, by establishing new homes for old-people - care centers, which will be increasingly demanding in the modern life age, in Latvian society is not popular lifestyle to live under one roof several generations. Children are no longer ready and they are not able to take care of their parents and grandparents because of the rapid rhythm of their lives. [5] [8]

This is why it is necessary to first break the stereotype of care centers, such as alms -house, poorhouses, and to form social entrepreneurship in rural areas. This would make it possible to find new jobs for a large number of rural populations, in addition to the elderly who have trouble finding a job not only because of their age, but also very poor skills and education.

It is very important to find a wide range of ways to employ, to engage the new generation in the labour market, since large funds have been invested in their education, there is a lot of investment in rural schools – especially colleges (technical schools, professional engineering Branches in rural areas.

It would be irresponsible in the near future to have these schools closed down due to the number of students or to let young people with good education to leave Latvia and go to earn money and pay taxes in other countries, at the same time companies in Latvia will reduce their activity because they haven't enough workers, especially educated specialists.

Currently in Latvia, young people have access to vocational training in 12 educational establishments which prepare specialists for various sectors for which the rural environment is more appropriate.

For example, Kandava State agriculture Technical school prepares mechanics for horticulture, Bulduru Agriculture School of gardening – Agronoms, gardeners, landscape architects,

Ogre State technical school – Prepares Woodmen,

Malnavas College, Saulaines Professional Secondary school, East Latgale Vocational School, Smiltene technicaly school, National Priekuļi agricultural technical school, etc.

Besides educational opportunities, the various financial instruments still available for business development, including social entrepreneurship development, are a good prerequisite and the opportunity to create social entrepreneurship as one of Businesses, which at the same time address not only social problems,

providing local authorities, promoting labour supply to rural entrepreneurs but developing existing ones and enabling new start-ups in rural areas; Taking into account the request.

Support for the start-up and development of new enterprises, including social enterprises, may be provided:

1. Municipalities (Business ideas will get financial support, rent of premises for symbolic payment, business consultants for free, The right of state and local authority to grant certain relief and support – the right to give (donate) movable property, to grant real estate tax rebates, to transfer to the non-refundable use of the property. [3] [4] [5]
2. Bank projects, small business schools, soft loans, preferential arrangements,
3. Altum programmes,
4. Erasmus + covers all existing schemes in the fields of education, development, Youth and Sport (Erasmus, Leonardo da Vinci, Comenius, Gruntvig, Erasmus for Young Entrepreneurs etc.)
5. Association of Private Investor of Latvia (www. biznesaengeli.lv)
6. Ideas contests, Projects (Bridge IT, Solis, Atsperiens, Pumpurs, etc.)
7. Kickstarter-a business idea web platform.

Social entrepreneurship also includes support or benefits in the field of taxation in order to promote the creation and development of such enterprises. The draft law obliges social enterprises to Support measures. This status acquired by an enterprise may not include in the corporate tax base a range of costs, such as the cost of measures for the rehabilitation and social inclusion of workers, Expenditure on the integration of persons into the labour market, the acquisition of assets that serve the purposes of the statutes, as well as donations for public benefit purpose entities. [4]

In the light of the above facts, while hearing the views of experts from business, local authorities and social Entrepreneurship, Author take the SWOT analysis of the social enterprise in terms of social entrepreneurship as one of the forms of social entrepreneurship in the rural are.

Table 1 (SWOT analyse)

Strenghts	**Weaknesses**
A new business niche, State and municipal support, Finansial support from EU, Tax incentives	Little and controversial information, Stereotype – people with special needs There are not many entrepreneurs who are socially responsible No profit for owners
Opportunities	**Threats**
Cross-border cooperation Social Enterprise – subsidiary for traditional LTD, to fulfil the socially responsible business function Sufficient workforce	Inability to earn for to sustain economic activity The change of the laws in state and municipality (non-long-term support agreement)

Links between social innovation and social entrepreneurship

Table 2 (Links between social innovation and social entrepreneurship)

Social innovations	Social entrepreneurship
New solutions to social challenges	New responses to social challenges.
Improvement of individual and collective well being and quality of life	Explicit pursuit of positive externalities.
Conceptual, process or product change, organisational change and changes in financing, and new relationships with stakeholders and territories	New forms of internal and external governance.
Changes in financing	Mixed financing (public, private, monetary and not monetary).
Changes in relationships with territories	Strong links with territories.

III CONCLUSIONS

The idea of social entrepreneurs helping shape the rural economy isn't new.

Social entrepreneurship is one of the business opportunities in rural areas, which is well-managed and organized can make a big contribution not only to the region, but also to the economy of the country.

The various roles of social entrepreneurs within rural destination development are explored.

Addressing social problems in regions by taking over a fraction of the social problems within the remit of national and local authorities, while providing support to other entrepreneurs in the regions, helping to keep Labour in the regions of Latvia. Special attention is paid to young people, who have learned education in a wide range of professional technical schools, with high-quality specialists in the countryside, which are not intended to meet the rural environment. This could also prevent the closure of training institutions with large financial resources in the future, due to the lack of learners.

The social companies that are already operating in Latvia have been successful in the way they have proven and need much more to tell them, to share their experiences, to encourage others to embark on social work.

There are many different types of business sectors that are able to build successful social entrepreneurship without fear of raw materials or shortages.

Close cooperation between national, municipal and economic operators is necessary to improve the situation and to realize the plan. Some of the same questions received from the different institution are often contradictory.

It is necessary to tell, explain, advise, and refer about social enterprises not only the entrepreneurs and representatives of nongovernmental organizations, but also leaders of municipalities and whole Society . There are often stereotypes about who are social enterprises and who are people with a special needs.

In the future, social enterprises should be built on the base of traditional companies, so that any socially responsible company will fill their functions, when a new tax law, valid from January 2018, is not favorable for donation and socially responsible events.

As one of the risks of a social business for successful development, Author can mention the desire to share the profit for owners when a social enterprise is the only source of income for the entrepreneur. In the long term it cannot be interesting for young entrepreneurs.

Entrepreneurship can have social results, intended (by what are often called social entrepreneurs) but also unintended (when a business idea leads to social change) or maybe partially-intended; moreover, new ideas, new products, or new services, may turn out to be social innovations regardless of any social impact intended by the inventor ,

The potential of social entrepreneurs to engage in rural development is huge. Rural areas are often the perfect places for renewable energy facilities to be located, which translates to increased employment opportunities for the local public as well.

Social entrepreneurs can aid in developing a sustainable business development model while finding the right opportunities unique to the local needs. This also helps the country focus more on R&D, and innovations in the rural economy translate to increased development progress.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 92-95

Marbled Crayfish (Procambarus Virginalis) as a Promising Object for Aquaculture Industry

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***Abstract*—Marbled crayfish / marmorkrebs, parthenogenetically reproducing decapod crustacean of pet aquarium origin conventionally has been recognized as an undesirable species since it a) is an invasive pest dangerous for aquatic ecosystem resources because of its hardiness, omnivorousness, fast growth, self-cloning abilities; b) has little commercial value for food industry.**
However, recently an idea has been introduced about marmorkrebs as a promising cheap protein source, which can help to fight world hunger. Accordingly, research performed at Liepaja University (Latvia) was focused on marbled crayfish farming system design issues. Research paper presented discusses marmorkrebs survival capacities in small-volume microcosm tanks (made from recycled material), under harsh abiotic conditions. Pilot research results obtained will be used to develop experimental project on low-input microcosmic indoor aquaculture for marmorkrebs.

***Keywords*—*Crayfish, aquaculture,* ecological microcosms**

I. Introduction

Inland waters crayfish often belong to environmentally important bionts: they could represent themselves keystone species [1] with a crucial role in aquatic ecosystems functioning and / or can also act as umbrella species for conservation support [2] – accordingly, freshwater crayfish must be taken into consideration when managing nature resources. Among European crayfish one particular species, marmorkrebs *Procambarus virginalis* represents itself a subject of specific interest.

Marmorkrebs or marbled crayfish has received lately a lot of attention from researchers, decision-makers / local authorities, hobby aquarists [3] since this crustacean **a)** is the only known obligatory parthenogenetic (i.e. asexually reproducing) species among large-sized decapod crustaceans [4], **b)** originated accidentally ("mysterious" puzzle of rapid speciation) in hobby aquarium environment from slough crayfish *Procambarus fallax* [5], [6] (crustacean native for southeastern *USA),* **c)** has an appealing carapace coloration (which is a key factor for crayfish trade both in case of food consumers and hobby aquarists [7]), and **d)** possess invasive species capacities – because of its hardiness and high reproductive output (the latter due to asexual propagation mode). Nowadays marmorkrebs successful distribution cases have been already reported for various countries [4].

Despite marbled crayfish has been judged as an undesirable invasive pest, certain food industry focused commercial exploitation is taking place, though. The most popular relevant example is related to Madagascar: since quickly spreading marmorkrebs populations provide a cheap and fast self-renewable food source local people do not care that this alien species is eliminating unique aboriginal aquatic fauna [4]. Similarly, facultatively parthenogenetic spiny-cheek crayfish *Orconectes limosus* (native for the east coast of USA) is accepted for human consumption in economically suffering European areas despite this invader is dangerous for local aborigenous crayfish species [8], [9]. It should be emphasized that besides harmful influence on indigenous aquatic biodiversity marbled crayfish could threaten also wetland vegetation (e.g. its potentially considerable impact on rice harvest has been discussed [10]).

The same traits (like fast propagation, hardiness, omnivorousness) which make marmorkrebs to be a successful pest also turn it into a cheap food source promising for world hunger abatement.

In order to use this advantageous resource in a secure way (i.e. without releasing specimens in wild) indoor aquaculture systems with marmorkrebs populations could be developed. As regards to marmorkrebs cultivation know-how there is a wide relevant experience among hobby aquarists since marbled crayfish are quite popular in pet trade (ornamental aquariums) [11], [12]. Still, there are just few evidences about their use in commercial aquaculture industry [4].

Our research performed at Liepaja University focuses on particularly cost-effective aquaculture design for marbled crayfish with strict space-limitations (microcosms), tanks constructed from waste materials, easy available and non-polluting food supply, low temperature environment (i.e. with no need for additional heating); such aquaculture devices could be used first of all for further aquaculture related experimental purposes and for rising marmorkrebs offsprings.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4174

II. MATERIALS AND METHODS

We propose cheap low-maintenance microcosmic aquacultures for marbled crayfish – initial research results will be revealed in this paper presented. The following pilot experiments have been performed:

Experiment # 1. Waste material recycled for aquarium micro-tank.

PET (i.e. polyethylene terephthalate) plastic bottles recently have been widely reused to design home-made hobby aquariums; still, long term exposure is necessary to judge about possible toxic impact on animals residing in habitats constructed from PET plastic (since relevant literature data are still contradictory, see e. g. [13] and [14]). The following aquarium system has been designed for qualitative experiment: 5 l empty PET bottle (previously used for drinking water) has been put in 25 l aquarium and equipped with small submersible water pump. Aquatic animal community (marbled crayfish, cherry shrimp *Neocaridina davidi* and guppy *Poecilia reticulata*) was housed in this tank and PET bottle was used as a biofiltering device: water with waste materials produced by animals have been pumped (recirculating) through this bottle, partially filled with rootless plants (Java moss *Taxiphyllum barbieri*). Experiment lasted from January 2017 till June 2018. Environmental conditions in experimental tank: water temperature was that of the ambient room temperature (~18-22^{o}C), illumination: natural light from windows, no bottom sediment (gravel, sand, mud or like) added. About ¼ of water volume have been exchanged once in a month, animals were fed 3 days a week by *Hikari* food (diet for fish and invertebrates, popular among hobby aquarists).

Experiment # 2. Limited space, frugal diet, low temperature environment.

Marmorkrebs single adult specimen has been housed in 5 l PET bottle half filled with aged tap water; no air pumping (i.e. oxygen supply and water circulation) provided. Specimen was supplied with black alder (*Alnus glutinosa*) fallen leaves which served both as a food source and shelter (the latter is a necessary prerequisite for marmorkrebs comfort, see e.g. [15]). This food was chosen because it is easy available / cheap and, according to our preliminary observations, actively consumed by marmorkrebs un has no risky pollution effects on microcosm environment (marbled crayfish are quite sensitive towards saprobic pollution, e.g. previously our experimental micropopulation partially died out when too much boiled vegetable food was added in their tank). Besides limited space, exposure to plastic bottle material and restricted / frugal diet this pilot experiment also included low temperature environment.

The latter was researched since literature data reveal certain contradictions as regards to marmorkrebs relations with coldwater environment. Thus, it has been argued that marmorkrebs as a thermophilic species cannot propagate in low temperature environments and, accordingly, there are restricted possibilities for marbled crayfish to spread within Europe [16], [17] and also to be raised in coldwater aquaculture. Alternatively, there are laboratory experiments which demonstrate that marmorkrebs can withstand low temperature conditions and even successfully reproduce afterwards [18], [19]. Temperature factor is also of academic interest since it has been hypothesized that marbled crayfish as a species originated through thermal (heat or cold) shock on captive slough crayfish eggs [3].

Accordingly, winter time has been chosen for our experiment (it lasted from 29.12.18. till 27.01.19) and aquarium tank was placed on the windowsill outdoors.

III. RESULTS AND DISCUSSION

Implementation of marmorkrebs experiments resulted as follows:

Experiment #1: aquatic animal community survived and even propagated during 19 month long exposure to environment with PET material; accordingly, it appears to be safe to develop small-scale aquaculture in PET bottle tanks. Nevertheless, further research is needed to prove are plastic bottle environment raised animals fully safe for human consumption.

Experiment #2: marbled crayfish appeared to be submitted to such outdoor ambient air temperatures which reflect mild winter conditions (see Table 1). Despite of stressing ecological factors (space, diet, temperature) marmorkrebs specimen survived and even gave rise to offspring: in 29.12.18 this crustacean was noticed carrying eggs and 6 juveniles were released in 27.01.19 (according to the literature data, single marmorkrebs can have 30-400 offsprings per batch [20]). Newborn juveniles were transferred then from experimental coldwater tank to indoor aquarium with water temperature ~ 20-22^{o}C (indoor habitat temperature was increased gradually to ensure marmorkrebs adaptation to temperature change); these crayfish larva successfully grew in the new environment (see Fig.1).

TABLE I. MARMORKREBS COLDWATER EXPERIMENT: AMBIENT AIR TEMPERATURE DYNAMICS

Date	Mean daily air temperature (^{0}C)
29.12.18	+4
30.12.18	+5
31.12.18	+2
1.01.19	+4
2.01.19	Storm (marmorkrebs put indoors)
3.01.19	Idem
4.01.19	+1
5.01.19	+1
6.01.19	+2
7.01.19	+2
8.01.19	+1
9.01.19	+1

Date	Mean daily air temperature (^{0}C)
10.01.19	0
11.01.19	+3
12.01.19	+3
13.01.19	+3
14.01.19	+1
15.01.19	+2
16.01. 19	+1
17.01.19	+5
18.01.19	+1
19.01.19	+3
20.01.19	+2
21.01.19	+1
22.01.19	-1
23.01.19	-3
24.01.19	-3
25.01.19	-4
26.01.19	-4
27.01.19	-4

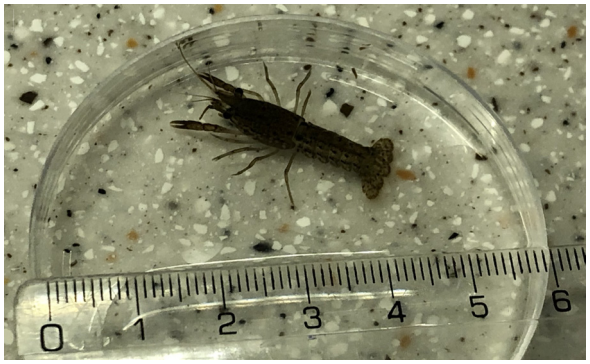

Fig.1 Marmorkrebs juvenile from Experiment # 2 (07.03.2019)

Our observation coincides with data mentioned above [18], [19], except as regards to reproduction while dwelling in coldwater environment: it has not been described yet.

Pilot experiment also demonstrates that marbled crayfish can survive and propagate on plant detritus diet only (it has been partially supported also by our another experiment where marmorkrebs were fed by fallen alder leaves in the course of 4 months with *Hikari* food only minute additions once a week; crayfish survived and successfully reproduced). Despite crayfish are omnivorous organisms, there are certain doubts, according to available literature data, about detritus and live plant material to be a sufficient food to meet physiological needs of these crustaceans [21], [22] – additional experimental research is necessary for relevant discussions.

Experiments carried out have been considered as an initial step to implement further marbled crayfish microcosmic aquaculture development related research.

IV. CONCLUSIONS

1. Marbled crayfish *Procambarus virginalis* predominantly has been recognized as a dangerous invasive species, appreciated only as an object for pet trade and biological research

2. Recently discussions have been started on marmorkrebs utilization for human consumption and, accordingly, research on relevant aquaculture design appears to be urgent

3. Since marmorkrebs belongs to hardy species, there are potentials to develop cost-effective, low-input aquaculture systems to raise this species

4. Our research demonstrates that there are possibilities to sustain marbled crayfish culture within a „frugal" environment: micro-scale tanks (microcosms), plant detritus as a cheap diet, low temperature conditions (i.e. with no additional heating needed).

5. Nevertheless, this was an initial, preliminary study to trigger further research with control and several experimental groups introduced, with more water parameters tested, with crayfish instar morphological examinations and marmorkrebs behaviour observations, etc.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 96-100

The German Energy Transition and Its Stumbling Blocks-Promotion of Power Generation from Photovoltaic Systems and Its Influence on the German Energy Transition

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***Abstract*—The energy transition that began in Germany in 2000 is widely accepted by the population. Opinion research institutes report that more than 90 per cent agree with the policy adopted. Nevertheless, in the public debate in recent years increasingly critical opinions were voiced. In particular, the increased costs of the energy transition are discussed, which are to be borne by the population and the economy.**

Despite increased burdens in all areas of the energy transition, the criticism is mostly due to the increased burden on electricity customers through the increased use of renewable energy. One reason for this is the increase in the Renewable Energy Act (EEG / Erneuerbare-Energien-Gesetz) surcharge, which finances the expansion of renewable energies and which ultimately has to be borne by the customers of the energy supply companies. This surcharge increased by 74 per cent in the years 2012 to 2014 alone. One of the main reasons for this was the excessive subsidization of electricity from photovoltaic systems from 2008 to 2012, which was primarily used by major investors and resulted in a massive expansion. Although the share of renewable energies in the German electricity mix has thus increased, an economic equivalent, such as a sustainable increase in jobs or high export figures among the companies that produce these plants, was not observed.

Today, economists ask to what extent this mistake could have been avoided and to what extent this has damaged the reputation of the energy transition. The economic policy debate on this issue is led by various interest groups whose opinions are widely divergent. Establishing public consensus is difficult, yet essential for a successful continuation of the energy transition.

***Keywords*—sustainable energy, sustainable development, solar energy, Germany**

I. Introduction

The German energy transition beginning in 2000 remains widely accepted by the population. According to public opinion research, more than 90 per cent of respondents agree with the adopted policy [1].

The reasons for the severe acceptance are as follows:

- It is widely agreed on phasing out nuclear energy;
- The effects of climate change become increasingly perceptible;
- Fear of missing the national climate control goals;
- Concerns about declining reserves of conventional sources of energy and rising global consumption.

Nevertheless, the public debate in recent years has been increasingly critical. Particularly, the rising cost of the energy transition, which are paid for by households and businesses, have been met with criticism. Despite increased investments in branches such as grid expansion and energy efficiency in mobility and housing, the discussion revolves around the rising cost of electricity and the burdens it entails for consumers due to the increased use of renewable energies.

An argument repeatedly cited by critics is the disproportionate funding of power from solar plants between 2008 and 2012. Today, science and politics wonder whether this mistake could have been avoided and how future damage can be averted from further proceedings of the energy transition.

II. Functioning, developments and discussion

After the first participation of the Green Party in the German Federal Government in 1998, its goal to introduce a law promoting renewable power sources was quickly implemented. The Green Member of the Bundestag Hans-Josef Fell and the SPD politician Herman Scheer were in charge of the respective piece of legislation.

The Renewable Energy Sources Act (Gesetz für Vorrang Erneuerbarer Energien, EEG) [2] introduced on 1 April 2000 provided for the following three framework conditions for power generation from renewable sources of energy:

1) Plant operators are obliged to connect their plant to the power grid while network operators must implement

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4204

the connection immediately [3].

2) Network operators must expand the grid in order to reliably transmit the generated power [4].
3) The plant operators receive specific and technology-dependent remuneration from the network operator rated per kilowatt hour fed into the grid [5].

The feed-in tariff is disbursed by the network operator for a period of 20 years and financed by the surcharge on electricity consumers. The EEG surcharge is equal for all customers regardless of the local power supplier and its amount is recalculated every year. For this purpose, the so-called EEG account is used. It is financed by the revenues of the EEG surcharge and used for remuneration of renewable power plant operators. For reasons of international competitiveness, a hardship provision was included for energy-intensive companies exempting them from the EEG surcharge.

Initially, this simple and transparent cost allocation system was hardly taken seriously by the representatives of the conventional energy industry and sometimes even ridiculed as an April fool's joke. However, as it had become evident that the EEG provided incentives for investments in renewable energies, similar measures have been adopted by other countries.

Eventually it has been agreed that this law was a milestone in the sought German energy transition. The share of renewable energies in national electricity production increased from 6.6% in 2000 to 35.0% in 2018 [6]. Germany ranks fourth in the world in terms of installed capacity of plants generating electricity from renewable sources. It also ranks fourth in terms of installed photovoltaic capacity [7].

The increase of the EEG surcharge has been the most regarded point in the public debate on the cost of electricity generated from renewable energies. As Fig. 1 shows, the EEG surcharge has risen since its introduction in 2000 from 0.19 to 6.41 euro cents per kilowatt hour consumed by the end customer in 2019.

Currently, the EEG surcharge accounts for about 20 per cent of the electricity price in Germany. Assuming an electricity price of 30 euro cent per kWh, a family of four with an annual consumption of 3,500 kWh receives an electricity bill of 1,050 euros of which about 224 euros are allocated to the EEG surcharge.

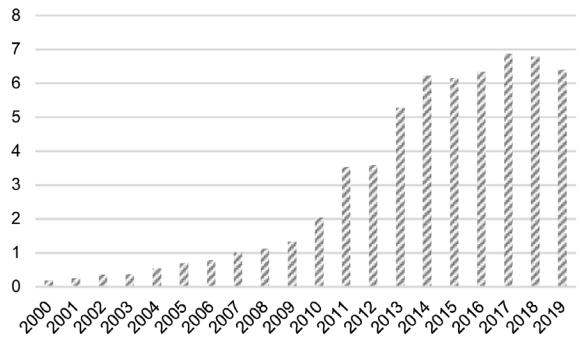

Fig. 1. EEG surcharge for end consumers [8].

The sharp increase of the EEG surcharge from 2012 to 2014 of 2.65 euro cents (74 per cent) is attributed to the funding of electricity production from photovoltaic systems in previous years.

Chronologically, this development can be summarised in three steps:

A. The years 2000 to 2007

Despite high remuneration rates, photovoltaic plants did not significantly contribute to the German energy production. Solar modules were priced uncompetitively high and their technical reliability was insufficient. Among investors scepticism about the ability of the then state-of-the-art technology to achieve an operating life of at least 20 years prevailed.

The first plants to profit from the EEG subsidy, on the other hand, were onshore wind energy farms due to the advanced level of technology and the attractive remuneration rates for investors. Also, building and environmental laws caused affordable expenditure and the planning procedure was usually quick.

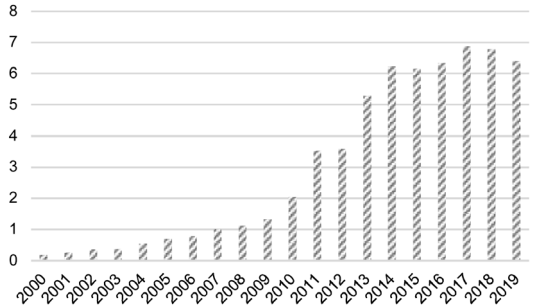

Fig. 2. Year 2003 in wind energy: Installation and total capacity [9].

With a growth in wind power output from 9.5 billion kWh in 2000 to 26.4 billion kWh in 2004 [10], Germany achieved the world's leading position in this power generation technology. As shown in Fig. 2, the year 2003 particularly depicts this advancement—Germany superseded countries with considerably higher wind potential such as England, Spain and the USA in terms of total installed capacity as well as increase in installed capacity.

Regarding the high population density of Germany and the fact that quality of life in the vicinity of a wind power plant leaves much to be desired, the disadvantages of this development are swiftly revealed. Eventually, the areas designated for the construction of wind plants decreased and the negative aspects of this rapid growth became visible. Voices calling for slower growth became louder and were heard by politicians. The first amendment to the German Renewable Energy Sources Act (EEG) in 2004 contained a significant reduction in remuneration rates for wind power plants. The later growth of wind power therefore predominately roots in the installation of new offshore wind turbines and repowering.

As the remuneration rates for wind power have had been reduced and the search for locations for constructing wind farms has had been restricted by building and environmental law, many investors in green technologies sought alternative investments discovering the potential of solar energy, particularly photovoltaic.

There were two predominant reasons for this development:

Firstly, in the initial amendment of the EEG of 2004, the legislator again increased the subsidy rates for electricity generation from photovoltaic [11]. This was a necessary measure since a reduction in the growth of wind energy was expected and needed to be compensated for in order in order not to jeopardise the overall objective to expand electricity generation from renewable energies. The remuneration of electricity generation from photovoltaic plants had already been the highest in the EEG of 2000 and has now reached a level of more than 50 euro cents per kWh. The gross electricity price for the end consumer at that time amounted to about 18 euro cents per kWh.

Secondly, the technological progress combined with increasing competition leading to more economic procurement prices of solar modules, improved quality as well as a longer operating life.

These aspects have triggered the boom in the German solar industry. The number of manufacturers of solar modules and also the newly erected photovoltaic systems rose rapidly.

As depicted in Fig. 3, the cumulative photovoltaic output in Germany grew from 1.11 GWp in 2004 to 4.17 GWp in 2007, and in 2012 even reached 33.3 GWp.

B. The years 2008 to 2012

Characteristic for these years was further technical progress and the increasing competition on the solar module market. Module prices declined as performance and reliability increased. Lobbying by the solar industry prevented effective countermeasures such as a rapid and substantial reduction of the remuneration for solar power or the introduction of a market-based remuneration linked to market energy prices. Thus the aforementioned ample growth was possible with new records after each year [13]. Balancing the EEG account however could only be facilitated by substantially increasing the EEG surcharge as Fig. 1 shows.

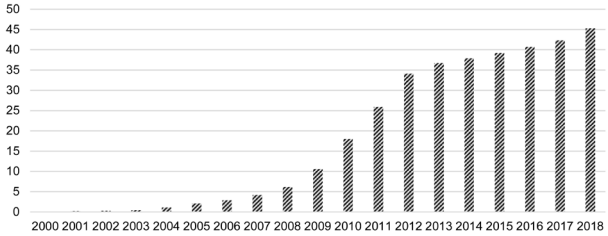

Fig. 3. Cumulative installed capacity of photovoltaic plants in Germany [12].

A major argument presented by the lobby was a vast job creation which was mainly enabled through national subsidies in economically underdeveloped Lands of the Federal Republic such as Saxony-Anhalt and Saxony. Unfortunately, this development was not sustainable, as the import of solar modules from Asia had already increased massively in 2009. The domestic solar industry was not competitive with suppliers from the Far East, who often received subsidies from their governments. The production costs of German companies alone were up to 15 percent higher than those of Asian competitors [14]. The market share of German manufacturers for the domestic market fell to 15 percent. Fig. 4 depicts the resulting decrease in the number of employees of the German solar industry starting in 2011.

There were no protective measures such as import tariffs for the domestic solar industry during this period. The increasingly adverse sentiment in the industry combined with rising electricity prices, which to a large extent were attributed to the rising EEG surcharge and thus directly to the growth of photovoltaic output, significantly changed public opinion from 2012 onwards.

Simply put—photovoltaic served as a scapegoat for the increase in the EEG surcharge.

In the first two quarters of 2012 discussions inflamed in the media about the sharp increase of the EEG surcharge pushing electricity prices and the struggling incipient solar industry. Lobby associations representing various stakeholders as well as the public demanded swift political intervention and—resultant thereof—changes in legislation.

The representatives of the solar industry demanded the high remuneration rates to be maintained, further state aid to be provided for the domestic solar industry and import duties to be imposed on foreign manufacturers. The latter were modelled on the US customs regulations, which imposed high import duties on Chinese solar modules in May 2012 to protect their domestic manufacturers.

The trade and industry associations of the other sectors criticised the high energy prices and warned of the resulting disadvantages for the German economy in international competition. The loss of purchasing power of the local population was also often cited as an argument here.

The representatives of the left-wing opposition parties and the trade unions criticized the electricity prices for citizens and businesses and questioned the further development of the energy transition with regard to costs [15]. For socially weaker sections of the population, the additional burden of rising energy costs remains a considerable risk of poverty today.

The then federal government, consisting of a coalition of the conservative parties of the CDU/CSU and the more economically liberal FDP, came under pressure, especially in view of the upcoming federal elections in 2013. The responsible Federal Environment Ministry under the then Federal Environment Minister Norbert Röttgen announced reforms of the EEG, which however were not considered sufficient by the government and other stakeholders with the exception of the German solar lobby. The remuneration rates were only reduced insignificantly and market-oriented remuneration models were not mandatory for investors.

Reducing the growth of electricity production from photovoltaic systems as well as the EEG surcharge could not have been expected and the loss of jobs in the German solar industry was already visible. In May 2012, the minister was dismissed from the government cabinet and thus was bearing a vast portion of the political responsibility.

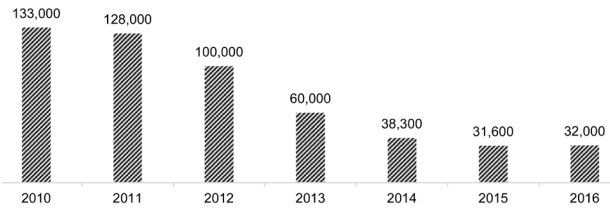

Fig. 4. Number of employees in the German photovoltaic industry from 2010 to 2016 [16].

Eventually, the German government decided to amend the EEG in August 2012 with retroactive effect to 1 April 2012. It included a retroactive reduction of the remuneration, but a mandatory market-based remuneration with a higher risk for the investors had not yet been implemented. Other countries in the European Union faced—albeit not to this extent—similar problems with the unbearably rapid growth of electricity production from photovoltaic plants, which were usually solved by retroactive reductions in subsidies. Economists agreed that this was the only way to prevent a further rapid increase in energy costs.

C. The years 2013 to 2018

In 2013, the German solar industry was in a rather difficult state. Numerous companies filed for bankruptcy, the number of employees fell from 133,000 thousand in 2010 to 60,000 in 2013 as shown in Fig. 3. The European Union's protective tariffs were not introduced until May 2013. For suppliers from China, a minimum price for the solar modules and an annual quota for imports were determined. The terms were negotiated cautiously as other industries headed by the automotive industry feared countermeasures restricting the access of their products to the valuable Chinese market. The declining trend in employment was not be stopped in the following years either. In 2016 there were only 32,000 employees left in the solar sector and in 2018 Solarworld AG, the last German mass manufacturer of solar modules, disappeared from the market. Only manufacturers producing specialised products with small quantities are still available today.

In response to rising electricity prices, politicians have made numerous attempts not to allow the EEG surcharge to further increase. In 2013, the new Federal Environment Minister Peter Altmaier presented proposals to minimize the further increase of the EEG surcharge containing a provision limiting the increase to 2.5 per cent annually. However, the possible measures of reducing the remuneration combined with a suspension of disbursement were not implemented in the current EEG.

In 2014, the EEG was again amended to include a mandatory market-based solution for large solar power plants. The last amendment to the EEG in 2017 introduced a new regulation, requiring tenders for large solar installations. In these cases, the bidder with the lowest bid for feed-in remuneration is awarded the contract. This amendment to the EEG enables a controlled promotion of the individual forms of energy with binding target corridors.

These measures stabilised the EEG surcharge at the high level and prevented further growth. However, a significant reduction is not to be expected in the next few years, due to the 20-year funding period of the rigid old regulation.

III. Summary

In summary, it is to be stated that the history of the German law on promoting renewable energies is a successful one. The mistakes were not inherent in the law, but rather due to adhering to rigid remuneration regulations, which were also preferred by investors, for too long. The EEG surcharge, which has now increased to 6.41 euro cents, is an essential component of the high electricity prices in Germany of approx. 30 euro cents. This still provokes criticism in politics and business [17].

Also the lack of inclusion of the citizens is to be considered a problem here. A visible change in the landscape—especially in the case of wind energy—in conjunction with rising electricity prices has regularly caused dissatisfaction among the population. The population was and still remains positive about the energy transition, but the aspect of rising costs eventually allocated as profits to anonymous investors does not contribute to the positive image of the EEG. Here the partially already existing co-ownership of plats by citizens could soothe the waters.

Also the fast loss of thousands of jobs in the German solar industry can be seen as a stumbling block of the German energy transition, because especially in the economically underdeveloped regions the affected people faced difficulties when seeking new employment.

Prospectively, therefore, a swifter monitoring, quick political reactions to technical and economic changes and lowering the influence from individual lobby associations will be crucial.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 101-104

Modification of Humic Substances for Development of Materials for Environmental Technologies

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***Abstract*—Humic substances are high molecular weight refractory polycationites formed during decay of living organic matter and through biosynthesis of low molecular weight organic substances (metabolites or decay products of living organisms). Presence of many functional groups in the structure of humic substances determines their ability to interact with metal ions forming stable complexes and influencing metal ion speciation in the environment and mobility, behaviour and speciation forms in the environment. Presently humic substances are a product of industrial scale and quantities in amounts of hundreds of tons are produced. The aim of this study is to analyse derivatization possibilities of humic substances. To achieve this aim derivatization of humic substances using acylation (at first introduction of acetylgroups, but also changing length acyl chains are considered) are used. Also alkylation is used. Mild oxidation can help to obtain modified products with reduced molecular weight. Another approach includes introduction of new functional groups and structures. To achieve this aim, conjugates with short peptides, amines and sugar derivatives using coupling with water-soluble carbodiimides are obtained. As basic characteristics elemental analysis as well as functional analysis have been used, supported with Fourier transform infrared (FTIR), ^{13}C nuclear magnetic resonance spectrometry and other methods. Derivatives of humic substances containing sulpho, amino, and hydroxylgroups and thiolgroups were synthesized and their properties were analyzed in respect to their their elemental composition; functional group content changes in spectral characteristics. The derivatives of humic substances showed significant differences in the number and in ability to interact with the metal ions, which were reflected in their complexation properties towards metal ions. FTIR spectra gave evidence of the presence of metal ions, strongly bound and protected in inner sphere complexes. The obtained derivatives of humic substances can be used for remediation of environment contaminated with heavy metal ions.**

***Keywords*—humic substances, modification, functional groups, pollutants, remediation.**

Introduction

Humic substances (HS) are high molecular weight refractory high-molecular substances with numerous acidic functional groups formed as a result of decay of living organic matter as well as due to synthesis from low molecular weight organic substances (metabolites or decay products of living organisms) [1]. Humic substances are considered as refractory and inert, but they do have numerous functional groups which influence their behaviour in the environment. Humic substances do contain carboxylgroups, phenolic and carbohydrate hydroxylgroups, aminogroups, quinonic groups and reactive positions in aromatic structures [2]. Presence of many functional groups in the structure of humic substances determines their ability to interact with metal ions as well as organic substances forming stable complexes and influencing speciation forms in the environment and mobility, behaviour in the environment [3]. Considering the complex forming properties of humic substances, they are suggested for use in remediation of environments contaminated with metals [4, 5]. In many studies high complex forming capacities of humic substances in respect to metal ions are demonstrated [5-7]. At the same time humic substances are industrially produced in quantities of tons at first for applications in agriculture and thus can be considered as low-cost natural materials. Considering presence and high concentrations of many functional groups in structure of humic substances their derivatization can be done to increase concentrations of existing functional groups as well as introducing new groups. However use of many derivatization reagents for modification of humic substances is of limited use, considering low solubility and presence of labile structures in their molecules. Another problem is relatively low reactivity of main complex forming groups in the structure of humic substances (-COOH, -OH and other) [6, 7]. Thus a need for search of new derivatization methods for modification of humic substances is a challenge to obtain derivatives of humic substances as well as for development of environmental technologies. Several studies have been done to obtain derivatives of HS for their structural studies [6 – 8], however the use of expensive and toxic chemicals limit application possibilities of suggested modification methods. The real number of methods suggested for derivatization of humic substances is highly limited and their derivatization in general has been used mostly for their structural analysis.

The aim of the present study is to study derivatization

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4123

possibilities of humic substances to obtain derivatives of humic substances with increased complex forming ability in respect to metal ions.

Materials and Methods

A. Materials

Analytical quality reagents (Merck Co., Sigma – Aldrich Co., Fluka Chemie AG) were used without purification. For preparation of solutions, high purity water Millipore Elix 3 (Millipore Co.) 10 – 15 MΩ was used throughout the study.

B. Studied humic acids (HA) and their characterization

Humic acids were isolated from a raised bog peat (Dzelves Bog, peat decomposition degree 10 %, humic acid/fulvic acid ratio: 6.8). Peat HA properties: C 45.53 %; H 5.60 %; N 0.47 %; S 0.81 %; ash 1.29 %. Other determined parameters: concentration of carboxylic groups 4.2 mmol/g; total acidity 9.31 mmol/g; phenolic hydroxylgroups 5.11 mmol/g.

Elemental composition. Carbon, hydrogen, nitrogen and sulphur concentrations in the humic acid samples (elemental analysis of C, H, N, S) were determined by combustion-gas chromatography technique, using an Elemental Analyzer Model EA-1108 (Carlo Erba Instruments). Ash content was measured after heating 50 mg of each peat sample at 750 ^{0}C for 8 h. Elemental composition was corrected considering the ash content, and the oxygen amount was calculated as a difference.

Total acidity. An automatic titrator TitroLine easy (Schott-Geräte GmbH) was used for measuring total acidity of HA and their modification products. To estimate the total acidity [9, 10], 20 mg of humic acid or its modification product, were dispersed in 10 ml of 0.1 M $Ba(OH)_2$ solution, then shaken overnight under N_2 atmosphere, filtered and washed with water. The filtrate with the washing solution was potentiometrically titrated with 0.1 M HCl down to pH 8.4 under N_2 flow.

Infrared spectra. Fourier transform infra-red (FTIR) spectra were recorded in the 4000 to 500 cm^{-1} wave number range using Perkin Elmer 400 IR spectrophotometer, in KBr pellets obtained by pressing mixtures of 1 mg samples and 400 mg KBr with precautions taken to avoid moisture uptake.

C. Modification of humic acids

Synthesis of derivatives of humic acids modified with thiolgroups

Solution of 10 g of humic acids in 100 ml of 5 % NaOH were added with 9.3 g (0.1 mol) of 2,3-epoxy-1-chloropropane and the suspension was stirred at 20 ^{0}C for 6 h. The weight of 4.8 g (0.02 mol) of $Na_2S{\times}9H_2O$ was added to the reaction mixture and additionally stirred at 60 ^{0}C for 8 h. The reaction mixture was acidified with 6 N HCl to pH 1. The precipitated thiolderivatives of humic acids were filtered off, the precipitates redissolved into 0.1 N HCl and precipitated with 6 N HCl. Precipitates were washed with water, acetone and dried. The weight of 8.6 g of humic acids modified with sulphogroups were obtained with following elemental composition: C - 46.67 %; H - 5.33 %; N - 0.37 %; S - 3.67 %.

Synthesis of derivatives of humic acids modified with sulphoalkylgroups

To dispersion of 10 g of humic acids in 50 ml of formalin were added 10.41 g (0.1 mol) of $NaHSO_3$ and 10 % NaOH dropwise until pH 10 – 12. The reaction mixture was stirred at 80 ^{0}C for 6 h. The filtrate was acidified with 6 N HCl to pH 1 after filtration process. The precipitated sulphoalkylhumic acids were filtered off and washed with water, acetone and dried. The weight of 8.6 g of humic acids modified with sulphogroups was obtained with following elemental composition: C 42.91 %; H 5.21 %; N 0.26 %; S 4.76 %.

Synthesis of sulphopropylhumic acid

The weight of 10 g of humic acids were added into the solution of 100 ml of dimethylformamide 1,3-propanesultone (Table 1) and was stirred at 70 ^{0}C for 8 h. The reaction product was poured into 1 l of acetone, the precipitated modified humic acids were filtered off, washed with water, acetone and dried. Reaction conditions and properties of obtained products are summed up in the Table 1.

Modification of humic acid with amino groups

Twenty g of humic acid (Sigma-Aldrich Co) were dissolved in 60 ml of 0.5 N NaOH, after which 9.25 g (0.1 mol) of 1-chloro-2,3-epoxypropane were added. The mixture was then stirred at 60 °C for 2 hrs, after which 50 ml of ammonium hydroxide were added. Next, the mixture was stirred at 60 °C for 8 hrs, after which it was acidified by adding concentrated HCl until it had a pH of 1. Acidification resulted in precipitation of the modified HAs, which were then removed by filtration, washed with H_2O and dried to give 14.85 g of modified HA.

Modification of humic acid with hydroxyl groups

Ten g of humic acid (Sigma-Aldrich Co) were dissolved in 50 ml of 0.5 N NaOH, after which 30.0 g (0.5 mol) of 2,3-epoxypropane were added. The reaction mixture was then stirred at 80 °C for 24 hrs. Next, the pH of the reaction mixture was reduced to 1 by the addition of concentrated HCl. Acidification resulted in precipitation of the modified HAs, which were then removed by filtration, washed with H_2O and dried, to give 8.99 g of modified humic acid.

D. Humic acids-metal complexation.

Study of the interaction between metal ions and humic acids using ion selective electrode

Metal-humic binding were analyzed with Consort Cu^{2+} ion selective electrode (ISE) (pHoenix Electrode Co.). ISE was filled with 10 % KNO_3 solution and conditioned with 5 M $NaNO_3$. Calibration curve in the 6.3×10^{-4} to 3.17×10^2 M Cu^{2+} concentration range was determined. 10 ml aliquots of HA solution (10 mg/l) were mixed with 40 ml aliquots $Cu(NO_3)_2 \times 3H_2O$ solution with final Cu^{2+} concentration 100 mg/l and hold for 24 h. In the filtered solutions the unbound Cu^{2+} concentration was measured

with ISE (all measurements were done in triplicate).

Conditional stability constants [16] were determined for complexation reactions which can be written as equation (Scatchard equation):

$$Ko = \frac{CuHA}{[Cu] \cdot (HA - CuHA)}$$

where: Cu – total number of moles of Cu^{2+};

HA – the total number of moles of humic acid in solution;

CuHA – number of moles, which are linked in complexes.

Results and Discussion

Humic substances have significant quantities of reactive structures [12, 13] in their molecules and thus provide possibility to obtain derivatives of humic substances with significantly different properties in respect to natural ones. To increase complex forming capacities of humic substances, modification of HS with sulphur containing groups (sulpho- and thiol groups, as well as amino groups) - strong complex forming groups. The aim of modification is to increase ability of obtained modified humic substances to bind metal ions.

The suggested modification approaches are based on reactions of hydroxylgroups in the structures of humic substances with reactive modifiers: 1) with 1,3-propanesultone to obtain sulphopropylhumic acid; 2) etherification with sulphoalkylgroup by treatment with 2,3-epoxy-1-chloropropane and following thiolysis of epoxygroup to obtain humic acid modified with thiolgroups; 3) treatment with 2,3-epoxy-1-chloropropane and following aminolysis of epoxygroup to obtain humic acid modified with aminogroups; 4) treatment with 2,3-epoxy-1-chloropropane and following hydrolysis of epoxygroup to obtain humic acid modified with hydroxylgroups...

Selection of experimental conditions are based on cellulose modification reactions, considering experience of humic acid modification conditions in previous studies [6, 7, 11]. Selected derivatization conditions allow to obtain sulphopropylhumic acid (III) with differing derivatization degree (Table 1).

TABLE 1

CONDITIONS* OF SYNTHESIS AND YIELDS OF SULPHOPROPYLDERIVATIVES OF HS

Amount of 1,3-propanesultone	T C	T hrs	S, %
0.1 mol	80	8	8.34
0.2 mol	80	8	8.66
0.1 mol	20	25	8.55
0.05 mol	80	8	8.15
0.01 mol	80	8	3.42
0.05 mol	40	8	2.18
0.05 mol	20	8	1.38
0.05 mol	80	4	1.22

*Conditions of the synthesis in details are described in Materials and Methods

Yields of humic acids modified with sulphoalkylgroup, thiolgroups and aminogroups are less variable and rather limited by experimental conditions, but also allows obtain correspondingly substituted substances. During derivatization process the molecular mass of humic substances is reduced. On one hand it can be explained by destruction of humic macromolecules during derivatization process, but in the same time disintegration of hydrogen bonds of HA subunits [12] allow to use obtained derivatives for structural studies of HA.

Obtained sulphur, amino-, hydroxylgroups containing derivatives of humic substances are characterized using weight gain during synthesis, elemental analysis as well as FTIR spectra.

In FTIR spectra sorption maximum characterizing for C-S (780 cm^{-1}), S-S (466 cm^{-1}), organic sulfates (1388 cm^{-1}) and other bonds can be seen and for humic substances modified with aminogroups similar presence of groups can be observed.

NMR spectra shows similar changes in the structure of obtained compounds and, if compared with NMR spectra of modified model, compounds allow to evaluate the sites of substitution in the molecules of obtained derivatives.

Thus, the combination of functional and structural analysis allows to describe obtained derivatives of HA. The obtained derivatives of HA do have significantly differing hydrophobicity as indicated by their K_{pegw} values [14] and, for example hydrophobicity of aminoderivatives is significantly higher than those of original compounds.

Derivatization of humic substances with sulphogroups, aminogroups and hydroxylgroups significantly influence their hydrophobicity as evident from changes in their polyethyleneglycol-water distribution coefficient (Table 2).

TABLE 2

CHARACTERISTICS OF MODIFIED HUMIC ACIDS

	Total acidity, mEq g	$K_{PEG/W}$	M_w, Kda	logK
Peat HA	4.4	17.6	22.5	4.89
Sulpho propyl HA	6.8	21.4	20.6	8.52
Sulphoalkyl HA	4.6	28.4	12.5	6.6.6
Thiol HA	4.4	21.8	14.8	7.97
Amino HA	4.4	32.5	12.5	5.23
Hydroxyl HA	4.5	33.7	11.9	4.92

Humic acids modified with sulpho, thiol, amino and hydroxylgroups have higher metal binding capacities and the formed complexes are more stable than with humic acids. Thus the obtained derivatives are prospective for use in contaminated environment remediation. To test it a well-known sequential extraction approach suggested by Tessier and others [15] and others were used. Accordingly to sequential extraction approach total metal amount in contaminated soil is divided as easily extractable metals (environmentally most dangerous fraction as far as metals present in this fraction are accessible to soil biota and plants), metals bound to carbonates, iron and manganese

oxides, organic matter and refractory fraction. The aim of remediation thus could be reduction of most easily available metal fraction [16].

The speciation analysis of copper present in contaminated soil after treatment with peat humic acids and modified humic acids demonstrates significant reduction of easily available copper forms in contaminated soils. Thus humic acids modified with sulpho- and thiol- groups are prospective agents for contaminated soil treatment. It could be expected that after mineralization of humic acids presence of sulpho- and thiol groups in humic acids could form stable sulphates or sulphides thus increasing stabilization effect of metal.

However considering high variety of modified humic substances they might find applications also in a wider array of environmental technologies, such as biomedicine, coloring industry and others.

Conclusions

Considering a large scale of production of humic substances, the obtaining of derivatives of humic substances, including HS with modified properties, are perspective and sustainable areas of use.

The derivatives of humic substances showed significant differences in the number and in ability to interact with the metal ions, which were reflected in their complexation properties towards metal ions.

The obtained derivatives of humic substances can be used for remediation of environmental contaminated with heavy metal ions. Modified humic acids with sulpho-, amino-, hydroxyl- and thiolgroups have higher metal binding capacities and the formed complexes are more stable, therefore the obtained derivatives are prospective for remediation of contaminated environment.

Acknowledgements

This study was supported by the LCS grant "Properties and structure of peat humic substances and possibilities of their modification" lzp-2018/1-0009.

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Effects of Anthropogenic Impact on Sexual Differentiation of Certain Species of the Genus Salix

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***Abstract*—Plant organisms actively respond to changes in the natural components of their environment. A sensitive indicator of the adaptation of the plant organism to the environment is the state of the reproductive system. The article discusses the results of a study of the sex composition of populations and the quality of pollen grains of two species of the genus Salix. The peculiarities of the sexual sphere Salix fragilis and Salix dasyclados revealed during the work show the feminizing effect on the sexual structure of the populations of these types of anthropogenic factors. During the increase of stress conditions the level of vitality and fertilizing ability of pollen grains decreases. The results of the study confirm the possibility of using these plants as bioindicators of the environment.**

***Keywords*—anthropogenic load, bioindicator, palinoindication, pollen fertility and viability, *Salix fragilis L., Salix dasyclados L*.**

I. Introduction

Today, against the backdrop of intense anthropogenic impact on natural ecosystems, a pressing issue in environmental studies is finding new bioindicators and checking their suitability for assessing the ecological state of the environment. Bioindicating methods are widely used as a comprehensive and accessible diagnostic of the state of the environment. The reproductive sphere of plants is highly sensitive to external influences [22], which can be used for bioindication studies.

As one of the environmental indicators to judge the quality of the environment, we chose the sex ratio, fertility and viability of pollen. The definition of sex in plants is understood as the formation of characters under the influence of both genetic factors and the conditions of the external and internal environment [28].

The influence of environmental factors on the manifestation of sex in plants is realized through the impact on the endogenous hormonal system, which in turn interacts with the genetic apparatus [24]. At the same time, the individual has a chromosomal form characteristic of one sex, and another appears in the phenotype [28]. Numerous experiments have shown that all physiologically active substances influence the process of sexual differentiation of plants [24, 28, 29]. Gibberellins promote the development of male genitalia. Auxins and cytokinins contribute to feminization [14].

Various external factors affect the change in the sex of a plant: day length [8, 24, 29], X-rays [22], ultraviolet rays [21], electromagnetic field [24], laser irradiation [19], radiation [5, 12, 13, 24].

The effect of trace elements, mineral nutrition [24, 26], temperature change [5, 29] and water regime [9, 17] on the sexualization of plants has been studied many times.

So, the floor of the plants is not a frozen symptom and may change under the influence of external factors. When adverse factors affect plants, changes can be observed both in the male (pollen) and female (ovule) spheres [22, 27].

The viability of pollen can serve as an indirect indicator of mutagenicity and phytotoxicity of environmental pollutants [3, 15, 20], which underlies the method of palinoindication. The worse the ecological situation, the more defective and sterile pollen is produced by plants [10]. The work carried out by different authors with different plants showed that the number of sterile plants in the zone of influence of factories and roads increases [2, 3, 4, 11, 15].

The study of the sexual structure of populations of some dioecious plants can serve as a bioindicator of the ecological state of the environment. According to the hypothesis V.A. Geodakian, in various dioecious species,

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4090

adverse factors cause a shift of the sexual proportion to the male side, if necessary, adapt to changing conditions, and catastrophic factors - to the female, for the survival of the species [6]. Females are more viable than males.

This circumstance serves as a basis for recommending the use of dioecious plants as bioindicators of the state of the environment [16, 25].

Objective: to study the sex structure of plant populations of the genus Salix (willow brittle — S. fragilis L. and willow – willow willow — S. dasyclados L.), the quality of their male gametophyte, and to assess the possibilities of using changes in the reproductive sphere in biological monitoring of the environment.

II. Materials and methods

As objects of study, we considered several populations of 2 species of the genus Salix. This is Willow fragile (Salix fragilis L.), representing a dioecious tree 15–20 m tall with a marquee, widely spreading crown. It has bare, slightly drooping branches of olive-green color, which by the fifth year of life become brittle at the base. It grows along the banks of reservoirs, in damp places [7].

Fig. 1. *Salix fragilis L.*

Fig. 2. *Salix dasyclados L.*

Woolly willow (Salix dasyclados L.) willow is a dioecious plant, tall shrub or rarely a tree, up to 5 - 8 m high with gray or white woolly young shoots, with large, woolly, ovate-beaked, dark brown buds. It grows along the banks of rivers and lakes.

In the course of the study, we examined the populations of brittle and willow willow willow in the following areas:

No. 1. The grove near the Nuksenskoye Lake (Mukhtolovo workers' settlement, Nizhny Novgorod Region) - a territory remote from the aggressive influence of anthropogenic factors was a control option. The phytocenosis is composed of such hardwoods as aspen, rowan, brittle willow, goat willow, three-willow willow, woolly willow.

No. 2. The territory of the former Kirillov dump of MSW (closed about 20 years ago) is located in the southeast of the city of Arzamas along the Vladimir-Arzamas regional road (P72), in the direction of the village of Kirillovka. This is a site with a high anthropogenic load (19.3 thousand cars per day). Any territory of the landfill is a carcinogenic-mutagenic zone, which remains such for a long time as a result of the accumulation of heavy metals, polyaromatic hydrocarbons (PAHs), and dioxins. It is an abandoned landscape, overgrown with trees and shrubs. Gas station adjoins the dump.

No. 3. The grove, located behind the Trinity cemetery in the south-east direction from the city of Arzamas, is an area that is 3.5–14 km away from the highways with an intensive level of traffic. The phytocenosis is composed of such tree species as white birch, common aspen, small-leaved linden, Norway maple, fragile willow, white willow, wool-willow willow, goat willow.

No. 4. The coastal territory of the Ramsay pond is a site with a high anthropogenic load, located in the eastern part of the city of Arzamas (May 9 st.). It is a willow-grown area, on the square of which there are species of willow: white, fragile, goat, sherstistoprebegovaya, blackening, ashen. Near the pond there is a highway with heavy traffic (18.1 thousand cars per day), a car wash, parking lots, OAO Arzamas Engineering Plant, emitting about 74 tons per year of 50 names of harmful substances.

No. 5. Turning to Maryevsky spring (Arzamas district) is a plot overgrown with willow on both sides of the inter-settlement road, with a low level of traffic intensity (1.7 thousand vehicles per day).

To study the sexual structure of the population of two willow species, we counted the number of males and females during the flowering period (April 2018) on the experimental and control plots of 400 m2. The values obtained were converted to percentages and the ratio of the sexes in the populations was determined. The sample for different areas ranged from 50 to 100 copies. The significance of differences between the control and experimental variants was evaluated by the method χ^2 [18].

$$\chi^2 = \Sigma \frac{(O-E)^2}{E},$$

where Σ is the sum of the results for all the classes observed in the experiment, O is the observed splitting, E is the expected splitting. In experiments, the number of degrees of freedom is K-1, where K is the total number of classes.

When organizing palinoindication studies in different areas, similar weather conditions were selected, the degree of maturity of pollen and the time of collection were taken into account. Collected pollen or anthers were stored in tubes closed with a stopper in the refrigerator at a tempo of + 2º - + 5º and humidity 50 - 70%. The acetocarmine method was used to determine pollen fertility [23]. The number of dyed and unpainted pollen grains was counted in five fields of view, in triplicate. Pollen fertility was determined by the number of colored pollen grains (percent) (Fig. 3).

Fig. 3. Willow pollen brittle, **colored with** acetocarmine

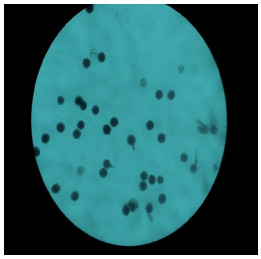

Fig. 4. Willow pollen brittle, colored with isatin.

Pollen viability was detected using an isatin reagent or a proline test [1]. Viable pollen reacts with isatin and turns

intensely dark blue, while non-viable remains colorless. The viability of pollen was determined by the number of colored pollen grains (percent).

Statistical processing of the research results was carried out by assessing the difference between the sample fractions of the general population using Student's t test [18]. The ratio of this difference to its error gives a random variable t = d / Sd, which follows t - Student's distribution. But the hypothesis or assumption that p1 = p2 is rejected if

tф ≥ tst for a certain level of significance P = 5%, 1%, 0.1% and the number of degrees of freedom k = n1 + n2 - 2 Error of the difference between the fractions taken from approximately equal-sized samples (when the number of groups differ by no more than 25%) are calculated by the formula:

$$Sd = \pm\sqrt{\frac{p_1 * g_1}{m_1} + \frac{p_2 * g_2}{m_2}},$$

m1 is the total number of controls, m2 is the total number of experience. p1 = m1 / (m1 + m2); p2 = m2 / (m1 + m2); g1 = 1 - p1, tf = d / Sd, d = p1 - p2

The value of tst for k = 28 at different levels of significance: p = 5% – 2,05 (*); p = 1% – 2,76 (**);

p = 0,1% – 3,67 (***).

III. Results and discussion

In the course of studying the sex structure of different populations of 2 willow species, a shift in the sex ratio to the female side was established in plants growing in two areas exposed to the most intense anthropogenic load (Table 3, Table 4).

The sex structure of Salix fragilis and Salix dasyclados in the control plot, in the area of the cemetery and spring is not statistically different from the ideal 1: 1 ratio, which indicates favorable environmental conditions for the growth of populations.

Table 3

CORRELATION OF FLOORS IN SALIX FRAGILIS POPULATIONS

Study area	♂/♀	*f* ♂:♀	*f'* ♂:♀	$\chi^2_ф$	χ^2_{st} at p=0,05
1. Grove Lake. Nuksen (control)	0,91	39:43	41:41	0,20	3,84
2. The former Kirillov dump	0,54	21:39	30:30	5,40	
3. Trinity cemetery	0,84	41:49	45:45	0,71	
4. Ramsay pond shore	0,45	13:29	21:21	6,10	
5. Maryevsky spring	0,84	65:77	71:71	1,01	

Table 4

CORRELATION OF FLOORS IN SALIX DASYCLADOS POPULATIONS

Study area	♂/♀	*f* ♂:♀	*f'* ♂:♀	$\chi^2_ф$	χ^2_{st} at p=0,05
1. Grove Lake. Nuksen (control)	0,87	52:60	56:56	0,57	3,84
2. The former Kirillov dump	0,47	21:45	33:33	8,73	
3. Trinity cemetery	0,82	27:33	30:30	0,60	
4. Ramsay pond shore	0,38	11:29	20:20	8,10	
5. Maryevsky spring	0,91	42:46	44:44	0,18	

At these sites, a reduced anthropogenic load is noted, which does not significantly affect sexual differentiation in the populations of S. fragilis and S. dasyclados. Statistically significant deviations in the secondary sexual structure compared to the control were found in the populations of S. fragilis and S. dasyclados in areas 4 and 5, where the actual chi-square value is significantly higher than the standard value 2 = 3.84. On the territory of the landfill for S. fragilis 2 it is 5.4, and for S. dasyclados - 8.7, which is the largest deviation of the values found. On the coastal area of the Ramsay pond, the matching criterion is equal for S. fragilis 6.1, for S. dasyclados - 8.1.

In general, the actual difference between the c2 values of the control and anthropogenically loaded areas: No. 2 and No. 4 in S. dasyclados is slightly larger (8.16 and 7.53) than the similar difference in the chi-square values of these areas in S. fragilis (at 5.20 - 5.90), respectively (Table 3, Table 4).

This indicates that severely adverse growing conditions of plants significantly affect the sexual imbalance of the population, increasing its feminization.

In all studied populations of the genus Salix, the numerical advantage was found in females. The ratio of male to female specimens for S. fragilis is shown in Figure 5, for S. dasyclados in Figure 6.

For S. fragilis, the ratio of males to females in the population in the landfill site (plot No. 2) is 0.54, in the coastal area of the Ramzai pond - 0.48 (plot No. 4).

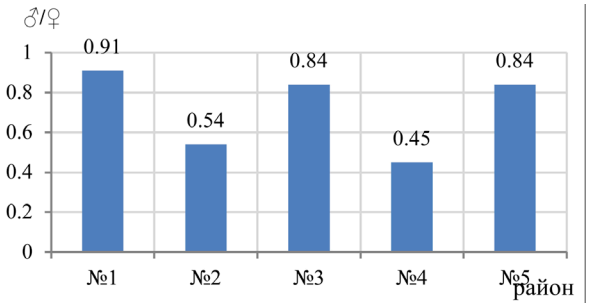

Fig. 5. Sex ratio in populations of Salix fragilis

A similar relationship between the ratio of females and males in these territories was also found for Salix dasyclados populations (Fig. 6). The coefficient of the secondary sexual proportion in stressful conditions (sections 2 and 4) is 0.47 and 0.38, respectively.

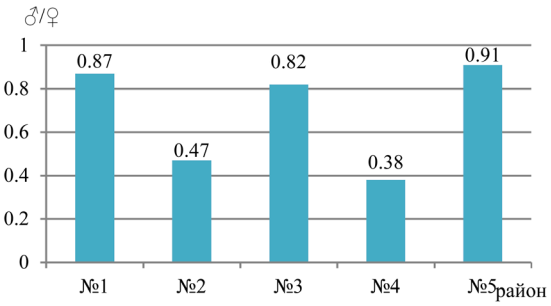

Fig. 6. Sex ratio in populations of *Salix dasyclados*

So, in the course of the study, no specific features of changes in sexual differentiation in the populations of the genus Salix depending on the species were found - similar trends in the dynamics of the sex structure were observed in all areas.

As a result of studying the pollen fertility, a significant difference in the quality of the pollen grains of 2 species of the Salix genus in the experimental areas from the control (Nuksenskoe grove), which is not experiencing intense anthropogenic impact, was shown. Control pollen fertility rates are the highest: 91.4% for S. fragilis and 94.1% for S. dasyclados (Table 5, Fig. 7).

Table 5

FERTILITY OF PLANT POLLEN (%) IN RESEARCH AREAS

Plant type / Study area	*Salix fragilis*	*Salix dasyclados*
1. Grove oz. Nuksenskoe (control)	91,4 ± 0,7	94,1 ± 0,6
2. The former Kirillov dump	47,8 ± 0,8***	53,6 ± 0,8***
3. Trinity cemetery	84,2 ± 1,0*	83,1 ± 0,7**
4. Ramsay pond shore	67,2 ± 1,0***	63,1 ± 0,8***
5. Maryevsky spring	90,1 ± 1,0	91,6 ± 0,7*
The average value of the studied areas	76,1	77,1

*P ≤ 0,05; ** P ≤0,01; *** P ≤0,001

The closest to the control indicators of the fertilizing ability of pollen grains are determined at site No. 5 (Maryevsky spring). The pollen fertility of S. fragilis here is 90.1%, which is only 1.3% less than control. The differences in the S. dasyclados fertility rates between this and the control sites are significant, but relatively small and differ by only 2.5%. Consequently, favorable conditions for the growth and reproduction of plants have developed in this area, and the low intensity of traffic on the asphalted village road adjacent to the studied area does not carry a significant anthropogenic load.

The lowest fertility of pollen in both studied species was found on the territory of the former Kirillovsk dump: 47.8% in S. fragilis, 53.6% in S. dasyclados, which differs significantly from the control area by 43.6% and 40.5%, respectively (P ≤ 0.05).

Low pollen fertility values are also noted in area No. 4 - the coast of the Ramsay pond. The site is subject to high anthropogenic load: a large industrial enterprise (AMZ), a parking lot and a road with heavy traffic are located nearby. In S. fragilis, the pollen fertility here differs from the control area by 24.2% and is 67.2%. In S. dasyclados, the difference in fertility between the control and plot No. 4 is significantly higher - 31.0%, the percentage of fertility in the study area is 63.1%.

The pollen fertility rate in S. fragilis at site No. 3 (grove near the Trinity cemetery) is 84.2%, in S. dasyclados the similar value is 83.1%. The difference with the control plots in the first population is 7.2%, in the second - 11.0% can be caused by a negative effect on the male gametophyte of cadaver poisons and a small distance from the city.

When studying the viability of pollen collected from plants of different habitats, such a decrease was found in all areas of the study compared with the control of both Salix species (Table 6, Fig. 8).

Table 6

VIABILITY OF PLANTS OF PLANTS (%) IN RESEARCH AREAS

Study area	Plant type	
	Salix fragilis	*Salix dasyclados*
1. Grove oz. Nuksenskoe (control)	62,2 ± 0,5	65,7 ± 0,5
2. The former Kirillov dump	37,8 ± 0,6***	38,7 ± 0,6***
3. Trinity cemetery	49,7 ± 0,6***	47,1 ± 0,6***
4. Ramsay pond shore	37,9 ± 0,8***	40,6 ± 0,7***
5. Maryevsky spring	59,5 ± 0,9*	61,5 ± 0,8*
The average value of the studied areas	49,4	50,7

*P ≤ 0,05; ** P ≤0,01; *** P ≤0,001

Pollen viability indicators in the control region in S. fragilis — 62.2% and in S. dasyclados — 65.6%.

Values of pollen viability at station No. 5 (Maryevsky Spring) are observed close to the control: for S. fragilis here is 59.3%, and for S. dasyclados - 61.5%. These figures differ from the control in just 2.7% and 4.2%, but statistically significant. This makes it possible to assume that the growing conditions here are most close to favorable, and the anthropogenic load is insignificant.

In section 3 (grove near the Trinity cemetery), the pollen viability index for S. fragilis is 49.7%, the difference from control is 12.5%; for S. dasyclados - 47.1%, the difference with the control - 18.6%.

The lowest viability of pollen was noted at sites No. 2 and No. 4. Here, the values differ from the control in S. fragilis by 24.4% - 24.8%, the percentage of viable pollen grains in this species in the former landfill is 37.8%, and in the coastal area of the Ramzai pond - 37.9%. In S. dasyclados in section 2, viability was 38.7%, in section 4, 40.6%, the difference from control was 26.9% and 25.1%, respectively. These areas are subject to the greatest anthropogenic load among the studied.

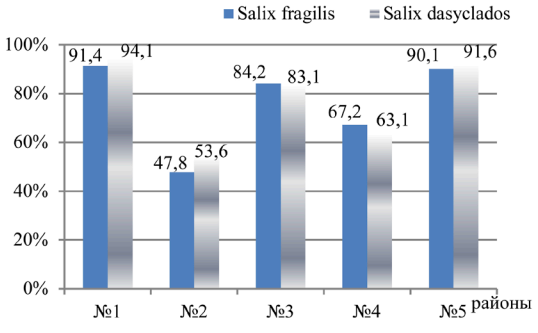

Fig. 7. Pollen fertility dependence,% of the study area

The average viability of pollen in all sites in S. fragilis is 49.4% and in S. dasyclados - 50.7%, that is, it does not differ significantly. The average fertilizing ability of pollen grains in the studied Salix species is also not significantly different in all areas: in S. fragilis - 76.4% and in S. dasyclados - 77.1%.

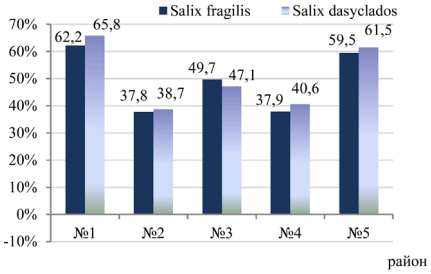

Fig. 8. The dependence of the viability of pollen,% of the study area

Therefore, S. fragilis and S. dasyclados are equally influenced by anthropogenic factors on the process of microsporogenesis.

IV. Conclusion

The study revealed that intense anthropogenic stress has a feminizing effect on the sexual structure of populations of 2 species of the genus Salix.

No peculiarities of changes in sexualization in the Salix populations depending on the species were found.

It was shown that with increasing stress conditions, the level of viability and fertilizing ability of pollen grains decreases. This can be viewed as a manifestation of the functional displacement of the sex ratio towards the female sphere.

Specific features of changes in the quality of pollen grains among the studied species of the genus Salix were not identified.

It has been established that changes occurring in the reproductive sphere of S. fragilis and S. dasyclados under the influence of anthropogenic influence can be used in the bioindication of the state of the environment.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 110-113

Economic Valuation of Ecosystem Services: a Case Study for Sustainable Management of Degraded Peatlands in Latvia

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***Abstract*—Ecosystem services (ES) are the benefits that people obtain from using ecosystems and can be divided into the following three categories: provisioning, regulating and supporting and cultural services. The strategical importance of ecosystem services is set by the EU Biodiversity Strategy, which put ecosystem services firmly on the EU policy agenda. The aim of the paper is to present and discuss the model for economic (monetary) valuation of ecosystem services for sustainable management of degraded peatlands in Latvia.**

Based on an economic valuation of ecosystem services (ES), it is possible to compare different territories and different management scenarios. Peatland ecosystems globally represent a major store of soil carbon, a sink for carbon dioxide and a source of atmospheric methane. Climate change may threaten these stocks due to the peat oxidation caused by the draught in areas where the peat extraction has been carried out, as well as the increased risk of forest fires. In Latvia, currently there have not been developed a strategy for the implementation of standard approaches and basic principles for the management of degraded peatlands. There are several options for re-cultivation of degraded peatlands, but for sustainable land use, it is very important to choose the most optimal option from the economic, ecological and society perspective.

The research was based on data obtained from a biophysical ES assessment for 28 indicators for 3 scenarios from a 5, 25 and 50-year perspective. The collection of primary data, as well as an aggregation and comparative assessment of secondary data have been carried out by using approbated scientific research methods and ES assessment indicators. The obtained data were adapted to the Latvian socio-economic situation by using correction factors. Depending on ES category, the following assessment methods were used: the market pricing method; the benefit transfer method and the direct market pricing method; the avoided costs method.

Economic valuation of peatland re-cultivation scenarios assists land-use planners and policymakers in making ecologically, economically and socio-culturally sustainable land-use decisions, where ecological and economic data are used for a calculated assessment of the land-use options.

Keywords – Ecosystem services, Economic valuation, degraded peatlands, Land use planning, Sustainable management

I. Introduction

The United Nations Initiative Millennium Ecosystem Assessment, which was started in the year 2000, defines ecosystem services as "the benefits people obtain from ecosystems" [1].

The assessment of ecosystem services has a significant role in the member States of the European Union (EU), reflected in the EU Biodiversity Strategy until 2020, which requires the Member States to map and assess the condition of the ecosystems and their services, as well as to assess the economic value of these services until 2020 and to promote the inclusion of economic values into the systems of reporting and accounting [2].

Ecosystem services (ES), in general, are divided into three major categories:

- Provisioning services – direct gains of materials and resources, which people obtain from ecosystems (food, drinking water etc.);
- Regulating services – the services that ecosystems provide by acting as regulators e.g. regulating the quality of air and soil or by providing flood and disease control;
- Cultural services – non-material benefits from ecosystem services, which influence the psychological and mental state of persons (active/passive recreation, environmental education etc. [3].

Economic valuation of ecosystems and their services is necessary in order to assess the anthropogenic impact on the ecosystems; by using the values, ecosystems and their services provide:

- Economic valuation methods of ES allow demonstrating the indirect values of the ecosystem

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4109

services, which are difficult to assess for society, but in the monetary form the values are demonstrated;

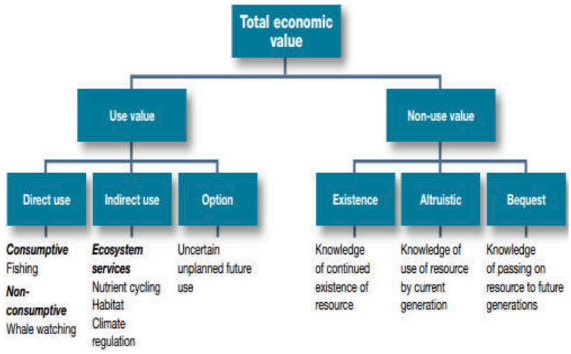
- ES economic valuation helps with the decision-making when two or more development scenarios have to be compared. When expressing the values in uniform monetary units, the scenarios can be compared.

Peatlands belong to most threatened nature types in Europe. The global importance of peatlands for carbon storage and climate change mitigation has only recently been recognised in international policy - only since 2008 organic soils have been a subject of discussion. While peatlands represent only 2% of cultivated land in the EU, they are responsible for more than 50% of the CO2 emissions of this sector [4].

Moreover, peatland ecosystems are globally valuable in terms of biodiversity, as well as economic importance of the areas varies with respect to the potential options of economic activities to be carried out within. The sustainable management of degraded peatlands has a particular potential to make an important contribution to climate change mitigation and both economic and environmental benefits to society.

II MATERIALS AND METHODS

When assessing the ecosystem services, a concept of economic values has to be taken into account, which involves Total Economic Value (TEV). TEV consists of direct and indirect values, and the non-use values, see Fig. 1.



Source: authors' study

Fig. 1 Total Economic Value for ES economic assessment.

An economic valuation was performed for five demo sites (degraded peatlands and their adjacent territories in Latvia) in the current situation and for three development (management) scenarios (for 5-, 25- and 50- year periods). The demo sites and scenarios are:

1) Kaigu mire → Blueberry plantations;
2) Kaigu mire → Energy wood plantations;
3) Lielais Ķemeru Tīrelis mire → Sphagnum (peat moss) plantations
4) Kaudzīšu mire → Cranberry plantations
5) Laugas mire → Re-naturalisation of the territory.

To assess the monetary value of ES, different methods are used: the direct pricing/market price method; the production function method; the avoided cost method, the replacement cost method; the contingent valuation method; the travel cost method; the hedonic pricing method; the benefit transfer method; other methods or their combination [5]. The authors performed an economic valuation by secondary data collection and comparative assessments, using the methods described in scientific research, and the indicators already prepared by ecosystem service experts prior to the economic evaluation. When assessing economic values of ES, the monetary value of the ecosystem service in a given territory (area) is expressed in comparative units (money units/ha/year, or EUR/ha/year).

Depending on the category (group) of ecosystem services, the following methods were used:

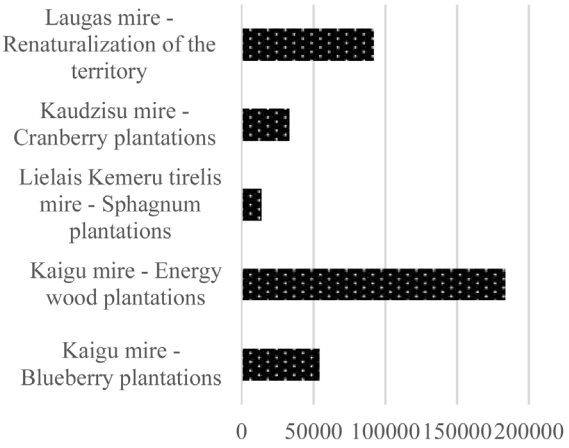
- Provisioning services – the *market price method and the production function method*;
- Regulating services – the *avoided cost method, the benefit transfer and cost replacement method*;
- Cultural services – the *market price method; the benefit transfer method; the contingent valuation method and the travel cost method* [6].

The results of the economic assessment of ES of the Project demo sites were adjusted to the Latvian socio-economic situation.

III RESULTS AND DISCUSSION

Monetary values and findings for the current situation

The authors have calculated the Total Economic Value (TEV) for each of the demo sites in the current situation. When summarising the findings of the monetary valuation, the highest economic value (EUR/ha/year) was found for the Kaigu mire demo site (where energy wood plantation is planned), followed by the Laugas mire and Kaigu mire blueberry plantation demo sites (Fig. 2).



	Kaigu mire - Blueberry plantations	Kaigu mire - Energy wood plantations	Lielais Kemeru tirelis mire - Sphagnum plantations	Kaudzisu mire - Cranberry plantations	Laugas mire - Renaturalization of the territory
TEV	54167.35	183431.77	13998.23	33269.27	91969.59

Source: authors' study

Fig. 2 Total economic value for the demo sites, EUR/ha/year.

When analysing by ES group, each of the demo sites demonstrates its own specifics. For example, it can be dominated by provisioning services (Kaigu mire energy wood plantation demo site – 95%) or regulating (as the Lielais Ķemeru Tīrelis mire Sphagnum plantation demo site - 99%). In the Kaigu mire energy wood plantation demo site, for example, a large proportion of provisioning services relates to peat production in the area of 250 ha, while in the other demo sites the peat production areas are smaller (e.g. Laugas mire, 132.75 ha) or there is no peat production at all (Kaigu mire blueberry plantation demo site, Lielais Ķemeru Tīrelis mire Sphagnum plantation site and the Kaudzīšu mire cranberry plantation demo site).

In all the demo sites, cultural services have the lowest value, proportionally being close to zero value.

Monetary values and findings for development scenarios

Economic values for the development scenarios were simulated for the following perspectives:

- Laugas mire – the re-naturalisation area scenario, for 25 and 50 years (providing that the situation will not change after 5 years);
- Kaigu mire blueberry, energy wood, Lielais Ķemeru Tīrelis mire Sphagnum plantations and Kaudzīšu mire cranberry plantation for 5-, 25- and 50-year periods.

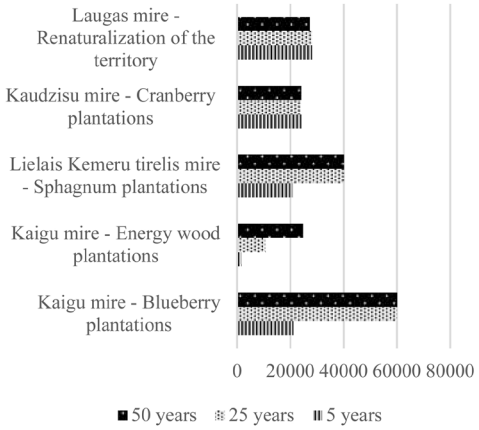
The methodology was the same as that used for assessment of the current situation.

Monetary values were changed in accordance with the changes in the indicators of biophysical evaluation of ES.

Fig. 3 shows the economic values for provisioning ES for the development scenarios in all the demo sites. The values of provisioning ES services for a 5- year period are similar for all the demo sites. The lowest value for a 5-year period is for the Kaigu mire energy wood plantation scenario, which can be explained by the fact that wood is not harvested in a so short time period.

The highest provisioning ES value for a 25- and 50-year period is for the Kaigu mire blueberry plantation scenario due to the highest productivity in every 25 years. Provisioning services for the Kaudzīšu mire cranberry plantation scenario remain the same for a 5-, 25- and 50-year period. It relates to the need to restore the cranberry plantations after a certain period of time.

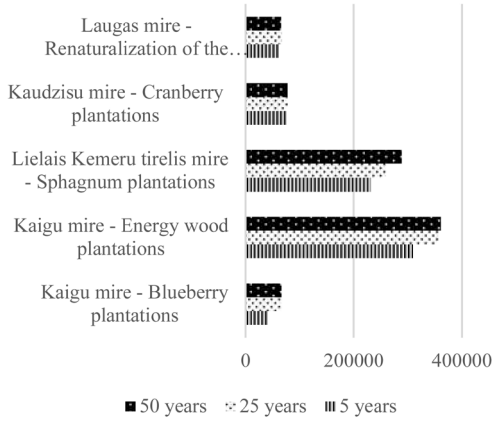
A comparatively high value of provision services is also for Laugas mire re-naturalised territory, mainly due to harvesting potential of wild berries and remedial herbs and Sphagnum donor material.



Source: authors' study

Fig.3 Economic values of **provisioning ES** for the development scenarios for all the demo sites, EUR/ha

By evaluating the demo sites and development scenarios regarding their ability to provide ecosystem regulating services, it can be concluded that there are very minimal changes in a 5-, 25- and 50-year period (Fig. 4).



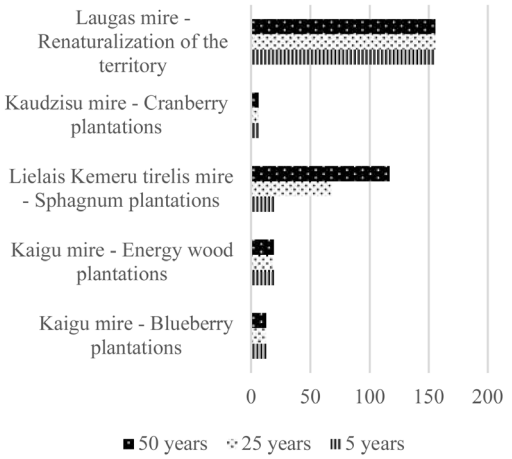
Source: authors' study

Fig.4 Economic values of **Regulating ES** for development scenarios for all demo sites EUR/ha

The highest regulating ES value is for the Kaigu mire energy wood plantation scenario, which mainly relates to the potential of reduction of adverse effects of climate change and micro climate regulation. A relatively high value of provisioning services is also for the Lielais Ķemeru Tīrelis mire Sphagnum (peat moss) plantation scenario. It relates to the fact that natural mire territory has high potential for filtration, sequestration, storage and accumulation of soil and water and wide biodiversity.

The lowest economic value of regulating services is for the Kaigu mire blueberry plantation demo site, especially for a 5-year period. It relates, firstly, to the fact that blueberry plants are too small to provide regulation services and, second, to the fact that blueberry cultivation should use a wide spectrum of fertilisers that decreases the value of the regulating services.

The values of cultural services in the demo sites are significantly lower than the economic values of the other ecosystem services groups (Fig. 5).



Source: authors' study

Fig.5 Economic values of **cultural ES** for the development scenarios for all the demo sites, EUR/ha

In addition, the economic values of cultural services are almost identical for all the development scenarios (for 5-, 25- and 50-year periods) for all the demo sites. An exception is the Lielais Ķemeru Tīrelis mire Sphagnum plantation demo site, where the value of cultural services significantly increases in a 25- and 50-year period. This can be explained by the fact that natural mire territory provides more possibilities for active and passive (recreation) and environmental education than degraded peatlands.

In general, the highest economic value of cultural services is for the Laugas mire re-naturalised demo site, because this territory can provide high potential of cultural services such as bird watching, active and passive recreation and environmental education.

IV CONCLUSIONS

Analysing the current situation within the demo sites in respect to their ability to provide ES, it can be concluded that existing peat extraction fields provide high economic values of provision services; on the other hand, they provide very low values for regulation and cultural services. The natural mire territories provide high values of regulation services and comparatively higher values of cultural services. The ES economic values of degraded peatlands are low in all the ES groups. This conclusion shows necessity for sustainable management measures for increasing the provision of ES from degraded peatlands.

Analysing the development or management scenarios for degraded peatlands, it can be concluded that a common feature is that the Sphagnum (peat moss) plantations in 5-, 25- and 50-year periods provide the highest economic values of ES. From the economic activity perspective, the highest economic value is for blueberry plantations and energy wood plantations. From the cultural services perspective, the highest economic value is for re-naturalised territory.

The economic assessment of ES allows comparing different land use management scenarios from different perspectives – their ability to provide supply of products and materials, ability to regulate viability of the ecosystem and climate and ability to provide cultural services.

Economic assessment of ES is an important support tool for decision-making on different land use scenarios, but at the same it is important also to assess the financial return from each of the scenarios.

ACKNOWLEDGEMENTS

The research underlying this manuscript has been conducted within the "LIFE REstore - Sustainable and responsible management and re-use of degraded peatlands in Latvia" (LIFE14 CCM/LV/001103) project, co-financed by the European Union.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 114-117

Sustainable Management of Peat Extraction Fields

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***Abstract*—Peatland self-recovery after peat extraction is restricted and without any purposeful actions, recovery of the territories is disproportionately long. The abandoned peat fields are not only worthless from the point of view of biodiversity but are also large SEG issuers.**

By developing an inventory of extracted peat fields, it has been concluded that there are about 18,000 ha that are not re-cultivated and for now have lost their natural functions. The peat formation in these areas and ecosystems functions are disturbed or destroyed.

There are a number of potential ways of re-cultivation of degraded peatlands that can provide different types of benefits – either to carry out economic activities or to re-naturalise territories. Each of the potential types of re-cultivation is able to deliver different types of benefits. Landowners should select the most appropriate and acceptable option for re-cultivation based on socio-economic, environmental and climate change mitigation criteria.

Based on the research and the results obtained, a model for the sustainable use of peat extraction fields has been developed, that provides support for the planning of further use of degraded peatlands. The developed model provides information about financial, economic and environmental benefits of implementing a particular form of re-cultivation. Developed model ensures the optimal information balance between GHG emission reductions, ecosystem service assessments and socio-economic aspects of land use.

Based on the findings and using the developed model, it is possible to implement deliberative management decisions regarding degraded peatlands, evaluate potential re-cultivation costs, plan the expected financial return, assess the benefits of climate mitigation and take into account natural values.

***Keywords*— Sustainable management, recultivation, abandoned peat fields.**

I. Introduction

Peatlands provide a wide range of ecosystem services. Most important role of peatlands is to ensure climate regulation and water circulation functions [1]. At the same time peatland ecosystems are globally valuable in terms of biodiversity, as well as economic importance of the areas varies with respect to the potential options of economic activities to be carried out within [2], [3].

In Latvia peat has been extracted since the end of the 17th century [4]. In 2015, 1.3 million tons of peat were extracted, 95% of which was exported to West Europe to ensure the supply for the needs of gardeners [5]. Peat is one of the major Latvian export products [6]. In 2016, peat exports accounted for 1.4% of Latvia's total exports. Based on information of Latvian Peat Association, the amount of peat extraction in Latvia accounts for almost one third of the amount of peat used in professional gardening in the European Union countries. Peat substrate produced in Latvia has been exported to more than 100 countries, including China, Japan and Australia [5].

On the one hand, peat resources obtained from mires, provide significant economic benefits [7], but at the same time, by changing the hydrological regime and removing natural vegetation during peat extraction, the area is no longer able to deliver the ecosystem services provided by natural bog areas [8].

In Latvia, the Regulations No 570 of the Cabinet of Ministers on the procedures of mineral resources obtainment determine the procedures for the extraction of the peat resources, as well as the procedures for re-cultivation of the territory after the extraction of peat [9].

As the degraded peatlands can be source of GHG emissions, as well as the CO2 sequestration function is limited, the management of these areas is essential for reduction of GHG emissions in long term [10].

Sustainable management of extracted peatlands has to focus on synergies between environmental and climate actions, by integrating the climate, environmental and biodiversity objectives into the responsible and sustainable management and re-use of degraded peatlands [11].

Sustainable land use management should contribute to the transition towards a low emission and climate-resilient economy, society and integration of climate objectives into the public and private sector. The multiple risks posed by climate change, according to the GEO 2012 and IPCC (2013) [12] include the conclusion that wetlands and peatlands are seriously disrupted ecosystems causing significant GHG emissions in most major drainage basins. Moreover, forests – a major carbon storage system, are being over-harvested, threatening both the global climate and local well-being and leading to loss of biodiversity [13]. Testing and implementing of innovative approaches to climate change mitigation will be one essential aspect for making the shift towards sustainable land use management.

II. Methods

Sustainable management of degraded peatlands has to be based on thoughtful use of territories and long-term decisions. Activities related to the land-use management can be divided into two categories: (1) to gain economic benefit and (2) to restore natural functions of mires or to transform territories into other natural areas.

The first group includes such re-cultivation actions

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4116

as (1) berry cultivation, (2) tree planting with the aim to get wood for energy purposes, (3) agriculture and (4) grassland cultivation.

The second group includes the creation of natural areas – (1) bog re-naturalisation, (2) afforestation (3) creation of water bodies.

Each of the above-mentioned peatland re-cultivation scenarios provide different types of benefits – financial profit from economic activity, diversified ecosystem services, GHG emission reduction.

By comparing and evaluating the re-cultivation options, it is possible to make sustainable and well-considered decisions from the above-mentioned perspectives and to support the process of planning for the further use of degraded peatlands.

The information gathered within the framework of LIFE programme project "LIFE REstore – Sustainable and responsible management and re-use of degraded peatlands in Latvia" (hereinafter referred to as LIFE REstore), has been summarised in one single model that reflects the financial, economic and environmental benefits of implementation of a particular re-cultivation scenario.

The model calculation algorithm ensures a linear correlation between the size of the areas to be re-cultivated and the financial and economic indicators of the re-cultivation of these areas.

The precision of model output data is determined by the correctness of the assumptions made by the model user and the data entered, such as the field geological exploration, costs of re-cultivation, planned yield, etc. used in the calculations. The economic values of ecosystem services and data of carbon dioxide reduction of re-cultivation scenarios that has been included in model has been based on research data obtained within the LIFE REstore project. Data reflecting the required investments and potential revenues are based on information of the Latvian Rural Advisory and Training Centre.

Inventory of the area affected by peat extraction that has been carried out within the LIFE REstore project shows that there are about 18,000 ha of degraded peatlands in the territory of Latvia that has to be re-cultivated [14].

However, the preconditions for implementing each type of re-cultivation are different. By implementing one of the territory management plans, it is necessary to evaluate the criteria characterising the territory. These criteria determine both which one of the re-cultivating scenarios can be implemented and what amount of investment is necessary to implement the particular re-cultivation scenario.

By using inventory data collected within the LIFE REstore project and the developed optimisation model, the possible re-cultivation scenarios for the degraded territories were modelled and evaluated based on the potential of the environment, climate mitigation and socio-economic benefits.

The most important methodological limitation is related with the precision of geological and necessary investment data. When analysing and reviewing the summarised information described below, it is important to take into account that the data reflects general information and serves only as a tangible comparison of the scenarios.

III. Results and discussion

By using the developed model and by modelling possible re-cultivation scenarios for the degraded peatlands in Latvia, it has been concluded that in most cases it is possible to re-naturalise the territories (Figure 1). It can be explained by the fact that this type of re-cultivation has the least restrictive criterion. This re-cultivation scenario has only two limiting criteria – the remaining peat layer must be at least 0.3 meters of thickness and the area cannot be flooded for more than 90 days a year. As a result, re-naturalisation could be implemented in approximately 96% of 18 000 ha of the degraded peatlands.

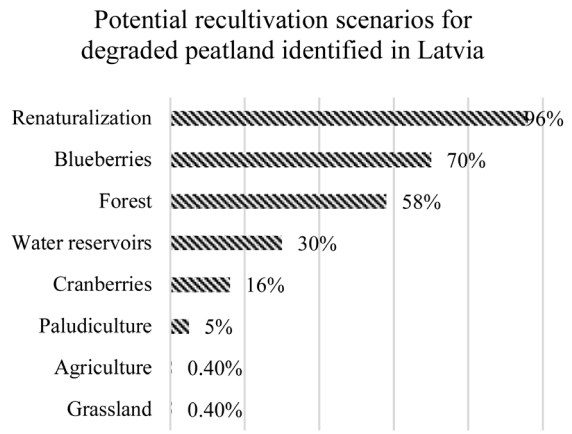

Fig.1. Potential re-cultivation scenarios for degraded peatland identified in Latvia

At the same time, model data confirm the assumption that peat extraction sites are less suitable for agricultural activities and for the cultivation of permanent grasslands. The abovementioned re-cultivation scenarios are possible only at 0.4% (each of the types of re-cultivation) of all degraded peatland territories.

It is interesting to note that although the cultivation of blueberries and cranberries can be classified as one type of re-cultivation – berry growing, the implementation possibilities for these berries in peatlands are very different. As can be seen in Fig.1, blueberry cultivation is possible in 70% of degraded peatlands, while cranberry cultivation is an option only available in 17% of degraded peatland areas. Also, more than half of the degraded peatlands can be afforested.

Socio-economic benefits

Investments are needed for the site re-cultivation and for each scenario the amount of investment is different. The average investment required to implement the particular re-cultivation scenarios is visualised at Fig. 2. In the calculation, it is assumed that the area to be re-cultivated is 10 ha and that all the preparation activities of the area mentioned in the model (such as the construction of the drainage system, removal of vegetation, etc.) are necessary.

As can be seen in Fig. 2, blueberry and cranberry

cultivation require significantly higher investments than other scenarios. Mostly this is due to the purchase of planting material, planting and installation of the irrigation system.

For such re-cultivation scenarios as arable land development, paludiculture cultivation, re-naturalisation, permanent grassland creation and establishment of water reservoirs, investment costs are significantly lower than for berry plantations.

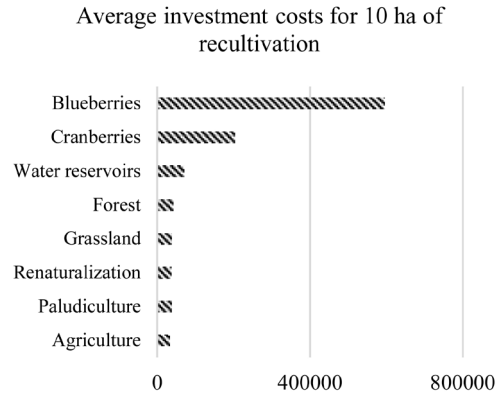

Fig.2. Average investment costs for 10 ha of re-cultivation

Fig. 3 shows the potential production revenue modelled on a 10-ha area over a 10-year period. As can be seen from the Fig. 3, the highest potential revenue is expected from blueberry cultivation and cranberry cultivation. It is natural that revenues are not expected from the establishment of water reservoirs and re-naturalisation, as these re-cultivation scenarios do not profit in the nearest 10 neither 50 years. In the long term, as a result of re-naturalisation, it can be expected that formation of peat will be started in the re-naturalised mire, but calculation of such revenue is not foreseen within the developed model.

Afforestation of degraded peatland is not profitable in the nearest 10 years. This can be explained by the fact that for the calculation of afforestation scenarios the birch was chosen, which in 10-year period does not provide the necessary amount of wood.

By comparing potential production revenue and investment in re-cultivation, it can be concluded that blueberry cultivation is the only form of re-cultivation that pays off over a 10-year period.

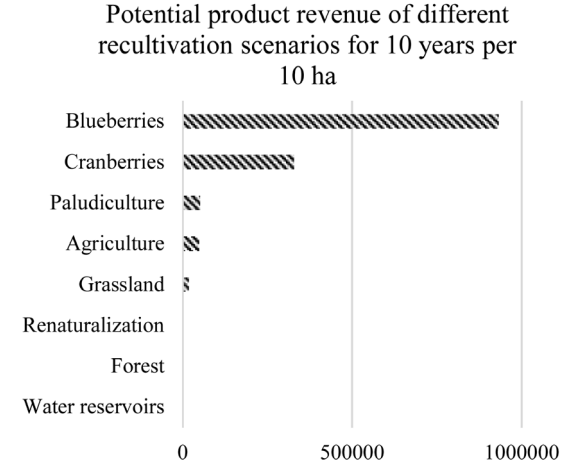

Fig. 3. Potential product revenue of different re-cultivation scenarios for 10 years per 10 ha

However, it has to be taken into account that the re-cultivation of degraded peatlands is necessary not only to bring economic benefits but also to benefit the whole society.

Climate mitigation benefits

Benefits for society through degraded peatland re-cultivation by landowners are the reduction of carbon and the conservation/restoration of biological values, which are modelled from the point of view of ecosystem services provided.

Fig. 4 illustrates the reduction of CO_2 emissions from different re-cultivation scenarios. As shown in Fig. 4, the most valuable form of re-cultivation providing the greatest public benefit in terms of CO_2 reduction, is afforestation. At the same time, two less efficient options for degraded peat re-cultivation are the establishment of permanent grasslands and the creation of arable land that does not provide reduction of CO_2 emissions. Other re-cultivation scenarios provide very similar effects of CO_2 reduction.

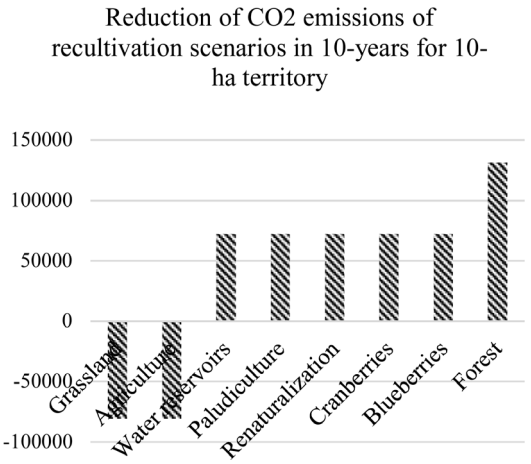

Fig.4. Reduction of CO_2 emissions of re-cultivation scenarios in 10-years for 10-ha territory

Environmental benefits

Fig. 4 shows the monetary values of ecosystem services for degraded peatland re-cultivation scenarios for 10-year period and for 10 ha area.

It can be concluded that natural areas are able to provide significantly higher ecosystem services, while agricultural areas provide ecosystem services at significantly lower volumes.

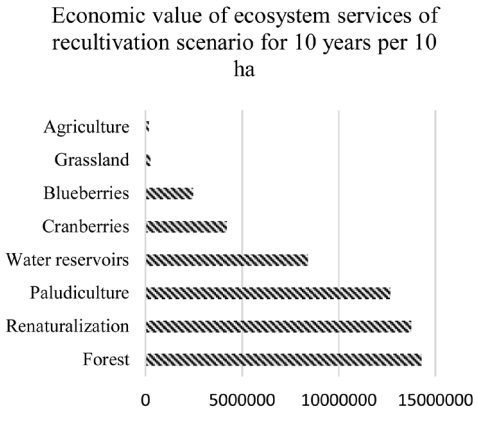

Fig.5. Economic value of ecosystem services of re-cultivation scenario for 10 years per 10 ha

Afforestation, re-naturalisation and paludiculture cultivation provide significantly higher value of ecosystem services than other scenarios. Analysing re-cultivation scenarios that are related with economic activity, it can be seen that cranberry cultivation provides higher ecosystem services than other scenarios.

IV. Conclusions

Evaluating re-cultivation scenarios from all three aspects - environmental, climate and socio-economic benefits, it can be concluded that although blueberry cultivation requires the highest financial investment at the beginning of economic activity, the financial return from this type of re-cultivation is the highest in 10-year period.

Assessing the re-cultivation scenarios from the climate change mitigation perspective, it can be concluded that in the 10-year period, the highest benefit is from forest areas (regardless of whether trees are planted for the purpose of creation of natural area or for the purpose to grow trees for energy use).

Assessing potential re-cultivation scenarios from an ecosystem service point of view, it has been concluded that natural areas have the greatest value. The greatest economic value of ecosystem services is gained from forest areas.

By evaluating the results described above, it can be concluded that the decisions of the re-cultivation of degraded peatlands should be thoughtful, sustainable and based on the common development of Latvia.

It is important to take into account that after peat extraction and land use transformation within the area, it is excluded that peat resources will recover and the statement that peat is a renewable resource is only true when the area is restored to a natural bog.

Acknowledgments

The research underlying this manuscript has been conducted within the project "Sustainable and responsible management and re-use of degraded peatlands in Latvia" (LIFE REstore, LIFE14 CCM/LV/001103), co-financed by the European Union.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 118-122

Local Food Procurement Tendencies in Latvia

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***Abstract*— The OECD has emphasized that regions need to boost their growth by placing local resources and means in circulation in order to benefit from their competitive advantages. It encourages the search and analysis of those regional key factors that are driving development in the regions. Local authorities can boost their region with the use of territorial capital and the promotion of entrepreneurship. One of the ways how to do this is to buy food from local producers. Giving preference to local suppliers, even if it means spending a little more, can actually benefit a region's finances. When local governments spend their money on locally owned firms, those firms in turn rely on and generate local supply chains, creating an "economic multiplier" effect. Each additional dollar that circulates locally boosts local economic activity, employment and, ultimately, tax revenue. In Latvia, since 2014, attention has been focused on increasing the consumption of local food. Improvements in regulatory enactments have been made, which stipulate that green public procurement criteria should be used in food procurement, where one of the criteria, the supply distance, directly contributes to this aim by giving preference to the local producers. The research aim is to analyze the data of local government food procurements carried out in Latvia from 2010 to 2018 and to evaluate the share of local suppliers in these procurements. The food procurement winners were divided into four groups: agricultural producers, food processing companies, wholesale companies and retail companies. The study evaluates how each group's share in total food purchases varies over the years, and how procurement volumes vary depending on the winner's belonging to the one of the groups previously defined. Such an analysis shows the proportion of local producers in procurement, but does not fully reflect on the volume of local production, as it is not possible to obtain data on the share of production which producer purchased from others to provide the necessary volumes of food, and there is no data on the origin of products supplied by wholesalers. The following research methods were employed to carry out the present research: analysis and synthesis, induction and deduction, the monographic method, statistical analysis and the graphic method.**

***Keywords*— Local food, public procurement, regional development.**

I. Introduction

Territorial and economic sustainability of the economic complex of the region is determined by its ability to maintain a continuous expanded reproduction, which is ensuring the stabile increase of a given level of output production and economic indicators. It means that the economic sustainability of the economic system of the region is the basis for sustainable development of the regional economy [1].

The OECD has emphasized that regions need to boost their growth by placing local resources and means in circulation in order to benefit from their competitive advantages [2]. It encourages the search and analysis of those regional key factors that are driving development in the regions. Local authorities can boost their region with the use of territorial capital and the promotion of entrepreneurship [3]. One of the ways how to do this is to buy food from local producers.

As McCrudden [4] admits, the spatial patterns of public expenditure and government procurement have a significant impact on contemporary economic and social development in localities and regions. Consequently, wider socio-economic benefits for communities and regions can be achieved through contracts concluded by municipalities.

Efficient public procurement is crucial for solving many key policy challenges that the EU is currently facing. This includes growth and jobs, fiscal discipline, modernising public administration, the fight against corruption and collusion, market access for SMEs, citizens' trust in public authorities and democracy[5]. The latest update to the EU public procurement rules resulted in renewed interest in using this instrument not only to achieve efficiency, but also to more actively support local growth and employment by linking procurement to broader policy objectives like sustainability, social inclusion and innovation [6] - [8].

But here the researchers [9] observe that transition to more sustainable procurement is very dependent on political will and leadership and an infrastructure that is able to balance the complexity of the inter-relationships between economic, environmental and social drivers to effect change. And that's one of the reasons why European public sector food procurement contracts tend to be awarded on the basis of 'best value' and 'the economically most advantageous tender' (i.e. low cost), with little or no consideration for the effects on human health and the environment of the entire agrifood cycle [10].

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4175

Some studies on small businesses (SMEs) [11] show that their role as suppliers to public authorities has not only environmental benefits through provision of green products or technology, in particular for the procurement of organic food, but also contributes to local economic development, especially in low-income areas.

SMEs have difficulties in getting their products to the market. Their competitive position is, therefore, weak and the economic situation of the small producers is often insecure. Contracts with institutional customers are potentially important. They provide secure income, and the entrepreneurs can shift the focus from marketing to developing their core activities [12], which also directly contributes to the economic development of the region. Studies [13],[14] find that local businesses recirculate a greater share of every dollar in the local economy, as they create locally owned supply chains and invest in their employees.

The researchers [10] suggested that the EU reforms could improve access to markets for small food producers and SMEs through more opportunities for public sector food procurement contracts. Firstly, simplified rules and procedures should enable public authorities to use more contract 'lotting' where large contracts for food commodities are divided into more manageable lots that make tendering a possibility for SMEs. Secondly, by widening the range of criteria (including environmental, social and labor requirements) through life cycle costing that defines the object of procurement, the reforms could expand how public authorities make decisions for awarding contracts when assessing which tender is the most 'economically advantageous'.

These criteria may deal with overall impacts on regional economy, employment and entrepreneurial activity and on environment as well as various specific quality attributes such as nutritional requirements, packaging size and their recyclability, delivery times and frequency, freshness and eventually organic production thus balancing economic, social and environmental aspects of sustainable development [15],[16].

In the study, the author concludes that the most economically advantageous criterion in Latvia as a mandatory procurement condition was introduced only in 2017, so the impact of these legislative changes on public food procurement will be visible only after several years. Many municipalities in Latvia still believe they are most aware of their needs, so each municipality organizes the same purchases separately and maintains the necessary administrative equipment. Local municipalities who organize small, simpler procurements usually have relatively limited resources to carry out market feasibility studies, develop sophisticated technical specifications, and define and describe the criteria to be considered when assessing the most economically advantageous tender. Hence, it is hoped that the elimination of the lowest price could contribute to closer cooperation between procurers and centralization of procurement.

II. Materials and methods

The first stage of this study includes a review of articles and a research conducted in areas of the impact of public procurement on regional development, and also of importance of using local food in municipal authorities.

In the second stage of the research, data of food procurements made in Latvia from 2010 to 2018 were collected, and all procurement winners were divided into 4 large categories: agricultural producers, food processing companies, wholesale companies and retail companies. Data analysis was then carried out to evaluate how each group's share in total food purchases varies over the years, and how procurement volumes vary depending on the winner's belonging to the one of the groups previously defined. It was also analyzed whether the structure of procurement winners differs in different NUTS 3 regions of Latvia.

The following research methods were employed to carry out the present research: analysis and synthesis, induction and deduction, the monographic method, statistical analysis and the graphic method.

III. Results and discussion

A. The role of local food in regional development

Food policy is moving fast. Food industry is increasingly being understood as a sector with great potential for regional economic development, if only supply chains linking farmers with customers can include local processors and traders.

Food purchasing and catering services, including those in hospitals, care homes, schools, prisons and state companies etc., represent a significant part of public sector procurement budgets. The dominant economic paradigm has led to a growing focus on market-based green growth strategies to pursue sustainability goals and it is argued that an ecological shift is required in order to create further understanding of how human health is interwoven with the health of eco-systems, and to enable policymakers and practitioners to move towards creating more sustainable food systems and better public health nutrition [9].

Researchers [17] explain that "Local food" refers to genuinely short supply chains, i.e. production, processing and consumption that are geographically close to each other. In addition, the focus is on basic food items of local origin. Supplementing, Finnish Government [18] has defined that local food is locally-produced food that promotes the local economy, employment and food culture of the region concerned, it has been produced and processed from raw materials from that region and is marketed and consumed in that region.

Considering that Latvia is a small country, in this research there is defined that "local food" is food produced and processed in Latvia.

Local food and organic products are increasingly valued by consumers. People are becoming more and

more interested in the origin and production methods of the food they eat. Day-to-day choices are seen as a way to influence the state of the environment and the future of our planet.

The use of local food can be justified for a number of reasons. In addition to the fact that local ingredients can be delivered to kitchens fresher than food produced further away, the use of local food is supported by many ecological, economic and social factors. To increase the use of local food, quality criteria have been defined for different product groups taking into account the principles of sustainable development. The themes can also function as a source of new criteria for the procurement of local food.

Preferences of local food [18]:

- Enhances well-being and the local economy in local municipality
  - generates tax revenues for the region
  - local procurements create jobs and promote entrepreneurship in rural areas
  - food production in the municipality is maintained, which improves the region's food self-sufficiency
- Is safe, clean and traceable
  - when food is bought nearby, you know what you are eating and where the food comes from
  - when transport distances are short, heavy use of additives is not necessary to ensure the storage life of food
- Is an environmentally responsible choice
  - environmentally responsible food includes plenty of locally produced seasonal vegetables, fish and berries etc.
- Promotes the local food culture
  - local flavours, ingredients and food traditions become familiar and are sustained when children learn where their food comes from and who makes it;
- Encourages the use of seasonal products
  - seasonal changes create variety in a diet
  - SMEs have better opportunities to offer their local products.

B. Local food procurement tendencies in Latvia

In Latvia, since 2014, attention has been focused on increasing the consumption of local food. Improvements in regulatory enactments have been made, which stipulate that green public procurement criteria should be used in food procurement, where one of the criteria, the supply distance, directly contributes to this aim by giving preference to local producers.

In Latvia, public procurement is regulated by the Public Procurement Law of 2017 [19]. On March 1, 2017, the new Public Procurement Law came into force, with significant improvements and amendments to include the requirements of Directives 2014/24 / EU and 2014/25 / EU.

The new Public Procurement Law defines the criterion of the most economically advantageous tender as the main criterion for evaluating bids. The contracting authority determines it, taking into account the cost or price, the cost and quality criteria, or the price only. The Public Procurement Law states that the contracting authority is still entitled to use the price only as a benchmark for the comparison and evaluation of offers, in cases where the technical specifications are detailed and other criteria are not relevant to the selection of the offer. This does not apply to "small procurements" where the estimated procurement contract price is Euro 10 000 - Euro 41 999.99. In these types of procurement the procurer is still eligible for the lowest price criterion, and this procurement category includes a large part of public procurement by public authorities, in particular where procurement is carried out in decentralized way [20].

It should be emphasized that according to the delegation stipulated by the Public Procurement Law, the contracting authority is entitled not to use the full procurement procedure for food supply contracts, if the estimated contract price of food products is up to 42 thousand euros, which means that not all such food purchases are officially compiled by the Procurement Monitoring Bureau.

On June, 2017, the Cabinet Regulation No. 353 "Requirements for Green Public Procurement and Procedures for their Application" [21] entered into force, which, among other things, requires that food supplies are made in an environmentally friendly way, - by limiting distances which helps to give preference to locally produced or Latvian food.

In order to evaluate the impact of changes in regulatory enactments on local food procurement, the author compiled and analyzed the data of the Procurement Monitoring Bureau on public food purchases made for 2010-2018 [22].

The food procurement winners were divided into four groups: agricultural producers, food processing companies, wholesale companies and retail companies. The study evaluates how each group's share in total food purchases varies over the years, and how procurement volumes vary depending on the winner's belonging to the one of the groups previously defined.

Such an analysis shows the proportion of local producers in procurement, but does not fully reflect on the volume of local production, as it is not possible to obtain data on the share of production which producer purchased from others to provide the necessary volumes of food, and there is no data on the origin of products supplied by wholesalers.

As it can be seen in Fig. 1, the largest number of suppliers remains the wholesale companies that win about 63% of all food procurements. Considering that in most purchases the winner is selected on the basis of the lowest price, the wholesale companies are thus more competitive than other operators. This can be explained by the availability of a highly developed logistics system as well as the availability of warehouses and the fact that a wholesale company can purchase the cheapest product available on the market as needed to ensure order fulfillment.

Interestingly enough, in 2018, despite the various changes in legislation that encourage local producers to engage in procurement, the share of winning wholesale companies is the largest of all years - 70.7%. It is therefore necessary to think about other measures that would stimulate the involvement of local food producers in the public procurement and enable their ability to win. Starting from 2011, when data comparison is possible, it can be observed that the proportion of the winning retail companies decreases every year (from 6.8% in 2010 to 1.1% in 2018). Despite the growing role of supermarkets and hypermarkets, small, traditional stores still hold their own position in the retail market. However, as they are predominantly owned by private entrepreneurs, small stores cannot compete with large retail chains and the number of such stores is decreasing every year. [23], which reduces the number of these companies in food procurements.

The positive trend also can be observed that the involvement of primary agricultural producers in purchases has slightly increased in recent years (from 3.8% in 2010 to 6.5% in 2018 or by 1.46 million euros). Although there is currently no study on what has contributed to this trend, the author assumes that it is related to educating the purchasers, as a result of which purchases were in most cases divided into lots, dividing the local vegetables and potatoes separately.

However, when analyzing whether there are differences in the structure of winners of public procurement in NUTS 3 regions (Fig. 2), one can conclude that the situation in Pieriga and Riga region is significantly different from other regions.

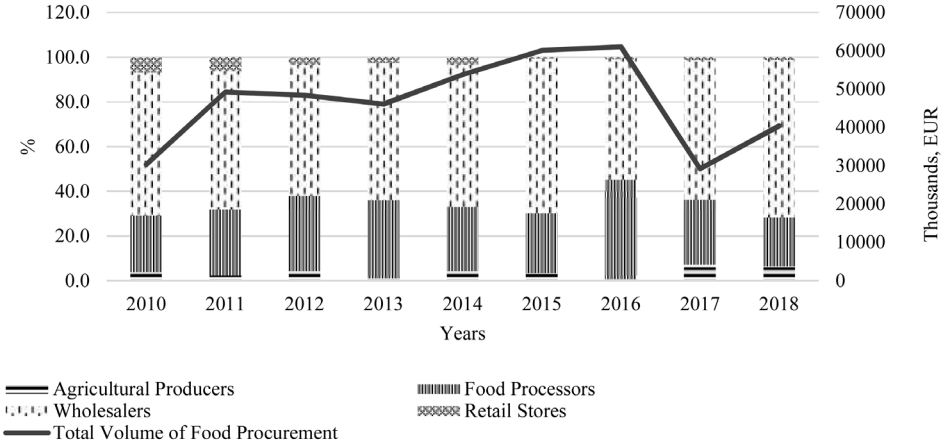

Fig. 1. Structure of local food procurement winners in Latvia in 2010-2018

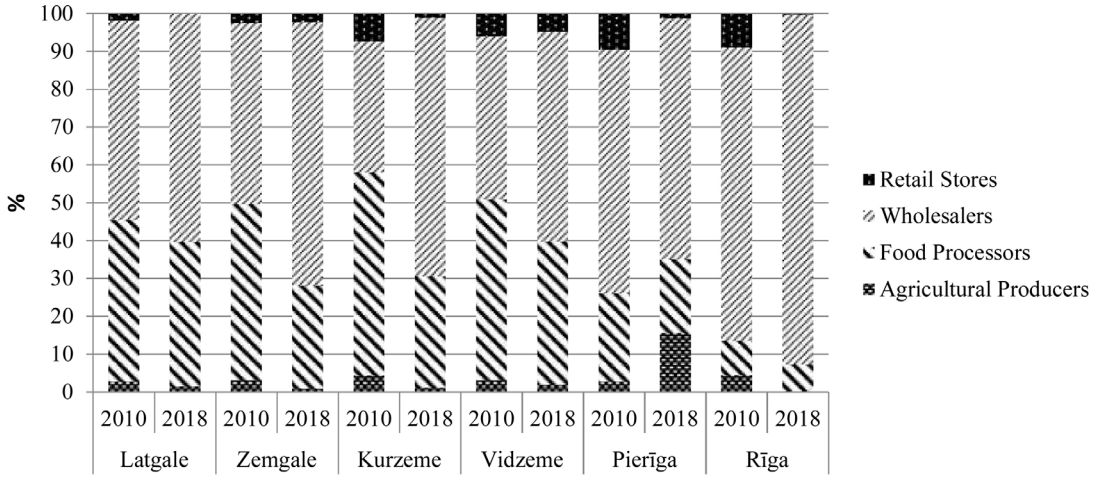

Fig. 2. Comparison of local food procurement winners' structure in Latvian regions in 2010 and 2018

Since Riga region only includes the capital of the country and the area around it - region of Pieriga, it is only natural that in these regions there is a significant dominance of wholesale companies comparing with other regions.

When assessing the differences between other regions, they are not overwhelming and can be explained by the concentration of food processing or food producing businesses in one region or another. Thus, there is an atypical situation in Pieriga region, where in 2018 the share of primary agricultural production is significantly higher (on average by 12% higher than in other regions). This is due to the fact that in this region is located the largest chicken meat and egg production company in the country.

In general, when evaluating the structure of the winners of food procurements in Latvia, it should be concluded that it reflects the tendency in the society - to buy food in supermarkets because of convenience and lower prices. Thus, SMEs which, according to the above-

mentioned studies, have a significant impact on regional growth, both through newly created jobs, tax increases and money circulation in the local economy, are also not preferred.

IV. Conclusions

Public expenditure and government procurement have a significant impact on contemporary economic and social development in localities and regions. Consequently, wider socio-economic benefits for communities and regions can be achieved through contracts concluded by municipalities. This includes growth and jobs, fiscal discipline, market access for SMEs and efficiency, also broader policy objectives like sustainability, social inclusion and innovation.

Local food is locally-produced food that promotes the local economy, employment and food culture of the region concerned. The use of local food is supported by many ecological, economic and social factors.

In Latvia, since 2014, attention has been focused on increasing the consumption of local food. Improvements in regulatory enactments have been made, which stipulate that green public procurement criteria should be used in food procurement, where one of the criteria, the supply distance, directly contributes to this aim by giving preference to local producers. Nevertheless the data analysis shows that in 2018, despite the various changes in legislation that encourage local producers to engage in procurement, the share of winning wholesale companies is still very big – 63-70.7%. It is therefore necessary to think about other measures that would stimulate the involvement of local food producers in the public procurement and enable their ability to win.

When analyzing differences in the structure of winners of public procurement in NUTS 3 regions, it can be concluded that the situation in Pieriga and Riga region is significantly different from other regions, but among another regions, there are no significant differences.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 123-126

The Evaluation of Stable Isotopic Ratios $\delta^{13}C$ and $\delta^{15}N$ in Humic Acids along a Fen Peat Profile

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***Abstract*—Mires are known as consistent environmental archives, but humic acids are the fraction of peat that is most recalcitrant and refractory to organic matter degradation, thus data on environmental changes during mire development can be recorded into them. This work was focused on the studies of stable isotopic ratios delta carbon-13 and delta nitrogen-15, and their distribution in humic acids within fen peat layers of different depths and peat composition. The variations in delta carbon-13 reflect isotopic variations in peat-forming plants over time and can be considered as a function of photosynthetic pathway that is being used to fix carbon dioxide. At the same time, variations in delta nitrogen-15 show nitrogen fixation in peat-forming plants and can be traced along with peat decomposition degree and depth. Properties of humic acids were studied in 2018 at 3 fens located in Latvia and Southern Finland, and comparatively they show properties. The method used for the determination of stable isotopes was the isotope-ratio mass spectrometry that was performed in the Faculty of Chemistry, University of Latvia. Results on delta carbon-13 indicate signal of C3 peat-forming plants, while signal of C4 peat-forming plants is not evident, which can be explained by non-efficient carbon dioxide fixation in fen vegetation. Results on delta nitrogen-15 show variations in nitrogen fixation in fen vegetation. Data show nitrogen fixation in terrestrial plants, however significant shifts in absolute isotope values indicate dependence on variations in peat decomposition degree and botanical composition. Data suggest that differences in peat botanical composition, decomposition degree and site dependent characteristics reflect in differences in delta carbon-13 and delta nitrogen-15 variations.**

***Keywords*— environmental changes, fen peat, humic acids, stable isotopes.**

Introduction

The formation of raised bogs is directly linked to the atmospheric conditions during peat accumulation, while the development of fens is also significantly affected by terrestrial conditions, notably - groundwater composition. Therefore, mires are known as consistent environmental archives and peat profiles can be used to reconstruct past environmental conditions in both minor and major scale [1].

Humic acids are the fraction of peat that is most recalcitrant and refractory to organic matter degradation over time, thus data on environmental changes during mire development can be obtained from their analysis [1]. Fen peat humic acids form due to microbial decomposition of peat-forming plants in fens and, alongside fulvic acids and humin, are the major part of peat organic material.

The vegetation of fen ecosystems has developed in nutrient-rich conditions and thus fen peat consists of disintegrated and decomposed remains of higher vegetation, containing both C_3 and C_4 plants [2]. The majority of plants in fen vegetation are C_3 plants (most grasses, reeds, sedges etc.) and have no special features to combat photorespiration that initially reduces the efficiency of photosynthesis. The photorespiration takes place during plant metabolism when the enzyme of ribulose-1,5-bisphosphate carboxylate or oxygenase oxygenates ribulose 1,5-bisphosphate and in the process reduces photosynthetic output up to 25 %. At the same time, the C_3 carbon fixation is the most common of metabolic pathways for carbon fixation in photosynthesis [3], [4]. The minority of plants are C_4 plants (several reed and sedge species) and they differentiate from C_3 plants with the ability to minimize the photorespiration by separating the initial CO_2 fixation and the Calvin cycle. In the C_4 plants CO_2 typically is drawn out of malate (salt of malic acid, which is produced by plants), but not directly from the air. The Calvin cycle is the set of light-independent chemical reactions that take place in plant chloroplasts during photosynthesis after the energy has been captured from sunlight [4].

Therefore, it can be concluded that fen peat-forming vegetation is an assemblage of C_3 and C_4 plant communities and their signal can be found in fen peat humic acids in the form of stable isotope signatures.

Stable isotope variations in humic acids depend on the isotopic compositions of reactants, the pathways and kinetic modes of reaction dynamics, and physicochemical conditions [1]. The isotopic signature is unique to the

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4127

origin and history of the substance and thus each organic material has its own specific signature. To establish an isotopic signature for fen peat humic acids, the ratios of stable isotopes ^{13}C and ^{12}C, and ^{15}N and ^{14}N can be measured. The isotopic abundances of carbon and nitrogen were fixed when the planet was formed and, on a global scale, has not change ever since [5]. At the same time, the variation of isotopic composition of fen peat humic acids was introduced during various biological, chemical and physical processes within mire ecosystem and thus allow to monitor changes in the environmental and ecological settings due to peat-forming plant production. These variations in the natural abundance of stable isotopes usually are expressed using delta (δ) notion. Accordingly, - $^{13}C/^{12}C$ is expressed as $\delta^{13}C$ but $^{15}N/^{14}N$ is expressed as $\delta^{15}N$. The delta values are commonly reported in parts per thousand (‰). One of the most common techniques for measurements of the relative abundance of stable isotopes in organic materials, including humic acids, is the isotope-ratio mass spectrometry [5].

The variations in $\delta^{13}C$ values typically reflect isotopic variations in plants over time, the signature of an inorganic source, organic carbon burial and the type of vegetation, and can be considered as a function of photosynthetic pathway that is being used to fix CO_2. The $\delta^{13}C$ value most commonly is affected by primary production and organic carbon burial [6]. Plants typically take up lighter ^{12}C isotope and depending on metabolic pathways have the $\delta^{13}C$ value around -25 ‰. An increase in this value usually indicates decrease in the production of vegetation. The $\delta^{13}C$ value in fen peat humic acids can be described as a function of the amount of organic carbon burial. After the burial more ^{12}C isotope is locked out of the cycle in peat. The C_3 and C_4 plants have different $\delta^{13}C$ signatures [7]. In C_3 plants the $\delta^{13}C$ is in the range between -33 and -24 ‰, while in C_4 this parameter is ranging between -16 and -10 ‰ [8].

The $\delta^{15}N$ values of a variety of nitrogen pools in vegetation depend on its source nitrogen in the fractionation of ^{15}N and ^{14}N during nitrogen assimilation, and on nitrogen transport within and nitrogen loss from plants. Typically, the $\delta^{15}N$ values reflect the interaction between nitrogen sources and metabolic $\delta^{15}N$ fractionation [9]. The $\delta^{15}N$ values for non-N_2-fixing plants are usually greater than for N_2-fixing plants and therefore differences in this parameter provide nitrogen transfer information between plants [10]. Positive $\delta^{15}N$ values indicate ^{15}N enrichment, whilst negative values show ^{15}N isotope depletion in plants. However, there is an uncertainty about the meaning of particular $\delta^{15}N$ values due to nitrogen pool mixing and fractionation [11]. Regarding fen peat humic acids, $\delta^{15}N$ can be used to detect the assimilation of NH_3 by peat-forming plants [11]. Nitrogen is lost from peat-forming plant by efflux reaction from roots and by volatilization from plant leaves [11]. Part of nitrogen is also transformed during assimilation, amino acid synthesis and protein turnover [11].

This work was focused on studies of stable isotope ratios $\delta^{13}C$ and $\delta^{15}N$, and their distribution in humic acids within fen peat layers of different botanical composition, depth, decomposition degree and research site to detect differences in humic acids of peat of different origin.

Materials and Methods

Properties of fen peat humic acids were studied in 2018 at 3 fens located in Latvia and Southern Finland. Fen peat samples were collected in two Latvian mires – Opulu mire (56°25'24"N and 28°10'22"E) and Viku mire (56°30'58"N and 22°54'32"E), with an additional fen peat sample from Southern Finland (Table 1).

TABLE I. Basic properties of sampled fen peat

Mire	Parameters		
	Depth range, m	Type	Decomposition degree
Finnish peat	0.50 – 1.25	Grass-sedge	29
Finnish peat	1.25 – 1.50	Grass-sedge	29
Finnish peat	1.50 – 1.75	Grass-sedge	40
Finnish peat	1.75 – 2.00	Grass-sedge	40
Opulu mire	0.00 – 0.50	Wood-grass	44
Opulu mire	0.50 – 1.00	Wood-grass	44
Opulu mire	1.00 – 1.50	Wood-grass	44
Opulu mire	1.50 – 2.00	Wood-grass	44
Viku mire	0.00 – 0.10	Wood	41
Viku mire	0.10 – 0.20	Wood	41
Viku mire	0.80 – 0.90	Grass	40
Viku mire	0.90 – 1.00	Sedge	27

Peat botanical composition and decomposition degree were determined microscopically according to the methodology suggested by Lishtvan and Korol (1975) [12].

Fen peat was treated with 0.1 M KOH extracting solution at room temperature and shaken for 24 h and filtered. After this procedure the alkaline extract was acidified with 50 % H_2SO_4 to pH 1.5 and allowed to precipitate for 48 h in cold storage at 4°C. Humic acids were precipitated from acidified solution and washed until neutral pH.

The method that was used for the determination of stable isotopes in humic acids was the stable isotope-ratio mass spectrometry (SIRMS) that was performed at the faculty of chemistry, University of Latvia. The analyses were carried out with Nu Horizon SIRMS using certified reference materials USGS-40 and USGS-41 (L-Glutamic acid). The $\delta^{13}C$ values were expressed relative to VPDB (Vienna Pee Dee Belemnite) and the $\delta^{15}N$ values relative to AIR. For internal quality control L-Glutamic acid (analytical grade, Sigma-Aldrich) as laboratory reference material was used after each ten samples. For the SIRMS measurements ~1000 ± 50 μg of samples were

weighed in to tin capsules (5 x 9 mm, EuroVector) and carefully pressed in to a ball (<4 mm) and inserted in to autosampler. For the determination of $\delta^{13}C$ and $\delta^{15}N$ values, the isotope-ratio mass spectrometry measured the ratio of ions that correspond to CO_2 and N_2 gasses [5]. Fen peat humic acid samples underwent combustion in O_2 atmosphere. The molecules of evolved gasses CO_2 and N_2 were ionised, but ions were separated and detected in the mass spectrometer.

Results and Discussion

Properties of studied fen peat comparatively show similar botanical composition between study sites, while peat decomposition degree is rather varied (Table 1). Finnish fen peat consist of grass and sedge remains with the decomposition degree between 29 and 40 %. At the same time, Opulu mire peat contain remains of wood and grass with the decomposition degree of 44 %, but Viku mire peat contains wood, grass and sedge remains with the decomposition degree between 27 and 41 %. In the case of Finnish peat, samples seem to have higher decomposition degree with an increase of depth range, while Viku mire peat shows the opposite. The variations of $\delta^{13}C$ in studied Finnish (Fig. 1), Opulu mire (Fig. 2) and Viku mire (Fig. 3) humic acids reflect isotopic variations in peat-forming plants over time and can be considered as a function of photosynthetic pathway that is being used to fix CO_2. Although overall range of $\delta^{13}C$ values amongst study sites is rather similar, the distribution of stable carbon isotope in humic acids varies with peat parameters.

The $\delta^{13}C$ value in Finnish fen peat humic acids is between -27.5 and -27.2 ‰ and represent CO_2 fixation in C_3 plants and humic acids from top peat layers seem to have more stable carbon isotope than bottom peat layers, that can be explained by the production of current vegetation in this mire and lower peat decomposition degree.

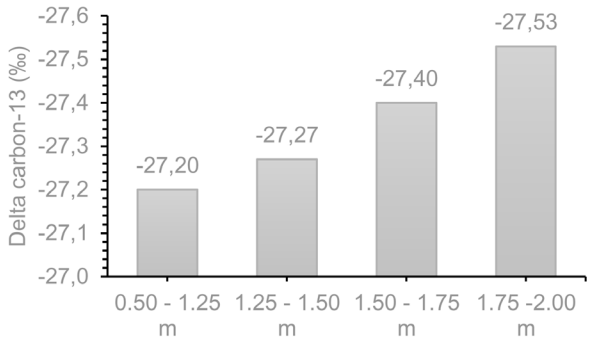

Fig. 1. Delta carbon-13 values of Finnish fen peat humic acids.

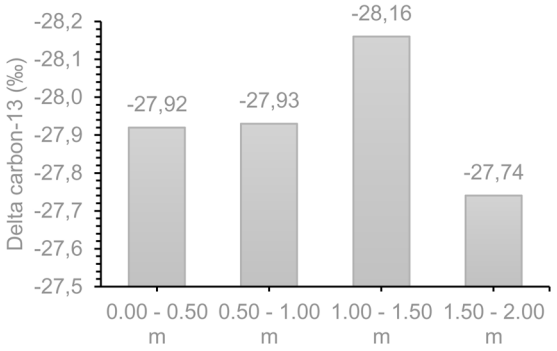

Fig. 2. Delta carbon-13 values of Opulu fen peat humic acids.

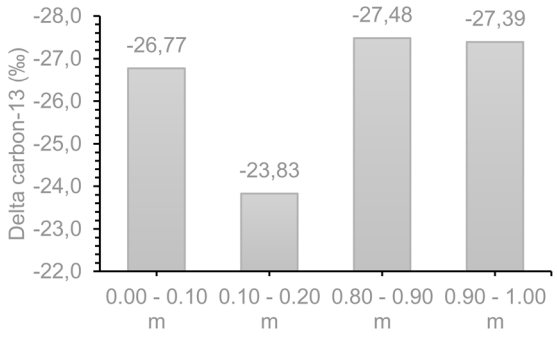

Fig. 3. Delta carbon-13 values of Viki fen peat humic acids.

The value of $\delta^{13}C$ in Opulu mire humic acids vary between -28.2 and -27.4 ‰, which overall is very similar to Finnish fen peat humic acids, and the distribution of $\delta^{13}C$ seems to follow the pattern that can be traced in Finnish fen peat humic acids, with the exception of bottom peat layer, that can be explained with differences in the origin of both mires. The value of $\delta^{13}C$ in Viki mire fen peat humic acids is between -27.5 and -23.8 ‰ and thus it is rather different from carbon isotopes in Finnish and Opulu mire humic acids. Moreover, the $\delta^{13}C$ distribution pattern in Viki mire humic acids due to complex botanical composition and rather varied peat decomposition degree does not follow any particular pattern.

Variations in $\delta^{15}N$ in studied Finnish (Fig. 4), Opulu mire (Fig. 5) and Viku mire (Fig. 6) humic acids show nitrogen fixation in peat-forming plants and seem to be site dependent as data show significant differences amongst study sites, depth range, peat botanical composition and decomposition degree. Moreover, due to differences in the environment amongst study sites there can be noticed both enrichment and depletion of ^{15}N isotope that are of different rates depending on botanical composition and properties of particular peat, - most likely due to the ratio between remains of N_2-fixing and non-N_2-fixing plants and nitrogen transformation during assimilation, amino acid synthesis and protein turnover.

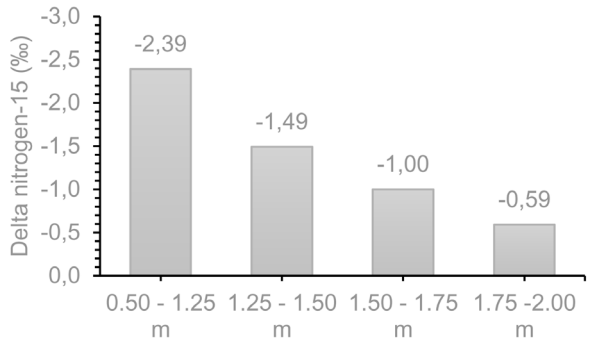

Fig. 4. Delta nitrogen-15 values of Finnish fen peat humic acids.

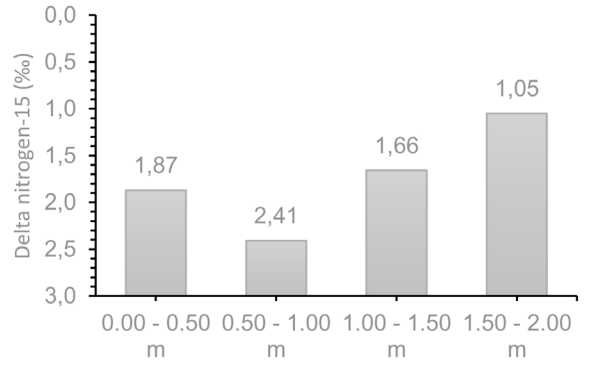

Fig. 5. Delta nitrogen-15 values of Opulu fen peat humic acids.

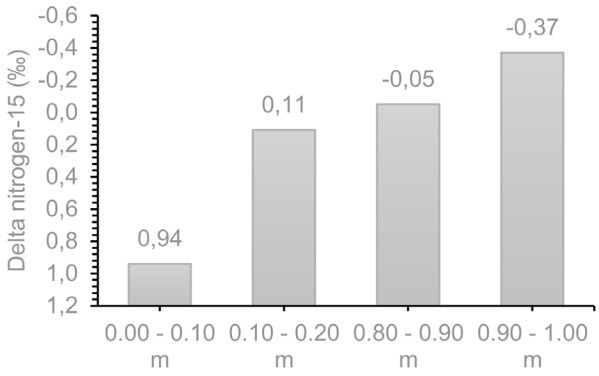

Fig. 6. Delta nitrogen-15 values of Viki fen peat humic acids.

The $\delta^{15}N$ value in Finnish fen peat humic acids varies between -2.4 and -0.6 ‰ that describes stable ^{15}N isotope depletion, the most active nitrogen depletion is characteristic to the top part of peat profile and seems to be reversely proportional to ^{13}C isotope in Finnish peat humic acids. The $\delta^{15}N$ value in Opulu mire fen peat humic acids vary between 1.0 and 2.4 ‰ and indicates the ^{15}N enrichment throughout full peat profile that might be caused by nitrogen stress and the fractionation of stable nitrogen isotopes and/or by mixing of nitrogen from internal and external sources (anthropogenic activity). The $\delta^{15}N$ value in Viki mire fen peat humic acids is between -0.4 and 0.9 ‰ and shows on both enrichment and depletion of ^{15}N. The depletion can be identified in the bottom part of the peat profile, while the top part shows an enrichment that might be caused by the anthropogenic activities (agriculture) in the local area. Data on $\delta^{15}N$ distribution in Opulu and Viku mire humic acids show no relation with $\delta^{13}C$ distribution in these humic acids.

Conclusions

Results suggest that differences in peat botanical composition, decomposition degree and site dependent organic matter transformation into humic acids also reflect in differences of $\delta^{13}C$ and $\delta^{15}N$ distribution. Although data show typical nitrogen fixation in terrestrial plants, however significant shifts in absolute isotope values amongst study sites can be explained with variations in the botanical composition of fen peat material and human activities in particular areas.

Acknowledgements

This study was supported by the European Regional Development Fund Project No. 1.1.1.2/VIAA/1/16/001 (PostDoc Latvia) under the post-doctoral research project "Innovative use of fen peat in environmentally friendly applications", No. 1.1.1.2/VIAA/1/16/008; and by Latvian Council of Science grant "Properties and structure of peat humic substances and possibilities of their modification", No. lzp-2018/1-0009.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 127-130

Formation of Risk-balanced Style of Professional Activity among University Students

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***Abstract* — The basis of the sustainable development of society with ever-growing scientific and technical progress is noxology as a science about the dangers of the world, since the risk of being in modern society is higher than ever. In this regard, a scientific noxospheric picture of the world is being formed as an integrative knowledge system, which should be the basis for the formation of a new, noxological worldview, in which security is the main value norm of risk-oriented thinking. The article is aimed at the theoretical substantiation of the necessity of dev+eloping a risk-balanced style of professional activity among university students on the basis of risk-thinking as an objective property of the personality. The article also reveals the authors' concept of the noxological consciousness and explains the term of a risk-balanced style of professional activity. The definition, structure and main constituent elements of this personal phenomenon are given. It is determined that noxological style of professional activity includes such components as risk-thinking, self-regulation, intellectual features and capabilities, "labor model", individual biological rhythms, will, as well as habits and special techniques of activity. Various characteristics of risks in the professional activity of a specialist are considered. Based on the analysis of scientific and pedagogical literature on the problem and the method of observation, the modeling of the pedagogical system of training a specialist with a risk-balanced style of professional activity is presented, the effectiveness of which is confirmed by the formative experiment.**

Keywords—noxological consciousness, risk-balanced style of professional activity, risk-thinking, technospheric safety expert

I. Introduction

It is believed that the reproduction system of a new, sixth technological order is currently being formed in the economy, the formation and growth of which will determine global economic development in the next two to three decades. The intellectualization of production will continuously increase, the transition to a continuous innovation process in most industries and continuous education in most professions will be realized [1]. Great importance will be attached to the quality of life and comfort of the habitat. Among the current professions will be those that will directly form this most comfortable environment. There are, among others, an urban ecologist, an ecology preacher, and a specialist in overcoming systemic environmental disasters.

According to the Atlas of New Professions [2], an urban ecologist will design new environmentally friendly cities, an environmental preacher will form an environmentally conscious lifestyle, conduct educational programs on relevant topics for different age groups. A specialist in overcoming systemic environmental disasters is designed to prevent disasters that people gradually realize, namely: pollution around industrial centers, radiation waste, melting glaciers, etc. Thus, civilizational changes, change of cultural-value and scientific-educational paradigms become inevitable and feasible in a fairly foreseeable future. The technosphere as a human habitat that has arisen as a result of direct or indirect anthropogenic impact, aimed at meeting the socio-economic and physiological needs of man, must consistently undergo changes based on the rationalization of material and energy processes to ensure the sustainability of civilization [3].

The basis of sustainable development with ever-increasing scientific and technical progress, in turn, is noxology. Noxology is known to be the science of the dangers of the world, since the risk of being in modern society is higher than ever. It seems reasonable to believe that a scientific noxospheric picture of the world as an integrative knowledge system is currently being formed [4]. It should be the basis for the formation of a new noxological consciousness, in which safety is the main value norm and risk-based thinking. The subject of our article is the noxological consciousness, risk-thinking and the risk-balanced style of professional activity based on it as the objective characteristics of the personality of a future specialist and a member of the society.

II. Materials and Methods

Before considering the indicated phenomena of personality their definitions should be determined. It is considered that risk-thinking is the process of reflecting objective reality in conclusions, concepts, judgments, in which danger and risk as an objective factor of life are evaluated and analyzed [1].

Following the meaning of this definition, it is most

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4034

expedient to consider such a personal phenomenon in which relationship with the environment will be built in such a way that the risks of being would not potentially carry tangible threats or would be detected and eliminated in a timely manner in the process of building individual life scenarios. Thus, it seems that risk-thinking should be linked in disclosing the genesis of professional individuality with the noxological style of professional activity.

To substantiate this position the following arguments should be presented. In scientific and artistic literature, attention has repeatedly been drawn to the changes that occur with a person in the process of mastering and carrying out a long-term performance of any activity. These changes occur on the psychophysiological, mental and personal levels: the higher the professional skills, the more confident the personality. These changes are gradually reflected in common external manifestations (motility, speech, emotionality, speech, etc.). At a deeper personal level, the formation of the corresponding elements of professional consciousness (professional attention, perception, memory, thinking, emotional sphere) takes place. In a broader context, we can talk about the development of a professional worldview, changes in the relevant components of the subject in relation to the object of activity. This is manifested in the cognitive sphere (the level of awareness of the object, the degree of awareness of its importance); in the emotional sphere (interest in the object), in the inclination and satisfaction from interacting with it; in the practical field.

It is believed that in the process of becoming a professional a spontaneous restructuring of the personality takes place, which should be used to provide optimal assistance to the future professional, to give this process a meaningful character [5].

It's obvious that the period of life in the student's age, when the processes of reflection are most mobile and qualitative personal-professional changes occur, is the optimal time for an organic connection of the professional-noxological worldview and their translation into personal values and life orientations.

In this connection, the concept of an individual style of activity is used, on which a risk-balanced style of professional activity will be built.

Thus, an individual style of activity is understood as a self-developing, and, therefore, periodically changing system of techniques and methods of activity, the strategy of which is determined by the typological features of the nervous system and temperament, and the tactics of its performance are provided by the unique combination of strong-willed, intellectual and emotional qualities consciously selected and fixed individual in the process of its development.

In the context of risk-balanced thinking in the noxological style of professional activity, the following components of its structure can be distinguished:

- risk reflection;
- self-regulation;
- intellectual features and capabilities;
- "model of labour";
- individual biological rhythms;
- will;
- habits and special techniques of professional activities.

The backbone element is risk reflection, and the elements indirectly associated with it and each other are all the other elements represented in the structure. Below are the characteristics of the coordinated elements of the style of activity and in more detail risk-reflection as the basis for the risk-balanced style of professional activity.

Intellectual features and capabilities of a person are associated with such characteristics as the degree of development of intellectual capabilities, the dominant type of thinking, the volume and features of memory, the individual's leading modality, etc. The "model of labor" is associated with the manifestation of the external dynamic aspect of human activity, its "unique pattern" of activity (continuous intellectual offensive, flexible switching, rhythmic periodization method, etc.). It is the "labour model" that is the typical side, which is based on the individual characteristics associated with the first level of the integral individuality of a person. They can be called styles that provide the first adaptive effect to the conditions of activity, and characterize them as typical styles inherent to the groups of persons within which that unique and strictly individual set of techniques and methods exists that constitutes a true individual style. Thus, the "model of labour" is deeply individual, and at the same time typical for a group of people with a similar type of nervous system and temperament. It is individual because it is associated with individual rhythms - periods of alternation of work and rest time. It is typical because a certain external form of behaviour is preserved.

Individual habits are also part of the system. They are caused by factors of a twofold kind: tastes, predilections, inclinations of a person and his social and material possibilities.

The technical techniques of intellectual activity include such features as the ability to read, observe and listen, taking into account various tasks, for example, the selection of the main from the secondary, speed reading, a quick scan, decoding of visual information, note-taking skills, etc. A set of these techniques will be different for each individual due to the individual and personal characteristics of perception, memory, thinking, skills, abilities, etc.

Of course, the above features of the style of activity manifest when this activity is performed without attributing it to the risk-balanced professional activity. But it is impossible to ignore these general patterns, since this is where the personality manifests itself in the concept of a systematic approach to it.

Such psychological phenomenon as the will of the individual requires special attention. The psychological phenomenon of the will somehow imperceptibly began to belong to the military and sports psychology and almost completely disappeared from the arsenal of classical science and pedagogy [6].

Many people today continue to demonstrate the ultimate achievements of personal courage, jumping from transcendental heights, plunging into the depths of the ocean, skiing down steeps, overcoming the World Ocean alone, soaring into space and suffering there for the sake of science. And these are all high risks of being and not always justified, but causing admiration and delight. But at the same time, the mass of people give up the slightest

effort to start work in the morning, abandon fatal pleasures, force themselves to ponder over an unresolved question, imagine the prospect of their own life. And here, too, may be risks, but delayed or implicitly expressed, but, perhaps, from this no less high risks for the basics of being.

It should be stressed that forgetting the psychology of the will as an independent direction is wrong. The importance of the psychology of the will for a person is determined by the fact that without it, the use of coercion and self-coercion, self-control, self-regulation, self-education is impossible. All that "self" is will. "Self" is a mental effort that binds together the motive and action of a person. This effort can be applied to person's actions, and can be used to shape the actions of other people, which is no less important for the risk-balanced action. Without an act of will, no action is accomplished, no conscious action is performed. Any success by all means is based on a huge resource of volitional efforts for overcoming external and internal obstacles. Possession of high volitional qualities is the key to the success of anyone and everyone.

Risk-balanced activity and the formation of the noxological consciousness require the presence of will in a person, perhaps more than in anything else, since the noxological worldview implies a voluntary and conscious limitation of one's needs and purposeful activity often in unpopular and not always comfortable conditions.

The following definition is used for the noxological consciousness. Noxological consciousness is such a system of relations to objective reality, which: 1) relies on the post-non-classical paradigm of the development of science and society; 2) considers safety issues for a person, his surroundings, and society as a whole as priority ones; 3) forms a high motivational activity to overcome anthropogenic crises through development, when a higher level of dynamic equilibrium with the environment is established; 4) regards the noxological worldview as a compensating factor the ever-increasing instrumental and technological capabilities of a person, maintains internal control over the manifestation of the aggression of the society and each person.

Risk-reflection, as already mentioned, is a system-forming element, since it is precisely the form of theoretical human activity aimed at the activity of self-knowledge and understanding actions and laws. The degree of development of reflection determines a person's self-regulation and will functions. Subjective assessment of the situation and making decisions related to risks is one of the functions of reflection.

What is risk-reflection in the risk-oriented style of professional activity?

It is necessary to state that in the context of the problem considered in this article, the concept of "risk" is associated not only with professional activities, but also has a more general character. Risk, as a rule, is considered as the probability of danger manifestation, taking into account the possible extent of harm, as the possibility of implementing the worst alternatives [4]. Zero risk does not happen. But since the concept of "risk" originated and developed primarily in the field of economics and entrepreneurship [7] and was associated with activities carried out at your own risk in order to obtain material profits, the concept of risk has positive sense.

Risks associated with production activities, when there is a threat to the life or health of the worker or the risks of being associated with technospheric changes in the environment, have a correspondingly negative value. In this regard, it should be noted that the concept of acceptable risk is gaining momentum.

But there is one more concept of risk - "reasonable risk". In the Criminal Code of the Russian Federation, article 41, this concept is considered as an action associated with the risk of causing harm, but aimed at achieving a socially useful goal, and, therefore, is justified or necessary in any situation [8].

There is the concept of dialectically related risk in society, which constitutes a unity of opposites: when one activity associated with risks is responsible for the performance of activities, the achievement of a new planned result, for progress, and the other for the safety of activities, for the preservation of life, health, property, status, etc. Thus, for one person in carrying out activities the risk has two sides: the risk associated with the desire for good and the risk associated with the desire to avoid hazards and losses.

The task of training technosphere safety specialists is to prepare a specialist who has such skills consciously or ideally. These skills form an individual style of risk-balanced professional activity.

Why is such a wide range of risks necessary?

First of all, it is obvious that life, including professional life, is often very contradictory and unpredictable. Secondly, the risks of being are steadily increasing and we all need to be prepared for these challenges. Thirdly, the more multifaceted a person is, the more likely he is to adapt to a rapidly changing world. But in the context of this article, this means the following.

Experts in the field of technosphere safety work in various sectors of the economy. Working in the supervisory and control authorities for natural resources, environmental protection, as well as at enterprises in labour protection and safety structures, these specialists should evaluate the activities of other people and the associated risks in order to maximize the preservation of life, health, material values and natural resources in terms of acceptable risk.

If technosphere safety specialists are engaged in environmental business (green products and packaging, reuse of resources, etc.), then the risks arising as a result of thisactivity are quite conscious for getting profit in business [9]. Finally, if the activities of other people are assessed in a criminal procedural context, then it is necessary to objectively evaluate a reasonable risk. Thus, a specialist in the field of technosphere safety should have free will, ensuring him both the freedom of choice and freedom of action within professional competencies but with a conscious necessary and sufficient degree of responsibility for making professional decisions. This will is a part of the structure of his professional risk-balanced style of activity.

III. Results and discussion

Pedagogical grounds for preparing students for risk-balanced activities as a pedagogical system are shown in Fig.1.

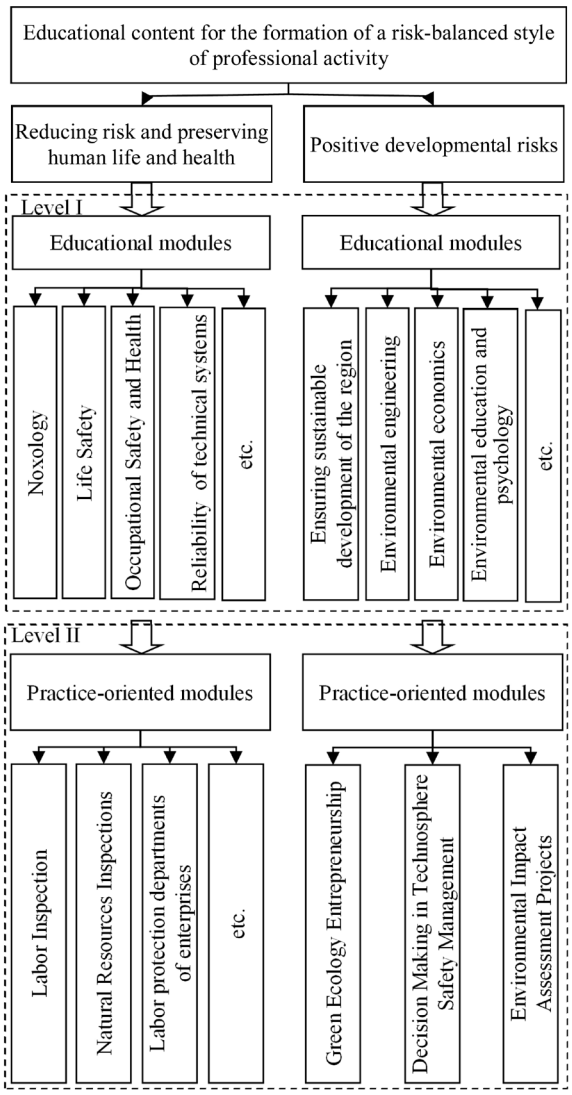

Fig.1.The block diagram of the model of education of a specialist in technosphere safety

The content of educational modules is aimed at the formation of a risk-balanced style of professional activity. For this purpose, the project method, case technologies and other educational technologies are used. These methodological instruments are aimed at the maximum possible independent work of students, the organization of their activities in solving the tasks set. In addition, purposeful work is under way to organize the interaction of students with specialists in the field of environmental protection, where a style of professional activity is formed, figuratively speaking in the first approximation.

Practice-oriented modules are aimed at improving the emerging professional activity. The practice reports of students include a section where it is necessary to analyze what types of risks are major during the passage of industrial and technological, production and organizational practices, when addressing issues of pre-project environmental impact assessment or drafting an environmental impact assessment project.

IV. Conclusion

In modern conditions, according to the concept of the noxospheric picture of the world, it is risk-thinking as an objective property of the personality of a future specialist and a member of society that forms the basis for the development of a risk-balanced style of professional activity among university students.

The formation of a specialist with a given set of qualities, including in the emotional-volitional sphere, is carried out in a specific environment of an educational institution, determined by many factors of a subjective and objective nature.

The phenomenon considered in the article is difficult to laboratory experiment, observation and description. In practical psychology at the moment there are no qualimetric characteristics for its description. These problems are beyond the scope of the discussed psychological phenomenon and are the subject of a separate study. For the time being, this phenomenon is estimated by indirect evidence of the correctness of making professional decisions in various areas of activity.

At Pskov State University, in preparing specialists for technosphere safety, in our opinion, the necessary pedagogical environment has been formed for the formation of a risk-balanced style of professional activity.

Graduates from the “Technosphere Safety” profile are almost 100% employed by the chosen profession. They work both in state environmental protection structures and in enterprises of various types of property. The quality of training is confirmed by the passage of professional certifications of various levels and rapid career growth.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 131-135

Application of Unmanned Aerial Vehicles for Glacier Research in the Arctic and Antarctic

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***Abstract*—Unmanned aerial vehicles or drones are nowadays widely used in a broad field of scientific and commercial applications. Despite this, it is quite a new method for glacier mapping in polar regions and has a lot of advantages, as well as disadvantages over more classical remote sensing instruments. Here we examine the main issues associated with the application of drones for glacier research from our experience in Iceland, Greenland and the Antarctic. We use DJI Phantom series drones for the obtaining of aerial photographs and produce digital surface models (resolution of 8 – 16 cm) and orthomosaics (resolution of 2 – 4 cm) for glacier mapping. Several issues related to the ground control points, geolocation using Global Navigation Satellite System receiers and creation of final products are addressed as well. We recommend the further use of drones in remote polar areas because it allows obtaining very high-resolution orthomosaics and digital surface models that are not achieved by other methods. Short summer season, raw weather with precipitation and winds, limited drone flight duration and problems with connection cables are the main issues everyone can encounter working in polar regions but all issues can be restricted with careful planning and readiness to gather data whenever it is possible during all field campaign.**

***Keywords*—drone, digital surface model, orthomosaic, polar regions.**

I. Introduction

Nowadays remote sensing is one of the most powerful tools in Earth Sciences and especially in glaciology and glacial geomorphology [1]. Different kinds of sensors and instruments are placed on satellites and aircrafts allowing mapping ice sheets in Greenland and Antarctica. The Randolph Glacier Inventory (RGI) provides a global inventory of glacier outlines [2]. Global Land Ice Measurements from Space project monitors the glaciers over the globe using data from optical satellite instruments [3]. High-resolution digital surface models (DSMs) are available for Antarctica (the Reference Elevation Model of Antarctica (REMA) with 8-meter spatial resolution) [4] and all the Arctic (the newest ArcticDEM Release 7 includes 2-meter resolution DEM covering all land area north of 60° and additional areas) [5].

Despite all available data, the mentioned datasets lack the information often needed for the detailed investigations of individual glaciers. To resolve this, unmanned aerial vehicles (UAV) or drones are being used increasingly. Glacier studies with UAVs is a new method [6], but nowadays its applications includes, for example, high-resolution investigation of glacial landforms [7] – [11], monitoring of glacier dynamics [12], calving and melting dynamics [13] and [14], identification of surface structures [15] and others.

During the last years, scientists from the University of Latvia have been using drones to map glaciers in Greenland (2016), Iceland (2018) and Antarctica (2018). The focus in these expeditions has been on the generation of high-precision DSMs and models of the subglacial topography from ground penetrating radar data. In this paper, we review our experience, problems, main results and future perspectives of using drones in remote polar regions.

II. Materials and Methods

For the capturing of aerial photographs we use drones DJI Phantom 3 advanced (Figs. 1a, b) and DJI Phantom 4 Pro V2.0 (Fig. 1e). These are rotary-wing quadcopters equipped with 1/2.3" CMOS 12.4 Megapixel and 1" CMOS 20 Megapixel sensors accordingly. Usually, two drones are taken to the polar expeditions, one of them serving as a backup. In remote areas, the question of battery charging possibilities arises, because the flight duration with one battery is only around 20 minutes. It was necessary to use a portable current generator during expeditions in Iceland and Greenland. In the Antarctic, the Vernadsky Station was used as a base that allowed

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4130

charging of batteries. On the expedition in Iceland, we used DJI Mavic Air (Fig. 1c) as a reserve in case of possible technical problems with the main drone. Mavic Air is so small that it fits in a pocket. In that way, it is so easy to transport it but because of the good operation of the main drone, we have used it only for photo and video background. Few studies [16] and [17] and our experience outside polar regions suggest that it is possible to use small DJI Mavic Air also for photogrammetry although due to several issues Phantom is recommended instead.

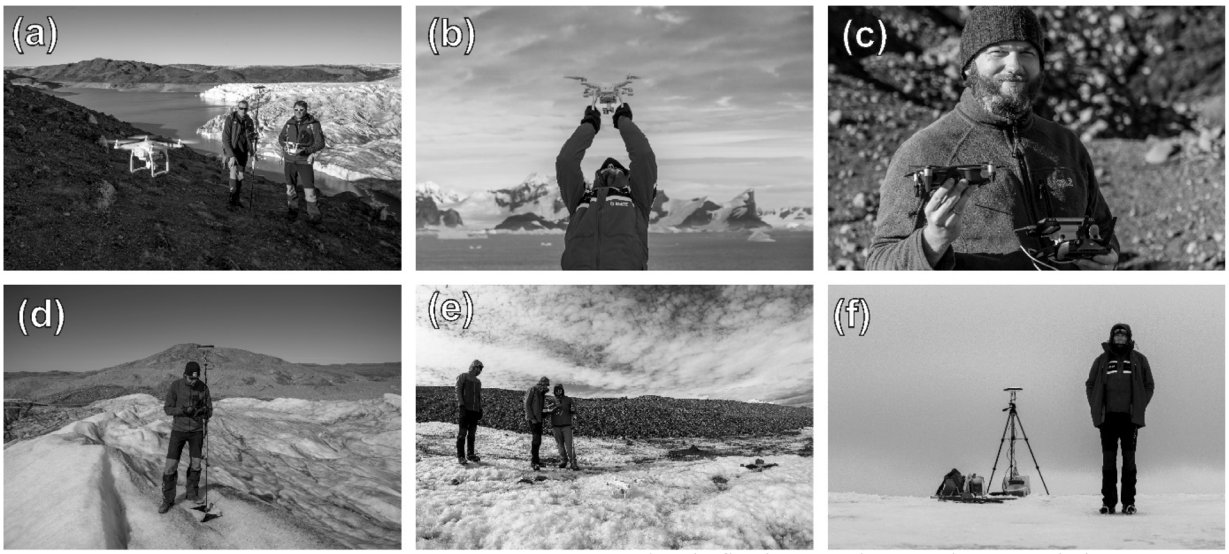

Fig. 1. (a) Using the drone DJI Phantom 3 Advanced in Greenland. (b) Hand catching of the drone DJI Phantom 3 Advanced in the Antarctic. (c) Operating one of smallest drones DJI Mavic Air in Iceland as a backup drone. (d) Measuring the GCP with Magellan Promark 3 GPS receiver in Greenland. (e) Operating the drone DJI Phantom 4 Pro v2.0 in Iceland. (f) Improvised GPS base station in the Antarctic using Magellan Promark 3 GPS system.

The control of drone and mission generation has been done by DJI GO 4, Drone Harmony and Pix4Dcapture mobile applications which are available for free or acceptable fee.

Flight altitude most frequently was set to 60-70 m over the take-off point which usually is at the highest elevation while image overlap was set to 80-85%. The accuracy requirements of DSMs are ensured using

ground control points (GCPs). In the first expeditions, we used GCPs from a firm plastic material with dimensions of 35 x 35 cm (Fig. 2b), while for the last expedition to Iceland larger (50 x 50 cm) GCPs that were made from a flexible fabric material were used (Fig. 2a). Different issues are related to both kinds of GCPs. Rocks which are used to secure GCPs on the ice can slip from the GCP made from the firm plastic material due to the fast melting of the surrounding ice (Fig. 2b). GCPs from the flexible fabric material (Fig. 2a) are harder to stretch evenly over the ice surface but overall such kind of GCPs is more preferable over inflexible GCPs.

Flexible GCPs are easier to transport to the survey territories, as well as they are much lighter. Bright colours of the fabric can be easily identified on the UAV pictures. Overall we use 10 – 15 GCPs on the area for one mission. For georeferencing purposes, only 7-9 GCPs are used, while other GCPs are useful for validation of the photogrammetric model.

UAV GCPs are measured with GNSS receivers Magellan Promark 3 (Fig. 1d) or Emlid Reach RS+. The measurement system consists of two GNSS receivers – one is used as a base station, but the second as a rover. A base station is usually placed at the highest elevation of the survey territory (Fig. 1f), and the log file is continuously recorded during the day as long as possible. Post-processing is done with

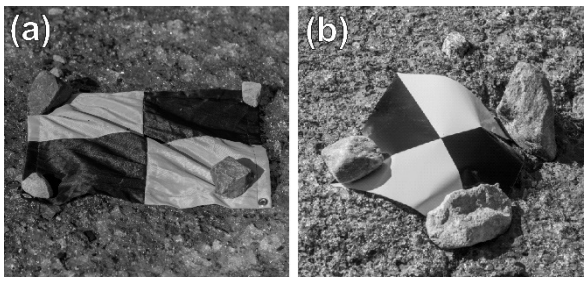

Fig. 2. Examples of used GCPs with dimensions of (a) 50 x 50 cm and (b) 35 x 35 cm.

GNSS solutions software [18] if Magellan Promark 3 is used or with RTKlib solution [19] if Emlid Reach RS+ is used. Base station location is always determined using GNSS signal corrections from the closest GNSS station, which is usually located several tens of kilometres away from the study area. While processing data from the Antarctic expedition we used signal corrections from the closest GNSS station "Palmer" that was located approximately 53 km away from the study area. It is not recommended to use base stations that are located more than 40 km away from the survey territory but in this case, it was the only opportunity and it allowed obtaining base station coordinates with a deviation of approximately 4 cm in all cases. Longer observation times of the local base station can improve the results of the positioning but require an additional power supply for the GNSS receiver.

Obtained aerial images allow the creation of orthomosaics with a resolution of 2 – 4 centimetres and DSMs with a resolution around 8 – 16 centimetres using photogrammetry processes in Agisoft PhotoScan Pro and Metashape software. Processing workflow and

parameters are set according to Agisoft guidelines [20] and our experience. As the number of images is usually larger than 1000, and often reaches several thousand, a workstation with a high-performance graphics card, fast multiprocessors and large RAM size is needed.

Photogrammetry processes in Agisoft software include the following steps:

- Camera alignment and generation of a sparse cloud;
- Generation of DSM and orthomosaic from the sparse cloud;
- Selection of the GCPs and assignment of the corrected coordinates;
- Optimization of cameras;
- Generation of Dense cloud;
- Generation of final DSM;
- Generation of final orthomosaic.

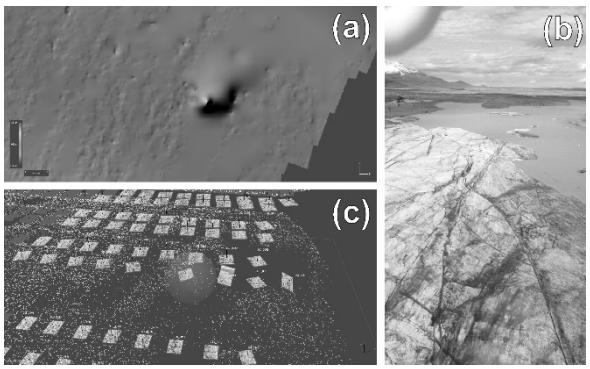

Fig. 3. (a) Sharp uplift in DSM of the Eyjabakkajökull glacier, Iceland. (b) An oblique photograph of the glacier margin causing an error in dense cloud and DSM. (c) Dense cloud with the oblique photograph.

III. Results and Discussion

A number of issues can be encountered during the capture of aerial photographs with UAV during polar expeditions. Smallest of them are damaged and wearied out connection cables. Problems with cables can occur even when they are completely new. Incomprehensible problems sometimes are associated with aircraft and remote controller connections, signal loss or application support. The main issues in Polar Regions are bad weather, usually precipitation and fog, coldness and strong wind. Too low drone and/or battery temperature can cause drone failure although usually cold batteries can be warmed up by the heat of the human body. Strong and sudden wind gusts are particularly troublesome and can cause the taking of oblique photographs (Figs. 3b, c). If all photographs, including oblique ones, are used later for photogrammetry, it can create errors in dense clouds and surface models as sharp uplifts (Fig. 3a). Of course, blurred and oblique images can be easily disabled during photogrammetry processes although sometimes it must be done manually, it can cause the shortage of images in places decreasing accuracy of the final model. An essential issue in the Antarctic and the high Arctic as well, is a short summer season. As orthomosaics and DSMs in glaciology are used for the monitoring of glacier area and elevation changes, it is usually important to take pictures when there is minimal snow cover over glaciers. The time spans when weather conditions are suitable for the UAV flights can be very limited. During our Antarctic expedition (2018) almost all flights over the Argentine Islands of the Wilhelm Archipelago were performed in February. In March, snowing was quite common thereby few islands in obtained orthomosaics were partially covered by snow. This caused local errors on DSMs, usually on the highest parts of ice caps where the surface was too evenly white.

Photogrammetry process results in several final products that can be used for the following interpretation and research. DSMs and orthomosaics are used more often but from the same picture set it is possible obtaining point clouds and 3D models (Fig. 4). The quality of these products depends on the camera system that is being used on the UAV, as well as the UAV survey parameters – flight altitude, an overlap between pictures, picture resolution, etc. For our purposes resolution of the DSMs around 10 cm/px is enough for most applications, while the resolution of the final orthomosaics is around 3 cm/px. These attributes of the DSMs and orthomosaics allow to interpret the surface of the glaciers and to map such small features as crevasses, crevasse traces, moulins, and supraglacial streams, which are not visible even on DSMs created from 0.5 m satellite imagery as, for example, ArcticDEM with 2-meter resolution [5]. The obtained DSMs then are used in combination with ice thickness measurements from ground penetrating radar that allows the creation of subglacial topography models.

Our studies show that it is crucial to take pictures in RAW format, rather than in JPEG despite of a few times larger file size. The RAW format gives more flexibility in the post-processing of the obtained pictures. Polar region areas usually consist out of glacierized and snowy areas that are very bright on the pictures, and rocky regions on the other hand that are much darker. Both types of areas require different exposition settings. RAW format allows making corrections of exposure parameters in post-processing, thus allowing to take pictures with locked exposition parameters and making corrections afterward.

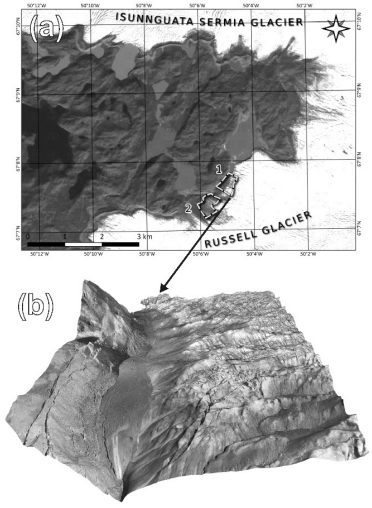

Fig. 4. (a) An example of the study areas (1 and 2) in the SW Greenland. Sentinel satellite image a the background. (b) 3D model of the glacier margin from UAV photogrammetry (orthomosaic draped over DEM).

Photogrammetry process can yield errors in DSM [21]. Our experiments show that results of the same photogrammetry set processed on different PCs or even repeatedly on the same PC can produce different models because of the random factor that is involved in the alignment of the picture set. Deviations in the model can be as high as 20 cm on a vertical scale and even larger on a horizontal plane. Some of these errors can be analysed visually, while some require another identification approach. We use additional GCPs for validation of the model that were not used in the alignment of the pictures. Fresh snow on the glacier surface can drastically increase the possibility of these errors, because of the strong reflections of the sunlight. Manual post-processing of the pictures often helps to reduce reflections.

IV. Conclusions

Our work in Iceland, Greenland and the Antarctic has demonstrated that the application of small drones in glaciology nowadays is an affordable and accurate method for the construction of high-resolution orthomosaics and digital surface models. Fast data acquisition and flexibility of flights opens new opportunities for glaciological mapping including remote regions where it is not possible to use other mapping methods. Automatic mission's option allows planning flight routes while still being in a camp, thus bearing in mind possible issues and errors. The small size of UAVs allows easier transportation to the study area.

Applications of UAVs in the remote polar regions still have few limitations, particularly short flight duration. Issues related to weather conditions always is a matter of chance but the newest technologies, even in small and affordable Phantom series drones, provide good weather sealing and camera stabilization allowing the taking of pictures even in damp and windy conditions. However, strong and sudden wind gusts can cause taking of oblique images or even deviation from the flight route thus forcing to repeat the mission.

With the advance of UAV technologies, it will be possible to use other sensors as well and acquiring broad spectre of spatial data. We recommend the further use of drones in remote polar areas because it allows obtaining very high-resolution orthomosaics and digital surface models that are not achievable by other methods.

Acknowledgments

This work was supported by the performance-based funding of University of Latvia within the "Climate change and sustainable use of natural resources" and by the specific support objective activity 1.1.1.2. "Post-doctoral Research Aid" (Project id. 1.1.1.2/16/I/001) of the Republic of Latvia, funded by the European Regional Development Fund, Kristaps Lamsters research Project No. 1.1.1.2/VIAA/1/16/118.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 136-141

Sizing for a Special Group of People: Best Practice of Human Body Scanning

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Abstract—Due to new circumstances of living, climate and environmental changes, varieties of human body shapes are growing. Therefore, obtaining uniformly clothes for special issues in the group of people with similar interests (dancing groups, choirs, etc.) are getting more and more complex. Besides the self-estimation and perception about the shape and size of the person varies due to different sizing from brand to brand. To dress-up the group of people with different sizes in uniformly way is not an easy task for the supplier – even if the model chosen for the gown is casual, most of the producers doesn't apply a large scale of sizes. Frequently sizing systems do not fit to the needs of the end-users. Size marked on the clothing describes only some information about body size, if any. Therefore, part of clothing supplied is not suitable for end-user groups, but if already purchased it is decided to discard them. Such a set of circumstances, in contrast to global progress towards sustainable development, which is also based on environmental responsibility, can serve as a contributing factor to further growth in clothing consumption. The main purpose of this study is to make an insight into sizing approaches for a special group of people focusing on the best practice of human body 3D scanning. The paper outlines a certain target group's understanding of the clothing size correspondence to their individual body characteristics. Advantages of human body scanning for analysing of body characteristics and solving sizing issues are discussed. Within the study, anthropometric data sets of 50 women group were obtained using a 3D scanner to develop the distribution of this special group into size groups and analyse individual body measurements that are significant for the design of appropriate garment patterns. Conclusions made in this paper acknowledge 3D scanning as an advantageous method for anthropometric data obtaining which are determinate for garment design and sizing system development.

Keywords—made to measure, non-contact measurements, sustainable garment producing.

I. Introduction

Recent industry studies within reports explain that today's almost completely linear system for producing, distributing and using clothing is extremely wasteful and polluting. Garment production has approximately doubled over the past 15 years and has been driven by factors such as "fast fashion" phenomenon, rapid change of collections and lower prices. Large amounts of non-renewable resources are consumed by the industry to create clothes that often are worn for a short time period if ever worn [1]. Such trends are not in line with global progress towards sustainable development when development in different areas must meet current needs, but without compromising future generation ability to meet their needs as well [2]. In the garment industry, one of the sustainable development bases - environmental responsibility - cannot be assured by not thinking about the reasons for the steady rise in irresponsible clothing consumption, and certainly about recycling and utilisation issues.

One of the vital factors in the clothing industry is the correct and broad understanding of the end-user anthropometric profile to review and ensure successful clothing production, distribution and use. However, given the constantly changing human body characteristics due to climate and environmental changes, as well as changes in living conditions and quality (obesity problems, medicine and sports development, lifestyle trends, etc.), defining standard sizes that would provide maximum end-user satisfaction is rather difficult [3]. The lack of knowledge about end-user size and shape is the reason for the creation of products that may not be suitable and can be disposed after the first use. Therefore, from the viewpoint of both manufacturers and consumers, reliable and distinctly sizing standards for efficient production circulation are essential [3].

A. Apparel Sizing and Fit

In mass production, garment patterns are usually adapted from a basic block pattern created to fit a standard average-sized person or a person within the target market. Then patterns are produced in a range of different sizes according to a set of grade rules which are derived from a size chart. The size chart, comprised of body key measurements, is used to define a range of garment sizes within a fashion line It is crucial to ensure fit consistency within the sizing [4]. Manufacturers in different countries use different population data, as latest measurements are too expensive and inaccessible. These tables may be compiled as long ago as they no longer correspond to the real situation, for example, Russian GOST (ГОСТ), and German DOB. Types and number of size designation

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4137

dimensions and intervals are also derived from the principles and experience of company designers. Sizing principles may be influenced by various tables used over time.

Fit problems caused by sizing of ready-made garments occur within both gender groups and different age groups, also not meeting the needs of individuals with differences in body proportions such as long arms and legs, stooped, normal, and curved stature, large neck circumference, broad shoulders, and people with increased body weight and adipose tissue folds in different areas of the body.

In the industry standards [5], [6], [7], [8], [9], [10] is explained that different systems for size designations and garment labelling are currently used in Europe, highlighting the purpose and need for development. The aim of standardization is to harmonize and simplify the size designation for both consumer benefits and industry in general [5]. Objective is to establish a size designation system that can be used by manufacturers and retailers to indicate to the final consumer (in a simple, direct and meaningful way) body measures ensuring fit of chosen clothing [7]. The third part [5] of the standard is a reference material that includes values and intervals serving as an example of best practice for size designations. In addition, they are developed by the newest sizing surveys in Belgium, France, Germany, Netherlands, Romania, Span and Sweden.

Developers of standards indicate a number of key aspects, for example: the processing of body measurement data as described in this document results in the grouping of body sizes appropriate to the studied population concerned; distribution of body dimensions can change due to changes over times; in order to get a garment-fitting correctly on a body, it is essential to collect the body measurements [8], [9], [10].

Flaws in mass production sizing systems may appear in cases when a specific, sufficiently large group of people need to wear the same style clothing, giving a good overall look in terms of consistent proportions and appropriate fit. Especially if the group has a large variety of body characteristics, it is practically impossible to find clothing for all the group from the mass production, while individual sewing is a time-consuming and expensive process. In such cases, it is necessary to find ways to customize the products according to end-user needs and anthropometric profile, the most appropriate solution is to purchase of made-to-measure clothing.

Made-to-measure clothing is designed specially to fit a person, based on standard sizes and design and adjusted to customer's measurements [11], [12]. In the case of a made-to-measure approach, reliable and sufficiently extensive information on the body measures of wearers is required. The traditional manual methods or contact methods for obtaining anthropometric data are time-consuming and require good skills. Therefore, modern methods of fast and reliable data acquisition – human body 3D scanning, may be the most appropriate solution.

B. Human Body Scanning in Apparel Industry

Human body 3D scanning is a modern measuring method that, thanks to its fast and reliable operation, contribute to the development of anthropometric studies and, consequently, to the knowledge about the characteristics of consumer body [13], [14], [15].

Body scanning is a non-contact method when, unlike traditional manual methods, there is no need to touch the human body. Contact methods involve touching a measurer (one or more) with a human body that may confuse the person being measured. As well as considering the duration of the procedure, a person can get tired and change postures, thus creating inconsistent data. Existing research results on the reliability of different types of 3D scanning equipment and data acquisition systems and the usage of gained anthropometric data [15] for pattern design, as well as on permissible measurement deviations mostly show good results [16].

The further use of anthropometric data obtained in 3D scanning is wide in various industries for solving various tasks, and data is mostly easily exportable for different purposes - further quantitative analysis of data, use in CAD systems, work with the virtual human shape/clone (scanatars) in other 3D systems, etc. The repeatability of measurements provided by the scanatar stored in the database is an advantage when it comes to obtaining additional data, for example, if a new/specific product is to be designed or modified design methodology requires the use of additional body measures.

Additional features that are practically impossible with manual measurement methods are exploring the specifics of the body stature, the asymmetry of the body, and the location of the adipose tissue. It is possible with additional measurement tools available in the system, the exact body shape reproduction and the ability to gain cross sections, as well as to superimpose scans. In addition, if the set of measures to be automatically obtained in the system is not complete, there is a possibility to program and later obtain additional measures automatically (for example, in AnthroScan system).

In the apparel industry body scanning is used for: anthropometric sizing surveys, mass customization, fit and shape evaluation, virtual modelling and online fit analysis purposes [17].

For issuing garments to special groups of people with the support of 3D body scanning and garment CAD is beneficial in different ways: saves time; reduces costs; gives size recommendations; for sizes out of sizing table scope made-to-measure patterns can be provided; 3D scanatar allows to analyse human body if the shape differs from standardized one; all garments issued are uniformly made and meets end-user needs. Size recommendation and pattern CAD brings new opportunities for inventory and new garment development optimization, virtual prototyping (virtual garment simulation), and online shopping to work on improvements on garment fit and consumer satisfaction [17].

Virtual prototyping, compared to traditional real sample sewing, provides opportunities to reduce product development costs (materials, production) and time (production). Critical factors for reliable virtual prototyping are access to appropriate virtual human body shapes and capabilities to define material properties for realistic fabric simulation. Regarding the virtual human body in virtual garment systems also have been developed standards [18], [19]. Studies of different types and approaches confirm the benefits of 3D scanning by obtaining human body reproductions to study and design both casual and special clothing with virtual prototyping techniques. For example, in research about special protective clothing for sport aircraft, a seated 3D body model was used for research [20]. Although still complicated and incomplete, similarly are analysed and evaluated possibilities to design clothing for people with different body shapes and different physical limitations [21].

II. Materials and methods

The special group of people in this study includes 50 women who are members of a choir and therefore encounter with a necessity to wear clothing of a united style. Supply of an equally well fit and appearance clothing for members of this collective can obviously be a difficult task given that the participants are aged 19 to 57 years (standard deviation (hereafter - SD) 8,4 years) and differ in terms of body shape: body height 154-181 cm (SD 6,2 cm), weight 52 to 132 kg (SD 19,8 kg), bust circumference 89-139 cm (SD 13,3 cm), waist circumference 66-125 cm (SD 15,3 cm) and hip circumference 91-145 cm (SD 12,5 cm).

Anthroscanner VITUS SMART XXL® (Human Solutions Group GmbH) with AnthroScan data processing system was used to obtain anthropometric data. Hardware and software meet the requirements formulated in ISO 20685 [22]. For every woman, 153 body measurements were automatically retrieved, data processing and compilation were performed for further analysis.

Within the study, the members of the research group were asked to indicate the size of clothing worn in daily life, both upper body and lower body garments. It was done with the purpose of finding out whether the end users themselves have the knowledge and clear approach of finding the appropriate size clothing.

The gained anthropometric data after processing and analysis allowed choir members to be grouped in the appropriate size groups and to compare the distribution with indicated sizes to determine compliance. For size grouping recommendations of EN 13402-3 for size designations and options for range and interval divisions were used [7]. Analysis of individual body measurements within a one-size group of wearers has been performed, selecting body measurements that can play a crucial role in pattern construction of upper body garments for providing fit, traditionally used bust circumference, across back width – armpit level, neck to across back width – armpit level and shoulder width.

III. Results and discussion

Summarizing the size of everyday-wear items indicated in the questionnaires, it has been observed that wearers are guided by different types of size designations, and, given the differences between manufacturers, some of the respondents have included several designation types. The following types of size designations and their frequency have been discovered, both of upper and lower garments:

a) numeric size - differ from 36, 40, 42, etc. to 52 (upper garments 31%, lower garments 53%);

b) letter size - differ from S, M, L to XXL (upper garments 5%, lower garments 2%);

c) different combinations showing that wearers are not confident about the appropriate size or choose different sizes depending on the manufacturer:

- numeric size - two sizes e.g. 38/40 (upper garments 13%, lower garments 20%);
- letter and numeric size - e.g. M, 40 (upper garments 20%, lower garments 11%);
- combinations - letter and numeric, e.g. M/L, 38/40 (upper garments 26%, lower garments 9%);
- completely different size type - e.g. UK size (both type garments 5%).

Most popular type used is a number size, nevertheless a relatively large part of group members have indicated combinations (multiple numeric, letter designations), showing an experience of respondents in size meaning diversity. Within this group of people, it serves as proof of confusing differences in sizing systems, which may affect the ability to choose the appropriate size clothing.

For further analysis, a conditional situation when the whole group should choose to clothe from one manufacturer guided by their own perception of the appropriate size is simulated. For this task, each of the indicated size designations is given a consistent explanation by a range in centimetres based on EN 13402-3 size ranges for numeric and letter designations. Already using obtained anthropometric data the size for each subject is determined according to the recommendations of EN 13402-3, for upper garments using bust horizontal girth as a primary dimension and for lower garments - waist girth. The aim is to make a comparison and analyse how many of the participants would be able to choose appropriate size clothing in this situation, given the lack of knowledge and understanding of size explanations.

Comparison of garment size distributions (Fig. 1) shows the differences in wearer perceptions and distribution by gained anthropometric data according to EN 13402-3 examples. The most distinct differences for upper garments are in the size groups of ranges 84-92-96, 100-104, 110-116 and 122-128 when part of the subjects does not belong to this group, consequently wearing smaller or larger size clothing. It can be concluded that some part of the subjects may be wrong considering

belonging to size 84-88 and 134-140, although they should wear larger size garments for appropriate fit. In the lower body garment distribution comparison significant differences appear in the size group 73-77. For the rest sizes - it can be predicted that a significant part can make a mistake and select a smaller size of lower garments.

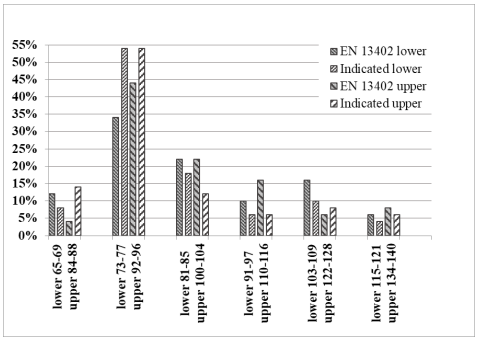

Fig. 1.Comparison of size group distributions of upper and lower body garments by indicated sizes and sizes according to measures.

Experimental comparisons confirm the need to obtain anthropometric data for a full picture of a particular group or population and the ability to develop an appropriate sizing system. Considering the size of the group, the most appropriate method for obtaining anthropometric data is the human body scanning. It is necessary to inform consumers about the size explanations (ranges) so that the end-users knowing main body measurements would be able to choose the most appropriate size.

The analysis described before is based on one primary dimension for upper and lower garments. In a further study, the whole group of subjects was divided into sizes by two measurements (primary and secondary) according to the distributions specified in EN 13402-3. The standard includes an example of division of upper body garment sizes by bust and hip girth ranges. A number of possible proportions of bust and hip girths are shown in the standard, when differnet hip range scales can mach to certain bust range scale (88 to 140). The combination of scales depends on the body measurement tables used by the manufacturer or on the availability of anthropometric data of a particular target group.

The distribution of the research participants (Fig. 2) points to the group differences in bust and hip girth proportions. Two scales of hip ranges are rather widely represented, including 21 (42%) and 13 (26%) subjects, however in total resulting in 7 different combinations of the bust and hip range scales. Manufacturers of mass production are not economically interested in producing such a large number of combinations of sizes that require extra time for pattern alterations and stock management without guaranteeing demand for rarely represented sizes. The most represented sizes in the developed table are marked with symbol "*", for example, 5 participants with a size 96-104 which means compliance with the bust girth interval 94-98 and hip girth interval 102-106.

	Bust girth ↓												
	88	92	96	100	104	110	116	122	128	134	140		
Hip →	84	88	92	96	100	104	108	112	117	122	127	count	%
			1		1							2	4%
Hip →	88	92	96	100	104	108	112	117	122	127	132		
		3	1	1						1	1	7	14%
Hip →	92	96	100	104	108	112	116	121	126	131	136		
		1	4*	5*		2	1					13	26%
Hip →	96	100	104	108	112	116	120	125	130	135	140		
	1	4*	5*	2	1	2	3	1	1	1		21	42%
Hip →	100	104	108	112	116	120	124	129	134	139	144		
	1	1	1									3	6%
Hip →	102	106	110	114	118	122	126	131	136	141	146		
								1				1	2%
Hip →	106	110	114	118	122	126	131	136	141	146	151		
		1			1					1		3	6%
count	2	10	12	8	3	4	4	2	1	3	1	50	

Fig. 2. Upper garment size distribution by bust girth (primary measurement) and hip girth (secondary measurement).

In another example for upper body garments, bust and waist girths are combined. The distribution (Fig. 3) reveals two broadly represented scales, including 22 (44%) and 10 (20%) subjects, but in total illustrates 6 types of proportions within the research participants.

	Bust girth ↓												
	88	92	96	100	104	110	116	122	128	134	140		
Waist →	67	71	75	79	83	89	95	101	107	113	119	count	%
	1	3	2	2					1	1		10	20%
Waist →	69	73	77	81	85	91	97	103	109	115	121		
		4*	8*	4*	2	2	1				1	22	44%
Waist →	73	77	81	85	89	95	101	107	113	119	125		
	1	2		2								5	10%
Waist →	75	79	83	87	91	97	103	109	115	121	127		
					1	1	1	2		2		7	14%
Waist →	77	81	85	89	93	99	105	111	117	123	129		
		1	2									3	6%
Waist →	81	85	89	93	97	103	109	115	121	127	133		
						1	2					3	6%
count	2	10	12	8	3	4	4	2	1	3	1	50	

Fig. 3. Upper garment size distribution by bust girth (primary measurement) and waist girth (secondary measurement).

The most represented size within 8 participants is 96-77 meaning compliance with the bust girth interval 94-98 and waist girth interval 75-79. Multiple combinations of scales are needed to satisfy the entire group of wearers if the sizes are based on bust and waist girths.

Sizing by hip girth as primary measurement and waist girth as a secondary measurement is an example for lower body garments (Fig. 4). The most represented waist range scale includes 14 (28%) subjects, and the rest of the total 7 types indicate the differences in hip and waist girth proportions that leads to the production of a large number of different sizes to ensure end-user satisfaction with the fit. The most represented size by 6 participants is 104-77 meaning compliance with the hip girth interval 102-106 and waist interval 75-79.

	Hip girth ↓													
	92	96	100	104	108	112	116	120	125	130	135	140	145	
Waist →	59	63	67	71	75	79	83	89	95	101	107	113	119	count	%
								1						1	2%
Waist →	61	65	69	73	77	81	85	91	97	103	109	115	121		
		1	3*	1						1			1	7	14%
Waist →	65	69	73	77	81	85	91	97	103	109	115	121	127		
	1		2	6*	2	1	1		1	1				15	30%
Waist →	69	73	77	81	85	89	95	101	107	113	119	125	131		
	1	1	4*	2	2									10	20%
Waist →	71	75	79	83	87	91	97	103	109	115	121	127	133		
						1	2	1	1		1			6	12%
Waist →	73	77	81	85	89	93	99	105	111	117	123	129	135		
	2	1	1	2										6	12%
Waist →	77	81	85	89	93	97	103	109	115	121	127	133	139		
			1			1		2		1				5	10%
count	4	3	11	11	4	3	3	4	2	3	1	0	1	50	

Fig. 4. Lower garment size distribution by hip girth (primary measurement) and waist girth (secondary measurement).

The production of all the necessary sizes would not be in accordance with the sustainable principles of manufacturing in terms of economic development and resource consumption. The review of the anthropometric profile of end-users is the basis for finding the most adequate solutions for issuing clothing if people are with specific needs and different body characteristics. Therefore, 3D scanning is a prerequisite for fast and reliable anthropometric data acquisition for ensuring the implementation of analysis and usage in sizing and pattern alterations for made-to-measure clothing.

A separate group of people which belong to the most represented size (8 subjects) of upper body garments (bust girth range 96 with interval 94-98 cm, waist girth range 77 with interval 75-79 cm) were chosen for an insight of value distribution of some individual body measurements relevant for upper garment pattern design. In total 4 basic patterns of close-fitting bodice were developed for the comparison within the study (according to Winifred Aldrich methodology [23]): by standard body measures compliant with EN 13402-3 charts made for women of medium height (160-172 cm), by the smallest gained values of the 8 subject group, by the largest values of the group and average ones. All the described allowances in the methodology were consistently used for all pattern design.

Body measurement analysis and visual comparison of patterns in Fig. 5 shows that main differences are observed in armscye depth which is defined by the neck to across back width (armpit level) measurement. According to the standard tables used in the methodology armscye depth for bust girth 96 cm is 21,8 cm, nevertheless, gained measurements show significantly smaller values from 16,5 to 18,3 cm (average 17,3 cm, SD 0,5 cm). The armhole may be too deep when designing close fitting clothing without additional analyse of the target group measurements.

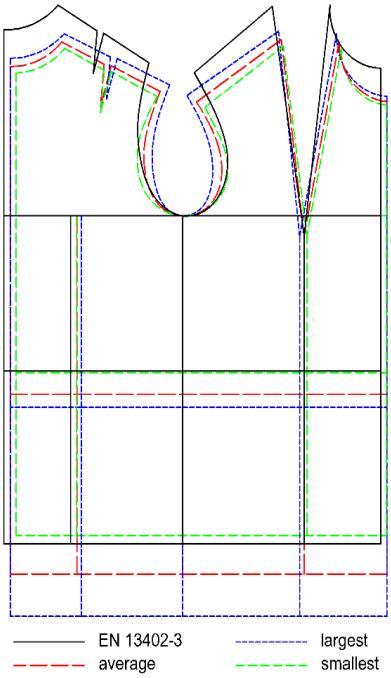

Fig. 5. Basic patterns of close fitting bodice.

The shoulder width, which determines the length of the shoulder, also shows significant differences (Fig. 6). The tables in the methodology compiled according to EN 13402-3 suggest 12,8 cm of shoulder length, however body measurement show values from 12,4 to 14,2 cm (average 13,3 and SD 0,7 cm). Product design by standard tables without additional measurements can result in tightness of the garment in shoulders at least for a part of the group.

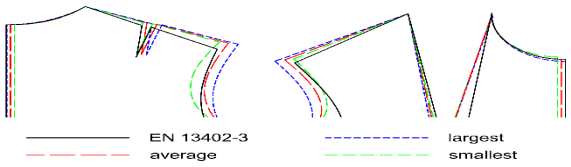

Fig. 6.Copmarison of shoulder length in close fitting bodices.

Differences decisively affecting the pattern structure are observed also in a nape to waist measurements and less important in the waist to buttock measurements. Following the observations, patterns were redesigned by using the most appropriate measurement values to satisfy fit and appearance requirements.

To conclude, the differences in body measurements compared to the standard tables observed in the studied one-size group are significant and may affect the fit and appearance, especially when close-fitting products are provided. Only by gaining a full set of body measurements the analyse is possible for further development of appropriate sizing system and identification of measures for implementation in patterns of made-to-measure clothing.

IV. CONCLUSIONS

Human body scanning provides a wide range of benefits for the usage in research and improvements of clothing fit. It serves as an effective tool for the rapid and reliable acquisition of anthropometric data of end-users. Without these capabilities, data acquisition for special groups would be difficult when it comes to the need for understanding anthropometric profile and looking for the most appropriate sizing solutions. Initially obtainable information and the possibilities of anthropometric data revision leads to a sustainable approach preventing the production of low-demand sizes and thereby consumption of materials. In addition, the usability of 3D scanning in analyses of body proportions and individual body features as well as in virtual prototyping is growing over time.

The distribution of 50 women by sizes in this research shows the potential difficulties in finding uniform apparel from mass production. The results are evidence to the group's confusion about the differences in sizing systems and their explanations as well as insufficient knowledge about their individual body characteristics for finding the matching size. Differences in close fitting bodice patterns made by standard tables and by real body measurements

indicate the need for knowledge about anthropometrics of the target group and made-to-measure approaches in garment supply for special groups.

In the cases where a special group of people with different body characteristics needs to be supplied with uniform clothing, human body scanning is the most successful method for anthropometric data acquisition for analysing, for sizing purposes and made-to-measure clothing production.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 142-146

Necessity of Customer Loyalty Formation and its Peculiarities in the Telecommunication Services

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***Abstract*— Everyday life is unimaginable without telecommunication services; they are the significant players in the national economy. All business activities, including the ones of telecommunication services, are directed towards the satisfaction of customers' needs and wants, and hence towards the profit earning. This process, in its turn, entails the formation of different company/customer relations, where both parties want to gain something out of these relations. The company strives, first of all, to increase the turnover and profit, while the customer wants to receive the desired services, information and the proper attitude. These customer gains can be basis of the loyalty formation, that is very important for the company, because the process of attracting new consumers always involves spending money, time and energy. The goal of this work is to explore the loyalty formation process and its peculiarities in the telecommunication services. Based on the results of the study, it was found that the experts rated the offer of corporate loyalty programs at the lowest, then followed the service offer and the price, but slightly higher the service quality. The experts assigned the highest rating to the prestige of the service. Based on the low assessment of the experts in the telecommunication industry of the loyalty program offer, the authors propose the conceptual consumer loyalty model for the practical use.**

Keywords*—Consumer satisfaction, loyalty, relationship management, telecommunication services.

I. Introduction

The importance of the behavioral economy nowadays is an indisputable concept, which is confirmed by the Nobel Prize awarded economist Richard Thaler. Focus on consumers, the research and satisfaction of their needs is geared towards the use of consumer relationship management within the company. The consumer satisfaction and its management have become the foundation of the company's competitiveness and the integral part of the business. On the basis of the research carried out, the cost of attracting a new consumer is 5-10 times higher than selling to an existing consumer, and the existing consumer spends 67% more money than new consumers [1]. Therefore, the company's mission is to develop a system that would ensure the consumer's desire to re-purchase and stay in touch. By gaining an understanding of the factors that shape consumer loyalty and using them skilfully, the company earns the greater customer trust and significantly increases its competitiveness. Properly researched and understood the consumer satisfaction factors form a competitive advantage of the company. The telecommunications companies in Latvia do not have the sufficient understanding of the customer relation management, especially the benefits of it.

The current study focuses on the factors affecting the consumer loyalty in the telecommunications sector, albeit the consumer loyalty formation process can never been finished, it is a business improvement mechanism. There are different consumer management systems, however, the unifying criterion for all of them is a satisfied, loyal customer that would ensure the competitiveness in the long run.

The goal of this work is to find out the main factors of consumer loyalty in the telecommunication sector and to define the peculiarities of this process, which would allow companies to improve their performance and ensure their competitiveness.

To achieve the goal, the following tasks were set:

1. To analyze the theoretical factors of consumer loyalty formation.
2. To describe the telecommunications sector and its development in Latvia.
3. To determine the main factors and peculiarities of consumer loyalty formation in the telecommunication industry with an expert interviews.

In order to determine the consumer loyalty trends in Latvia and to put forward the proposals for improvement of consumer loyalty formation, the experts have been interviewed during the research and the following restrictions have been identified: the problem is mainly studied from the methodological aspects. The research period: January 1, 2019 – March 1, 2019.

The following research methods have been used: the logical-constructive method - comparison of theoretical material and empirical results; the graphical method - for

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4124

the visualization and analysis of the visual information, as well as the expert interviews. The methodological basis of the research consists of the works and publications by R. Brandt, C. Homburg, I. Howard, and others, which provide an insight into the factors and processes of the consumer loyalty formation.

II. MATERIALS AND METHODS

Consumer satisfaction is one of the necessary conditions for building the long-term and beneficial business relationships with consumers, but loyalty is one of the most important end results. Loyalty is the result of the consumer's perception of the supply (product, service, brand, etc.), which has led to positive attitudes (cognition, trust and emotional) and positive action regarding the offer (repeated purchases, additional purchases, high consumption intensity, etc.) [2]. The process of attracting new customers to business is much more expensive than keeping the existing ones, since the regular consumers spend more, but the company costs less [3]. The researchers [4] have found that only about 15-20% of the costs necessary to attract new consumers are sufficient to maintain the loyal consumers. Based on empirical studies, the other authors [5] claim that costs of attracting the new consumers is 5 - 7 times higher than keeping the existing ones.

Most empirical studies show that there is a close relationship between consumer satisfaction and loyalty [6] – [7]. There is no single point of view on this relationship. Some researchers believe that the type of relationship may depend on the market situation, the characteristics of the offer, the peculiarities of the target audience. In markets with intense competition, it has been shown, the relationship between consumer satisfaction and loyalty is characterized by a progressive graphical form, but in markets with a relatively low intensity of competition it is characterized by a digressive graphical form [8] – [9]. The empirical studies have demonstrated that there is a relationship between the consumer satisfaction and loyalty, which can be graphically represented by a S-shape, because only when the consumer is seduced, the loyalty rises very fast; when he is in the indifference zone, the loyalty is stable, but the location in the frustration area leads to the loss of loyalty [10]. Other researchers, however, have found occasionally the illogical situations when there are the satisfied, but ill-fated consumers and the unhappy and loyal consumers [11] – [12].

The researchers in the service sector [13] have argued that the customer loyalty is influenced by the service quality, the emotional satisfaction and the corporate image / reputation. The authors have come to this conclusion after a survey of 600 respondents – the service company clients in Greece. Other authors [14] – [15] – [16] demonstrated that the quality of the product and the image of the company directly or indirectly affect the consumer loyalty in other sectors. Still, the authors of the current article disagree with the opinion of the above-mentioned authors that the emotional satisfaction is considered to be a factor influencing loyalty, because in essence emotion is a component of the loyalty attitude dimension, and the satisfaction is the result of the consumption.

In Norway, a special Consumer Satisfaction and Loyalty Measurement (EPSI) rating was developed based on the relevant model (see Figure 1). The model shows that the values perceived by the consumer includes: the image of the company, the consumer's expected supply values, the actual quality of the product and the quality of service. These perceived values determine the satisfaction and the resulting consumer loyalty [17]. Firstly, the model assumes that all factors affecting satisfaction can also affect directly, i.e. without the consumer's perception. In our opinion, this can be true for the consumers with a high degree of loyalty, when the pre-purchase selection is practically automatic. Secondly, the image of the company and the quality of service can directly affect loyalty even without a stage of satisfaction. Obviously, this relationship also depends on the level of loyalty of the consumer, that is, the higher the level loyalty – the higher the level of satisfaction.

Perhaps the study of loyalty attitudes and dimensions of action would have led to other conclusions about the direct impact of loyalty on the progress. The authors of the current research also disagree with the thesis that expectations of the consumer offer is related to values that affect the satisfaction. Before the satisfaction / dissatisfaction is determined, the actual and the expected offers are being compared, and this largely psychological process is linked to the perception of the consumer. Meanwhile, the monetary value is not included in the model unreasonably (see Figure 1).

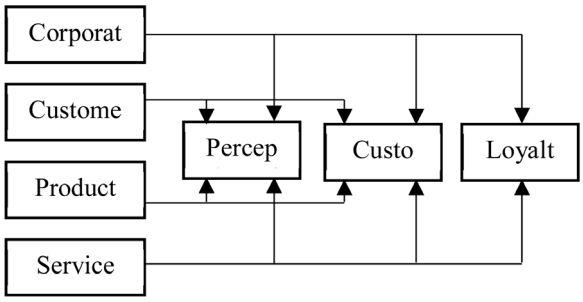

Fig. 1. Loyalty model according to EPSI rating (Source: Authors')

Based on the analysis of the advantages and disadvantages of loyalty models discussed above, the authors recommend to introduce the conceptual consumer loyalty model for the practical use (see Figure 2). This model is versatile in its nature, but can be used in practice, taking into account the peculiarities of the industry / product / brand.

It might be concluded, that the consumer loyalty processes include the following logically related elements:

- Factors influencing loyalty (values);
- Perception of consumer values;
- Peculiarities of the target audience;
- Consumer satisfaction;
- Dimensions of consumer loyalty.

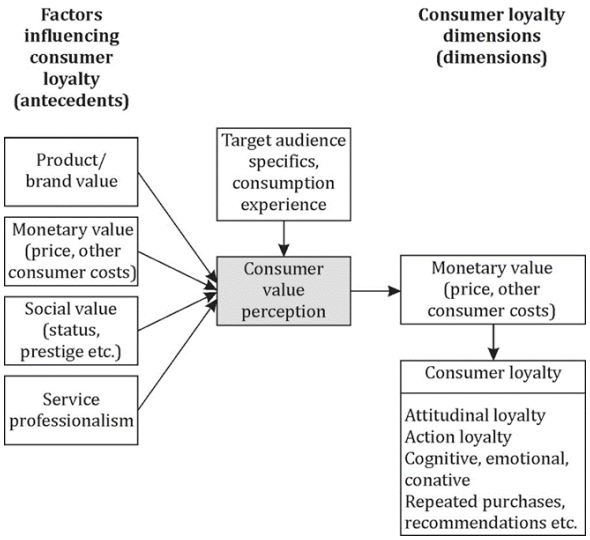

Fig. 2. Conceptual model of consumer loyalty formation (Source: Authors')

The loyal consumers have the following characteristics: they buy more and remain faithful for longer, they are less sensitive to the price increase, and they recommend other consumers to buy and consume / use a particular product / a brand. It is beneficial to the company, because:

- Communication from mouth to mouth costs nothing;
- Recommendations contain specific information based on the consumption / use experience.
- Communication comes from friends and / or acquaintances one can trust.

In essence, the consumer loyalty increases the value and competitiveness of a business because:

- It requires the lower costs for attracting consumers;
- Stable consumer database;
- Increase the product / brand prices within certain limits;
- Promote product sales and profits;
- Promotes a positive image and reputation of the company.

Of course, the peculiarities of the loyal consumer behavior and the benefits of the company depend on the level of loyalty. Therefore, it is necessary to study in more detail the loyalty process in a specific sector of the economy.

III. RESULTS AND DISCUSSIONS

Analyzing studies by various authors, it can be concluded that there are differences in understanding of the satisfaction process in three sectors of the economy: in the consumer goods sector [18] – [19], in the industrial goods sector [20], and in the service sector [21] – [22]. The object of the research of the current study - the telecommunications sector - is included in the service sector.

At the moment, there is a huge increase in the volume of information transmission in the world and the corresponding development of the telecommunications networks. Today's life is hard to imagine without the modern telecommunication means. The development of mobile telecommunication, cable television and fiber optic transmission systems, the strengthening of radio and television broadcasting stations create the increased demand for the services in question (see Figure 3).

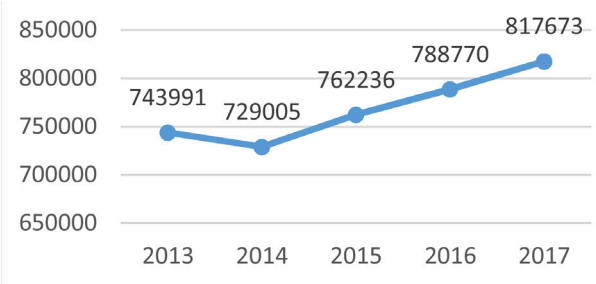

Fig. 3. Telecommunications industry turnover in Latvia in 2013 – 2017 (Thousands of EUR)
(Source: Authors' according to www.csb.gov.lv)

Despite the current growth rates in the telecommunications industry, the internal competition within the industry is increasing. On this basis, companies in the telecommunications sector need a tool that would ensure the competitiveness and create the continuous business relationships with the consumers.

Expert methods are increasingly used in the assessment and forecasting of socio-economic processes. The expert survey is mainly used for diagnosing and forecasting industry problems and analyzing and solving the research problem [23]. The expert is a qualified specialist in the field who expresses his / her opinion, for example, in the evaluation of the activity. In addition, the expert can evaluate different (significant and insignificant) factors, goals, better ways to achieve them, performance results, etc. Thus, the authors of the article have chosen the method of expert survey for the research, which is considered one of the most suitable methods for assessing loyalty in the telecommunications sector. Unlike statistical methods, the experts take into account a number of non-analyzed factors due to their experience and knowledge of the situation in the telecommunications sector.

In the implementation of the expert survey method, the authors followed four stages.

1. Preparation of the expert survey. The following tasks were solved at this stage:
   - the problem to be investigated was formulated and the purpose of the expertise was clarified - to evaluate loyalty processes in the telecommunications sector in Latvia;
   - based on the purpose of the expertise as well as the specificity of its object, a specific expert method was selected - a survey with structured questions;
   - A questionnaire was developed.

2. Selection of experts and composition of the expert group. At this stage, the numerical composition of the expert group was determined, the expertise of the expert group was analyzed, and the experts were provided with the necessary information. After consulting with several experts and taking into account the expertise of

the experts in this field, the authors identified a group of nine experts. When selecting experts, the authors of the thesis were guided by the experience and knowledge of the specialists and by the ability to understand the whole process. Potential experts responded to questions about loyalty factors and the specificities of the telecom sector and, on the basis of this scale, assessed their level of competence in each issue, scoring the maximum in the area in which the specialist is best. The authors then compared the individual evaluations of each specialist with the average self-assessment of all potential experts on all issues. The level of competence of a numerically potential expert was assessed by the formula [24]. As a result a group of experts was formed to include the selected experts, altogether 12 persons, that met all preconditions.

3. Characteristics of the expert survey. The expert survey was conducted in January-February 2019. Based on the objectives of the expertise and taking into account the peculiarities of the expert group, the authors of the thesis chose the following expert survey characteristics:

- An individual survey, where experts participate independently from each other;
- Extramural survey, where experts provide individual responses without the direct assistance of the organizers of the expertise;
- A closed-type survey when each expert is not informed about the answers of other experts;
- Closed-ended questions, where for each evaluation (according to Likert's scale in a 10-point system, 1 very low, and 10 very high), a certain scale has been given above, and the expert only has to choose one of the quantitative assessments.

4. Statistical methods of processing and analysis of expert assessments. If expert evaluations are given in scores, a broad statistical analysis can be performed. Using the SPSS computer program, the authors calculated the following indicators:

- the amount of expert assessment;
- Average Arithmetic Expert Assessment ($\bar{X}$);
- Median (Me);
- Mode (Mo);
- Variation amplitude;
- Standard deviation;
- Coefficient of variation [25].

Based on the factors influencing loyalty, five blocks of questions were created - service and service quality, service price, service provider's business performance, service prestige and service provider program offerings. The results are depicted in the Table 1.

Table 1 Evaluation of the loyalty formation factors by the experts in the telecommunications (Source: Authors')

Criteria of evaluation of telecommunication enterprises	Arithmetic mean	Average arithmetic standard error	Median	Mode	Standard deviation	Dispersion	Variation	Max evaluation	Sum
Quality of service and servicing	5.22	0.80	6.00	2.00	2.39	5.69	5.08	8.00	47.00
Service price	4.44	0.75	5.00	5.00	2.24	5.03	5.61	7.00	40.00
Performance evaluation of the service provider company	4.33	0.75	5.00	5.00	2.24	5.00	5.73	7.00	39.00
Service prestige	6.78	0.83	8.00	8.00	2.49	6.19	4.08	10.00	61.00
Offer of service provider loyalty programs	3.78	0.89	3.00	1.00	2.68	7.19	7.89	8.00	34.00

In order to assess the situation in the telecommunication sector, the authors of the article conducted analysis of the results of the expert survey (see Table 1). As it can be seen, the lowest rating ($\bar{X}$ = 3.78; Me = 3.0; Mo = 1.00) was assigned to the criterion "service provider loyalty program offer". Mostly, it was due to the lack of loyalty programs or an ineffective operation. This is a significant score, as consumer loyalty is a very important indicator of competition. It is also apparent from the data on the company's own performance ($\bar{X}$ = 4.33; Me = 5, 00; Mo = 5.00) and service prices ($\bar{X}$ = 4.44; Me = 5; 00; Mo = 5.00). The experts pointed out that the cause of the termination of the service is mostly related to the telecommunications companies themselves. This fact points to the unfair behavior by the company and the restriction of consumer choice. According to the information provided by the telecommunications industry, the business services are used by the consumers over a long time period, but there are signs of the forced loyalty, according to the experts. In general, it should be noted that the indicators have rather low ratings and a large amount of variation (see Table 1). In addition, there is a pronounced trend - the lower the average arithmetic (X,), the greater the variation volume. This means that different companies have different valuations for different aspects.

IV. CONCLUSIONS AND RECOMMENDATIONS

1. Consumer loyalty is the result of the perception of supply by consumers, which has led to positive attitudes and favorable behavior for the company.
2. The consequences of consumer loyalty are diverse, but its main aim is to facilitate the repeated purchases. Other signs of loyalty - low sensitivity to prices and positive "mouth-to-mouth" communication are less typical because they do not relate to retail valuation as a whole but rather to attitude to the individual products / brands.
3. Based on the results of the study, it was found that the experts rated the offer of corporate loyalty programs at the lowest (3.78), then followed the service offer (4.33) and the price (4.44), but slightly higher the service quality (5.22). The experts assigned the highest rating to the prestige of the service (6.78). Evaluations, in general, are very low, but do not reveal the real reasons for the assessment that goes beyond the present study.
4. Based on the low assessment of the experts in the telecommunication industry of the loyalty program offer, the authors propose the conceptual consumer loyalty model for the practical use (see Figure 2). This model is versatile in nature, but should be used by taking into account the peculiarities of the industry / product / brand. From the point of view of the authors, the loyalty model (see Figure 2) should be the basis of the relationship with the consumer formation and management process.
5. In the telecommunications sector, the consumer loyalty should be addressed more specifically, since by now there has been a little research.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 147-153

Application of Circular Economy in Shrinking Regions

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***Abstract*— Shrinking of rural regions is going on in Eastern and Western European countries. Shrinking phenomena includes Latvia, Lithuania, Estonia and other countries and regions. The shrinking region is considered as untoward and gone territory for economic growth particularly from the perspective of policy makers. Shrinking region requires specific tools for development. The aim of this study is to analyse theoretical options for circular economy development in shrinking regions. The growth economy which requires planning more and more profit, units of goods, jobs etc. is not an adequate strategy for shrinking regions. The desktop approach is applied by analysing research articles on shrinking phenomena and circular economy with aim to explore the potential benefits provided by application of principles of circular economy in shrinking regions. The study also reviews policy planning documents on circular economy and regional development at the European Union level and specifically in Latvia which has lost dramatic proportion of inhabitants in last few decades.**

The findings of the study show that at first, national policy and EU policy does not accept the phenomena of shrinking regions; second, principles of circular economy are applicable to shrinking regions. There are such challenges as cooperation, philosophy of consumption and values, willingness and availability to pay for services. The study will open a discussion about shrinking rural regions and circular economy from another perspective because until now circular economy is mostly related with the zero waste concept.

***Keywords*— circular economy, shrinking rural region, planning, balanced development.**

I. Introduction

Low population density is one of the characteristics common to European rural areas [1], [13] and rural regions currently account for 28% of Europe's population [5] also population shrinking is actual in economically well developed country as Japan [22], [15] and in fast growing China. As the number of residents is shrinking, including by ageing, density of the population is reducing more distinctly in rural territories where it is necessary to look for other development directions as opposed to the growth strategy. In general, the shrinking as such is not a new concept; however, urban shrinking has been studied more [26], but less attention has been paid to studies of this aspect in rural territories [28], [30]. European Union programme ESPON considers rural shrinkage as *a* demographic and economic phenomenon and refers to it as *"part of wider trends in European territorial restructuring, where agriculture has become less labour intensive and economic and employment growth has become progressively tertiarised, favouring larger urban centres"*. [5]. Thus shrinking of rural regions is a result of structural complex changes brought on by interrelated factors, including globalisation and coping with it requires new approaches to planning [30]. At the same time, we can note that the world as a whole is experiencing continuous population increase and economic growth, while overall the world's natural ecosystem is shrinking by size and volume [18].

In this article we will look at shrinking rural areas from such an angle that shrinkage in regions mainly is connected with a dramatic population decline, but there are also other challenges such as jobs, service provision, vacancy of buildings, downgrading of public transport, deterioration of the quality of the environment, not many alternative industries growing, maintenance of infrastructure, social problems longer travelling distance to services [25], [26], [28], [33]. In a shrinking region GDP per capita is lower, there is also higher unemployment rate, population ageing, interregional state aid transfers, loss of creative and innovative talents and the capacity to react to change [6], therefore it is not surprising that shrinking of rural regions and shrinking in general is automatically considered a failure and associated with low quality of living. It is necessary to see new opportunities, new economy to cope with this phenomena [26], [28], [32], [13]. Muller and Siedentop shows decline oriented planning characteristics that include recycling of land and buildings, qualitative development, cost efficient stock development, reconversion, small scale functional mix and taking account of life cycle of facilities and demographic changes etc. [25].

This study approaches to shrinkage as potential positive opportunity and identifies circular economy as an alternative way to cope with shrinking by reviewing previous studies and development planning documents. Also, studies on circular economy are more often related with development in an urban environment, and therefore the research paper binds together these two concepts with an aim to analyse the potential of application of circular

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4196

economy principles in the shrinking rural regions. According to Eurostat (2018) Latvia is among the top three countries experiencing the greatest population decline in the Europe, therefore development planning documents in Latvia will be placed under specific scrutiny.

A term *integrated rural development* focuses on modern comprehension of endogenous model by emphasizing the perceived need to break down barriers in sectorial policy among economics, society and environment at the local level. Integrated rural development contains three principles as integration, individuality, involvement. From circular economic point of view, it is significant to reach integration between sectorial policies for harmonising economical, social and environmental goals [1].

Latvia's population on March 1, 2011, in accordance with the 2011 Population and Housing Census data was 2,070,371. Since the previous Population and Housing Census 2000 the population has decreased by 13%. Before and including the Population and Housing Census 1989, the number of population has been growing rapidly. During the period between Census 1935 and Census 1989, the population of Latvia increased by almost 40%. The urban population in this period increased 2.7 times, while the rural population decreased by 35%. Since 1990, both the total population of the country, as well as urban and rural population has been declining [2].

Since the 1990s, Lithuania lost almost one-quarter of its population, and some regions within the country lost more than 50% of their residents caused by large-scale emigration, natural population decline and changing residential mobility patterns. According to United Nations (as cited in Ubarevičienė & van Ham, 2017), it ranks Lithuania among countries with the greatest population decline in the world. Between 2000 and 2010 in Lithuania, the population decline was –10.4% [36].

Researchers courageously write about shrinking regions in shrinking country in Lithuania by putting this phrase in the title of a research article in a scientific discussion as well as in policy making meetings, while in Latvia quite a few avoids to use such phrases as a shrinking region or shrinkage [28] however, Latvian situation is not unique as ESPON (2017) states that idea of accepting decline is often politically unpalatable. Ubarevičienė *et. al* mentioned that in Lithuania most of the regional planning is still growth-oriented in spite of the population decline. In the concluding part of Ubarevičaine's article, attention has been drawn to the situation that there are no elaborated long-term strategies for adaptation of shrinkage [35]. In declining areas, the most efficient strategy would be to accept a decline and concentrate services in the accessible regional centres.

Portuguese researchers suggest specific approaches, strategies and recommendations to deal with shrinkage: vacant properties and land banks, housing and integrated regeneration, de-suburbanisation and social capitalisation, regional, technical infrastructure, transportation and finance [34].

The report "The Impact of demographic changes on European regions" initiates alternative forms of production of services and options to improve economic development perspectives. Gløersen *et.al* (2016) offers to use silver economy, volunteering, residential economy, remittances and self-perception and branding for fiscal sustainability in regions and localities [11].

Paula (2016) analyses theoretical models for rural development by grouping them in two categories: exogenous and endogenous development models. Margarian criticises endogen development approach which is used in European Union for rural development [21], [27]. Ray (2001) introduced term neoendogeonous model where external factors are crucial for rural development, but at the same time it is indicated that local territory has a potential to advance its development [29].

The authors stress the significance of shrinking of rural areas and continue the string of studies exploring alternative ways how to cope with this phenomena, in this case, by focusing to the possibilities provided by circular economy.

II. Methods

Desktop research methodology consisted of several steps: first literature review on circular economy and shrinking regions were implemented by conducting analysis in the Web of Science core collection database and Google research engine by the searching topics "shrinking rural region", "circular economy for regions" in timeline from 1998 to 2019 February. It was followed by identification of related policy planning documents and reports at European Union level (9 documents) and as case example at national level in Latvia (3) suggesting application of circular economy practices in the context of development of rural territories. Finally, authors identified several principles of circular economy that can be applied to cope with shrinkage in rural territories.

III. Circular economy in the context of rural shrinking

The European Parliament study shows the typology of "shrinking regions" 2005-2030 into four categories. We will focus on the countries whose examples and studies have been used in the present article. Latvia and Estonia have been put into category "certainly decreasing", Lithuania into "probably decreasing", Portugal into "probably decreasing" and a few other regions into "probably increasing" (growing regions). According to EU statistics the most significant population shrink per 1000 people in 2018 was in Lithuania, Croatia and Latvia [9]. Pužulis&Kūle argue that in Latvia and other places in Europe, the he policy planning documents do not respond to phenomenon of shrinking rural regions adequately. Shrinkage requires planning for a smaller amount at a higher quality [12], [28]. Table 1 demonstrates findings of policy planning documents regarding shrinkage and circular economy approach in EU and Latvia.

Table 1 Review of policy planning documents and study reports on shrinking regions and circular economy

Year	Tittle of policy planning document, report	Mention of regions shrinkage	Mention of circular economy
2017	Shrinking regions and innovative solutions: entrepreneurship, employment and the accessibility of services. Study report.	Shrinking regions	Co-design service Product innovations (integrated social care and health)
2017	Report of the implementation of the Circular Economy Action Plan. (European Commission)	none	Changes in legislation to increase validity term of 2 years for goods, Ecodesign, Food waste, Secondary market operations, Green public procurement, Construction& demolition
2017	Shrinking rural regions in Europe: Towards smart and innovative approaches to regional development challenges in depopulating rural regions. Policy brief.	Shrinking rural regions, depopulation	Fostering ecosystem services and the green economy through circular economy
2016	The impact of demographic change on European regions	Ageing, population shrinkage at regional level	Income circulation between regions and localities, residential economy, volunteering
2016	EIO Bi-annual report 2016 "Policies and Practices for Eco-Innovation Up-take and Circular Economy Transition"	Local governments	Re-use, sharing, collaborative consumption, repair, user–led eco-design, material loops, resource efficiency
2014	Rural Development Programme of Latvia 2014-2020	None	Rural development includes activities with environmentally friendly management methods
2013	Common Agricultural Policy 2014-2002 (European Commission)	Challenges of areas touched by demography, economy and social issues Support for competitiveness in all regions	Food security, organizing of food chain, resource efficiency, quality of soils, water; Support and promotion of agricultural, forestry and food production activities which direct to climate change friendly management
2012	National Development Plan of Latvia for 2014–2020	Markets are shrinking (paragraph 66); Stability for Demographic Growth; Decline of population in regions	Waste separation, recycling, Green public procurement
2010	Sustainable Development Strategy of Latvia until 2030	"Intelligent shrinking" Silver economy	"Green economy" Eco-efficient economy
2010	The EU 2020 strategy	Ageing	Sustainable growth, greener economy, resource efficient Europe
2008	Shrinking Regions: a Paradigm Shift in Demography and Territorial Development. Study. European Parliament, 2008. Directorate-General for internal Policies of the Union.	Shrinking region	The chances of new and attractive economic zones developing; Mobile services
2001	Report The Nature of Rural Development: Towards a Sustainable Integrated Rural Policy in Europe	Remote rural areas Attractive peripheral areas Less favored area	Good management of the environment Integration across sectors

The National Development Plan (NDP) of Latvia for 2014–2020 has set three priorities: growth of the national economy, human securitability and growth of the regions. It has been stated in the planning document that the economy expands and Latvian regions are thriving (paragraph 52). The NDP is aimed at a growth model (paragraph 367). In order to stem these negative trends, it is necessary to increase economic activity in the regions and development centres by attracting and using the resources of the surrounding territories, encouraging the development of business activity and the transport and ICT infrastructure, developing and fully utilising the potential of educational institutions and boosting people's mobility. This would facilitate the creation of new businesses and jobs, providing an impetus for living and working in the regions. Cross-border international cooperation that provides greater opportunities for implementing strategic development projects is an important precondition for the regional development [3].

The EIO Bi-annual report 2016 "Policies and Practices for Eco-Innovation Up-take and Circular Economy Transition" shows that Latvia had the highest proportion of people (3,18) employed in selected recycling, repair and reuse sector per 1,000 inhabitants in 2014 among EU member states. The situation is radically different in relation to the turnover per 1,000 employees in the circular economic sectors. Researches name such factors as lack of skills and knowledge, social capital in

shrinkage regions [4].

Sepp and Vaamee found in a case study of Austria that regions with population decline are not automatically regions with work economic performance or low quality of life [32]. In case of Latvia, the government is concentrating services in the largest cities and in regional centres, but it brings to related problems that promote shrinking in Latvian regions. Pužulis un Kūle (2016) point at consequences of such policies, naming closure of schools as an example – in these cases loss to the local municipalities grows fourfold because teachers lose jobs, tax payments into the local governments' budget decrease, more financing will be transferred to the neighboring municipalities and there will be more expenses for transportation of pupils [28]. However, it is significant to emphasise that transport expenses and payments to other municipalities are hardly the only loses. School closure is frequently followed by cancellation of regular bus service, closed enterprises and increased flow of emigration. As a result, people from such places move to other areas, transport expenses grow, including for the local government to transport pupils to schools, the social capital that is needed to find new development opportunities in rural employment, self-employment, creation of services and export in the territory is shrinking [19].

Pužulis&Kūle (2016) mark further issues of study of shrinking rural regions, such as: What services are needed and how are they being provided? What settlement models can be proposed for shrinking areas?

The circular economy is increasingly debated on the agenda of the European Union, as well as several of Member States follow the calculation of circular economic benefits and it is included in their policy planning documents [17], [18]. Kalmykova *et.al* has analysed 118 documents from which 17 refers to circular policy. Universities follow the idea of circular economy and introduce it into their training programmes. One of the courses of the interhigh-school intensive study programme took place in March 2019 in Latvia, the University of Liepāja, which was implemented by partners from Finland, Estonia, Lithuania and Latvia.

Sepp and Veemaa (2017) indicate five activities for improving accessibility of services and responding to shrinking with new services: innovative mobility solutions, broadband ICT and Internet based e-solutions, delivery outlet solutions, co-design and co-delivery of services and new services responding to and capitalising on shrinking and ageing processes [32]. The concept of service co-design contributes in the circular economy context, at least as collaboration among different partners, researchers, designers, customers, potential customers and users. Circular economy approach is illustrated in product innovation by integrating social care and health services. Thus, these proposals on availability of services in the shrinking regions show on such circular economy component as sharing and sharing and cooperation in governance. The sharing economy is an opportunity for a circular economy that ensures sustainable development is identified in the studies of a number of researchers [16], Korhonen *et.al* (2018) note that the shrinking process is a complex issue that includes many parties (local municipalities, schools, NGO, private sector, clusters, inhabitants etc.). [18] Importance of society engagement in development processes is indicated by Vaeliverronen *et al.* (2017) stating that municipalities would gain if they invested more effort into creating a system to intensify community engagement instead of isolated project-based activities [37]. In order for the circular economy to operate successfully, the stakeholders should cooperate closely. Stahel argues that a circular economy builds on self-responsibility of economic actors and higher competitiveness through more efficient free market solutions, technical and commercial innovation [10]. Mobility solutions in shrinking and remote areas show that locals are using self-organising activities to find ways for mobility. In carried out interviews, we found that 79% of respondents to interviews are using ride-share mobility. Other option is transport on demand which is implemented in several remote rural areas in Germany, Finland etc. instead of regular public transport by saving resources and environment.

Franconi *et. al* (2016) name three key factors for circular business models: resource use, service lifetime, and economic value creation. The good match is when service lifetime is higher and economic value is higher [10]. Stahel indicates a statement that policy makers and economic actors of the manufacturing economy do not know principles of circular economy, nor their impact on the economy. Confirmation for this statement is made in report of Latvian rural spatial development (2012) by analyzing statistical data by sectors in rural municipalities, excluding municipalities in Pierīga statistical region): 63% of economically active units deal with agriculture, forestry and fishery; 28% in service industries, 5% in manufacturing industry, 2% in building and 2% in other [33]. Analyses of rural development areas as system (e.g. Paula, 2016) claim that traditional agriculture mainly dominates in rural policy planning documents; however, a consumption of bio products is increasing in the world. For example, there is conducted research about the role of psychological determinants for organic consumerism in Australia [23]. Taking into account the trend of bio product consumption, bio farming should be considered as an alternative economic development opportunity for shrinking rural areas.

IV. Results and discussions

On the basis if previous studies and analysis if regional planning documents, application of solutions in solving the problems of shrinking rural regions based on circular economy principles and elements are identified in Table 2. Five groups of challenges faced by shrinking rural regions have been analysed (mobility, vacancy of buildings, waste collection&recycling, service location, bio agriculture), offering the ideas how to apply circular economy principles in shrinking areas.

The circular economy in shrinking rural areas has the biggest potential to contribute to social field by integrating new mobility solutions such as ride sharing, renting rooms or houses for visitors in short term or in long term for living. The challenging precondition for sharing economy is established close cooperation among people in and outside the community. New workplaces are created, restructuring existing jobs with a new use of unused resources.

The main benefits in the circular economy in rural areas would be new markets for previously unused, usage of recycled resources for creation new products. Free resources can be leased, offered for rent, thus reducing potential start-up costs, and making a place more attractive to other entrants, including entrepreneurs. Successful business examples attract young people, entrepreneurs, who make the site attractive to both local residents and guests.

The components of the circular economy in the shrinking regions contribute to waste reduction, composting and to the smart use of water resources in the natural environment.

One of the challenges faced by shrinking rural territories are increased costs for servicing and maintaining infrastructure. In this context, the opportunities provided by circular economy to save resources and consequently costs, should be emphasized.

Table 2 Application of circular economy approach to rural shrinking regions

Principle, element of circular economy	***Problem in rural shrinking region***	***Application***
To increase level of efficiency of goods, less consumption Resource sharing principle	Mobility for people to services, work, recreation, lifelong learning etc.: · Limited options of public transport; · Restriction to use School bus for non-students.	At the moment mobility as ride-sharing (communicating by call, social media etc.) and self-organisation of mobility options exist. Self-organisation is viable approach without any additional resources. There is an option for changes to use efficiency of School buses in rural regions by allowing School bus service for others. In case of Latvia, mobility is paid twice by public taxes for the same reason at the same time
Resource sharing principle	Vacancy of buildings: · Empty houses, buildings; · Second homes.	Long-term rent, short-term rent for temporary workers, visitors. Option is to organise community-based NGO who is dealing with rent.
Zero waste strategy	Free and unused resources Recycling bins far away from residential houses. Less waste in rural areas: · Composting (+); · Burning of waste (-).	Used for new products, services as well as nature for inspirations of new designs Using bio composting Waste bags for recycling (free of charge) Use of food waste for animal feed
To reduce foot carbon emissions and to decrease food waste	Services are located in larger urban areas: · People need to travel longer distance for shopping; · Buy more than necessary at present.	Business is providing mobile retail shops in remote areas (service to people). · Goods are expensive, less preferences; · Limited socializing. Travelling to shop longer distances, but seldom: · Buy more than necessary ® use as food for chicken, pigs, rabbits; · More extra time and fuel spent. Option to use online shopping of biggest merchants, but delivery is more expensive in rural areas. Online shopping excludes socialising.
Organic farming in whole product chain	Organic agriculture options instead of traditional agriculture	There is potential to deal with organic agricultural production. Market growth for organic products (+) Rural area is added value for marketing, if it is not industrial and does not pollute the area (+) Far away from the market, includes expenses of fuel, time, quality of roads for fresh fruit etc. (-)

V. Conclusions

1.The application of circular economy principles provides an opportunity to decrease rising costs of services and infrastructure maintenance in shrinking regions.

2. Findings of the conducted literature review show that there is an opportunity to apply principles of circular economy in shrinking rural regions. The policy planning documents increasingly recognizes the shrinking regions recently; however, inappropriate instruments

for development of these regions are proposed, mostly applying the growth development strategy principles as confirmed by several study reports from different countries and policy planning documents at the EU level. Shrinking rural regions are a challenge to policy makers, requiring close cooperation and integration among sectors and stakeholders of all levels, as it has been confirmed by Hospers (2014).

3. Cooperation is the basis of successful functioning of circular economy. At present, separate circular economy principles are applied in the shrinking regions, for example, unofficial, self-organised ride-sharing service which is developed in a situation when there are no other solutions, namely, in a crisis situation, to ensure mobility. Thus, to strengthen the potential of circular economy in shrinking territories, municipalities should initiate and support activities strengthening local community and grassroot initiatives.

4. This study is based on desktop approach and provides novel, although rather general connections between shrinking regions and circular economy. It identifies the potential of circular economy to contribute shrinking economy; however, applied field studies in shrinking territories would be needed to design more elaborate solutions.

5. The development of circular economy in shrinking territories is related with a need to welcome new motivated entrants in shrinking territories which is not typical. Strategic support from both local and national government to initiatives that have potential to attract specific type of stakeholders to live or work in shrinking territories is one of the crucial preconditions to initiate and strengthen practices of circular economy in shrinking territories.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 154-158

The Role and Importance of the Protected Areas' (Emerald Network) Development for Amphibians and Reptiles on the Example of Ukraine in the Context of Various Factors' Influence

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Abstract*—Creation and expansion of the Emerald Network (EN) objects is one of the most promising directions of the nature conservation development in Ukraine according to European standards. The aim of EN objects designing is to assess the state of conservation of habitats and flora/fauna species' populations on a pan-European level. It is assumed that the EN should cover at least 60% of the populations of species and the area of habitats mentioned in Resolutions (4 and 6) of the Berne Convention (1979). Later on, the EN will be integrated into Natura 2000 system. The other countries' experience is of great importance in creating such territories. Since 2004 Latvia have joined this network and included 333 sites (12% of its territory). In Ukraine, such network is only being developed. Four Ukrainian biogeographical regions are inhabited by 6 amphibian and 5 reptile species for which according to Emerald Biogeographical Seminar ALP (Carpathians) - CON - PAN, 11-13 May 2016, Chisinau, Moldova, the EN in not sufficient, being indicated as IN MOD (moderately developed) in 90% of cases. A total of 63 suggestions of new EN (1628256,4 ha) objects aiming on herpetofauna conservation among others were designed during 2018-2019 and now are waiting to become candidate sites and later on – a part of Ukrainian EN. Most of these sites represent valuable territories of wild nature in the rivers' floodplains. For Latvia and Ukraine conservation of marginal populations of the following species is important: crested newt *Triturus cristatus* (Laurenti, 1768), fire-bellied toad *Bombina bombina* (Linnaeus, 1761), pond turtle *Emys orbicularis* (Linnaeus, 1758). In the work the importance and the ways in which the EN can act for the above mentioned species' conservation are highlighted, taking into account experience of European Union, future trends in the influence of anthropogenic factors, invasive species and climate change.

Keywords*—Emerald Network, amphibians, reptiles, conservation.

I. Introduction

Development of Emerald Network (EN), namely designing new sites and expansion and correction of already existing boundaries, is one of the most promising directions of the nature conservation in Ukraine nowadays. The Emerald Network (CM) is a modern network of protected areas of particular importance for the conservation of natural habitats and biodiversity. These areas are called Areas of Special Conservation Interest (ASCI). The legal basis for the creation of the EN is the Berne Convention on the Conservation of European Wildlife and Natural Habitats (1979) in Europe and observer countries, to which Ukraine belongs. 5 January 1999 is a date of the Berne convention's ratification by Ukraine. The territories of the Natura 2000 nature conservation system already include the territories of the Emerald Network after certain country becomes an official member of European Union [1, 2]. The key reasons for assigning particular territory to the list of perspective "Emerald" objects is the presence of the habitats from Resolution No 4, 1996 and the species of plants and animals from the Resolution No 6, 1998 of the Berne Convention on it. In Ukraine, intensive work on the identification and collection of information on potential objects to be included to the Emerald Network was conducted in 2009-2011. For today the inclusion of new proposed sites to EN is going on and is about to be

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4100

finished in 2020 [3]. *Triturus cristatus*, *Bombina bombina*, and *Emys orbicularis* are rare and protected herpetofauna species in Ukraine, Latvia and neighbouring countries [4], where the above mentioned species demonstrate decline of the populations' size and frequency of modern findings is getting lower [5, 6, 7]. The main reasons for this include anthropogenic transformation of habitats, impact of climate change, especially in Polissya region (Ukraine) [8], presence of invasive predators [9]. That is why these species require special conservation efforts.

All of them are listed in Resolution No 6 of Berne Convention and have their own codes: *E. orbicularis* (1220), *T. cristatus* (1166), *B. bombina* (1188). For these species according to Emerald Biogeographical Seminar ALP (Carpathians) - CON - PAN, 11-13 May 2016 (Chisinau, Moldova) and Emerald Biogeographic Seminar STE - ALP (Caucasus) - BLS, 6-8 September 2016 - Final Conclusions (Kyiv, Ukraine) the EN in not sufficient in almost all cases. Following this, these species have IN MOD status (EN moderately developed) for Continental, Pannonian and Steppic biogeographical regions which means they require designing of additional Emerald sites to be protected in. For *E. orbicularis* only 30% of actual registration points are covered by official EN, for *B. bombina* this figure is approximately 20% and only 12% for *T. cristatus*. What is more, due to rapid decrease of number of modern findings and habitat loss, crested newt is prepared to be included to the next edition of Red Book of Ukraine (2019).

As for 01.03.2019 106 new Emerald sites have been proposed to be included to the EN. Among them there are those proposed by authors of this paper. The main aim of this article is to assess whether new propositions improve the situation with EN sites for the mentioned species' protection and figure out the main risks and drivers that can be avoided according to the type of objects proposed as Emerald sites for protections of herpetofauna among other groups. Also the comparison between Latvian conservation of the species in Natura 2000 objects and Ukrainian Emerald Network taking into account the space of conservation areas will be done.

II. Materials and methods

The information of actual state of Emerald network in Ukraine was obtained from official Berne Convention web page through Emerald viewer soft (https://www.coe.int/en/web/bern -convention/emerald-viewer). The data on amphibians and reptiles conservation propositions within newly proposed Emerald sites was obtained from the Ministry of Ecology and Natural resources of Ukraine under the general principles. It should be noted that the authors actively participated in submitting the new Emerald objects' proposals, so original data is also presented in the paper. The info about herpetofauna representatives within the site was collected from the literature and from original authors' data for the past 20 years. The map was created in GIS programs: QGIS v.2.18.28 and DivaGis v.7.5. Statistical analyses was conducted in Statistica v.10. The representativeness of newly designed network is calculated as a percent of the areas designed for herpetofauna conservation from the whole Emerald Network territory in Ukraine and the entire territory of the country. Only the areas of Emerald objects are used in calculations. Habitats of mentioned species themselves occupy much smaller areas within the site, but their assessment has not been conducted yet. These species are confirmed for the site based on registration points and separate findings but it doesn't mean that the whole site territory is inhabited by the species. Nevertheless, site's area is quite reliable figure to assess the percentage of territories where conservation of mentioned 3 species is stipulated. Analytical forecasts related to climate change were carried out using the program BIOCLIM models - DIVA GIS v.7.5 (http://www.diva-gis.org). Climatic data consisted of 19 bioclimatic variables (http://www.worldclim.org/) [10] with spatial resolution of 2.5 minutes. Personal databases of herpetofauna findings were used: (Ukraine – Nekrasova O., Latvia – Pupins M., Pupina A., Ceirans A.) as well as GBIF (https://www.gbif.org/) of *E. orbicularis* (1126 points); *B. bombina* (2235 points); *T. cristatus* (2017 points) of the Eastern part of the range (from Ukraine to Latvia). For counting points, the SAGA GIS program was used.

III. Results and discussion

In 2019 a total of 106 new sites were proposed to be included to Emerald Network of Ukraine. 48 of them are aimed on protection, among other species, of *T. cristatus*, *B. bombina* and *E. orbicularis* (Fig. 1).

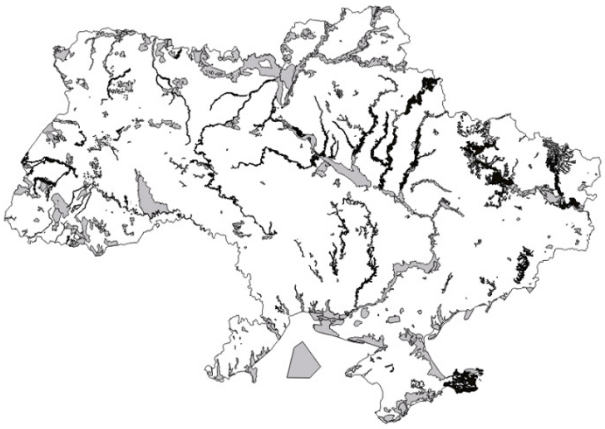

Fig. 1. Emerald Network of Ukraine. EN (2016) is highlighted in grey; newly proposed sites that include protection of *T. cristatus*, *B. bombina* and *E. orbicularis* are highlighted in black; newly proposed sites where protection of these species is not stipulated are highlighted in white.

E. orbicularis. Official EN of Ukraine provides sites with total area of 3905611,00 ha where protection of pond turtles is stipulated among others. This species is presented in all biogeographical regions: Continental (CON, 2483207,00 ha), Steppic (STE, 1289386 ha), Pannonian (PAN, 5392,00 ha) and Alpine (ALP, 127626,00 ha). Among objects, proposed in 2019 there were no areas from Pannonian and Alpine regions. The total area of newly proposed sites, where pond turtles' protection is stipulated, is 809543,09 ha for Continental region and 355236,08 ha for Steppe region. In total

the area for the species' conservation is proposed to be increased by 29,82% (Fig. 2).

B. bombina. Official EN of Ukraine provides sites with total area of 3497774,00 ha where protection of fire bellied toads is stipulated. This species is presented in 3 biogeographical regions: Continental (CON, 2430413,00 ha), Steppe (STE, 1061969,00 ha) and Pannonian (PAN, 5392,00 ha). Among objects proposed in 2019, there were no areas from the Pannonian and Alpine biogeoregions as well. The total area of newly proposed sites, where fire bellied toads' protection is stipulated, is 719313,12 ha for the Continental region and 295992,19 ha for Steppc biogeoregion. In total the area for the species' conservation is proposed to be increased by 29,03% (Fig. 2).

T. cristatus. Official EN of Ukraine provides sites with total area of 3478129,00 ha where protection of crested newts is stipulated. This species is presented in Emerald objects of 3 biogeographical regions: Continental (CON, 2685616,00 ha), Steppe (STE, 436052,00 ha) and Alpine (ALP, 356461,00 ha). Among objects proposed in 2019, there were only those situated within the Continental biogeoregion. The total area of newly proposed sites, where crested newts' protection is stipulated, is 3131992,75 ha. In total the area for the species' conservation is proposed to be increased by 12,83% (Fig. 2).

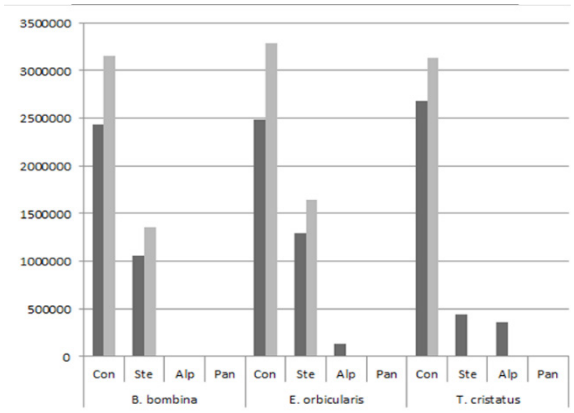

Fig. 2. Areas (ha) of Emerald objects (official network (2016) – dark grey, official network (2016) with proposed sites' areas added – light grey) where *E. orbicularis*, *T. cristatus* and *B. bombina* are mentioned in the list of target protected species of the site.

After the designing of new EN sites the number of registration points covered by the EN has significantly increased for all three species: from 29% to 42% for *B. bombina* (Fig. 3), from 15% to 25% for *T. cristatus* (Fig. 4) and from 32% to 43% for *E. orbicularis* (Fig. 5).

In Ukraine *T. cristatus* and *B. bombina* like other rare amphibian species (e.g. natterjack toad, *Epidalea calamita* (Laurenti, 1768)) continue to suffer from climate change, continuously losing their natural habitats [11]. Invasive fish species are considered to be a serious threat. Eels, carps and other fish prevent breeding success of *B. bombina* completely. Tadpoles usually don't survive and, what is more, adults refrain from spawning in the water that contains fish. In such a case toads will migrate to other localities if possible [12]. Both toads and newts suffer from habitat transformation and fragmentation as well as from invasive species (e. g. *Percottus glenii* (Dybowski, 1877) [9].

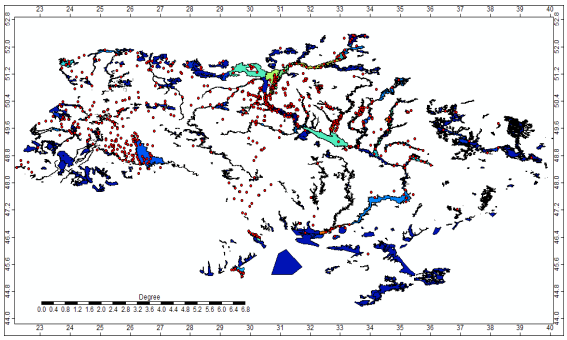

Fig. 3. Coverage of fire bellied toad registration points by extended EN (after adding of newly designed sites).

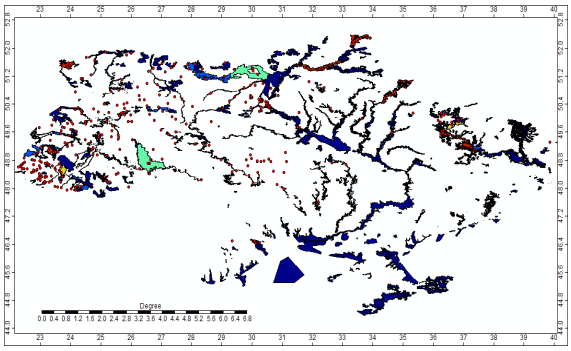

Fig. 4. Coverage of crested newt registration points by extended EN (after adding of newly designed sites).

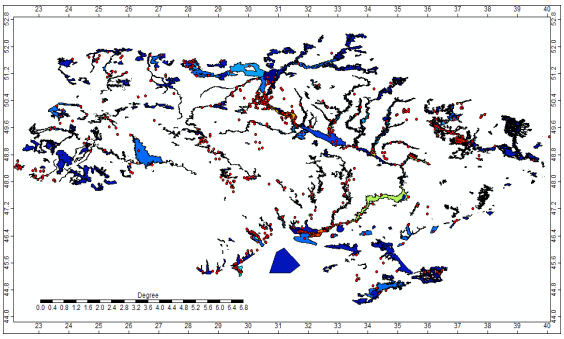

Fig. 5. Coverage of European pond turtle registration points by extended EN (after adding of newly designed sites).

Pond turtles are also becoming prey items for number of invasive predators (golden jackal (*Canis aureus* Linnaeus, 1758), raccoon dog (*Nyctereutes procyonoides* Gray, 1834). Numerous cases of turtle clutches' excavation by a raccoon dog indicate a targeted search for it. The eggshell was not found in the faeces, as it remains at the site of the excavated clutch. The situation in Ukraine is quite the same as in Belarus. Currently in the Belarussian Polissya zone approximately 40% of all turtles' clutches are excavated and eaten by foxes, raccoon dogs, wolves, stray dogs and other predators [4]. These facts are consequences of climate change and anthropogenic activity that allow invasive species to expand their natural areas while bioclimatic zones are slowly moving to the North. This allows to predict that it is highly likely that those countries where only populations' edges of the species were to be found, will become more suitable for them in future. For example, Latvia can be mentioned as a

country where all 3 species exist [16, 17] and are protected at national level within Natura 2000 sites, that occupies 12% of Latvian territory. Only marginal populations of *E. orbicularis*, *T. cristatus* and *B. bombina* exist within the country [18, 19] and the percentage of Natura 2000 objects where they are protected is considerably smaller, than in Ukraine, taking into account also the countries size (Fig. 6).

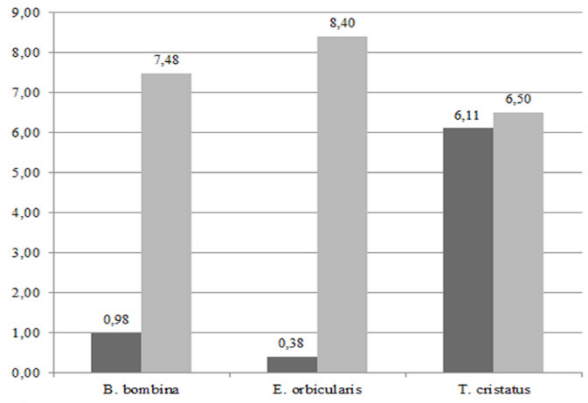

Fig. 6. Percentage of Natura 2000 and Emerald Network areas (from the area of the country) where protection of *E. orbicularis*, *T. cristatus* and *B. bombina* is stipulated: light grey – Ukraine, dark grey – Latvia.

IV. Conclusions

As a result of GIS modeling, it was revealed that the distribution of amphibians and reptiles depends on such climatic indicators as: Max Temperature of Warmest Month, Max Temperature of Warmest, Mean, Temperature dependence – for *E. orbicularis* and *B. bombina*; Temperature Seasonality (standard deviation*100), Temperature Annual Range - for *T. cristatus*. Modern bioclimatic conditions are favorable for the species on 15 to 18% of the territory of the Eastern part of the range (from Ukraine to Latvia). In the face of an increase in temperature by 1◦C, it is predicted that the area of this territory will decrease by one and a half times, and the range will shift to the North towards Latvia. Similar trends have been described using other programs [11]. Therefore, the southern populations of amphibians and reptiles will be severely affected. In this regard, the protection of the hydraulic systems (especially southern), such as rivers' valleys, natural marshes and adjacent territories is of great importance. After extending of Emerald Network with newly designed sites, areas, where these species should be protected has increased for all three species. Taking into account the further development of special management plans for each territory and for particular animal groups within, it is thought that more populations of *B. bombina*, *T. cristatus* and *E. orbicularis* will be saved in the terms of global climate change and "moving" of biogeographical regions' borders to the North. The creation of the new sites shows a positive trend for further conservation of mentioned species. Currently Ukraine has higher percentage of territories than Latvia, where protection of the 3 species is stipulated. Meanwhile in terms of global climate changes and successful reintroduction practices [13, 14, 15] in Latvia more space will be required for these species' conservation in future.

V. Acknowledgments

The authors thank anonymous reviewers for constructive comments on the manuscript. We thank the Ministry of Ecology and Natural Resources of Ukraine, International charity ecological organization "Environment. People. Law.", Polish environmental fund "Fundacja Dziedzictwo Przyrodnicze" for their help in collecting of material and work with Standard Data Forms of objects of Emerald Network in Ukraine. The study was conducted in accordance with legislation of Latvia and Ukraine. We thank Daugavpils University for support.

VI. References

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 159-163

Chemical Alterations of Hardwood Veneers Due to Thermal Treatment

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***Abstract*—Wood is the most popular building material in the world due to its universal versatility, although it has disadvantages - the difficulty to apply small diameter logs in construction, hygroscopicity and anisotropic swelling and shrinking. To solve these disadvantages, plywood from wood material is produced. Plywood is a material that can solve anisotropy, but it is still biodegradable by rot and stain fungi. Thermal treatment is a methodology that improves the durability of wood. In this paper aspen (*Populus tremula* L.), poplar (*Populus x canadensis* Moench) and birch (*Betula pendula* Roth) were treated by steam (WTT) and vacuum (TERMOVUOTO) devices under 160°C/50 min (birch and aspen), 204°C/2 h, 214°C/2 h, 217°C/3 h, 218°C/30 min (birch and poplar). Chemical changes in treated veneers were investigated by ATR-FTIR (Attenuated Total Reflection Fourier Transform Infrared Spectroscopy) in a range 2000 cm^{-1} – 800 cm^{-1}. ATR-FTIR is a non-destructive methodology, which is important during manufacturing process quality control. Untreated poplar wood and aspen wood had similar ATR-FTIR spectra because both species belong to *Populus* genus. Untreated birch wood had higher absorption intensity peak at 1740 cm^{-1}, which indicates the C=O bond stretching in the carboxyl group depicting more acetyl groups in birch wood than in aspen/ poplar. According to spectral data, birch wood, treated in TERMOVUOTO process at 200°C for 2 hours is chemically almost identical to untreated one. WTT process causes the most significant changes in the chemistry of both in aspen and birch. Therefore, regime 160°C/50 min in water vapour is more aggressive than treatments at higher temperatures and under reduced pressure. It is expected that plywood produced from WTT treated veneers will have reduced strength in comparison with TERMOVUOTO process produced ones.**

Keywords — FTIR, termovuoto, veneers, WTT.

I. Introduction

Wood is used extensively all around the globe since the beginning of civilization. Throughout history, men have discovered the advantages and disadvantages of the material. Wood has excellent strength to weight ratio [1], it is visually appealing and easy to handle. There are big differences among the wood species because of its density, hardness and durability peculiarities that should be taken into consideration for the chosen usage.

Several wood drawbacks are characteristic to all species – wood is a hygroscopic material with anisotropic properties depending on grain direction. Hygroscopicity leads to its sensitivity towards fungal attacks [1]. Rot and stain fungi are the two main groups, that threaten wood. Hemicelluloses are the main wood ingredient that is nutrient for fungi.

From the construction point of view, it is burdensome to use logs with a small diameter, therefore they are rotary-cut veneers and from them engineered wood – plywood is made. Plywood is a material that can solve the usage of small diameter logs. It has dimensional stability [2] and reduced anisotropy, but it still remains biodegradable.

Thermal treatment is a methodology that improves the durability of wood. Thermal modification occurs at elevated temperatures in the reduced oxygen environment. There are many thermal treatment methodologies available. Thermowood®, Plato wood® and Rectified wood® are commercial examples, but there are also the non-commercial methodologies as WTT (Wood Treatment Technology). Hemicelluloses are the wood constituent that is degraded the most during thermal treatment. The changes occur in lignin are mainly by self-condensation, but cellulose is the most rigid component of wood during thermal treatment [3]. Wood degradation is catalysed due to acetyl group cleavage from hemicelluloses and acetic acid formation. Wood thermal treatment with simultaneous removal of destruction products reduces the degree of degradation. Silvapro® [4], SmartHeat ® [5] and Termovuoto® [6] are the processes that use the reduced pressure for that.

Chemical changes in veneers due to thermal modification can be investigated by ATR-FTIR (Attenuated Total Reflection Fourier Transform Infrared Spectroscopy), which is a non-destructive methodology. This technique is based on the determination of the interaction between an IR (infrared) radiation and a sample. It measures the frequencies at which the sample absorbs (wavelength) and the intensities of these absorptions. Functional groups are responsible for the absorption of radiation at different frequencies, therefore this information can be used for identification of samples

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4147

chemical structure [7]. FTIR can be used also in quality control during manufacturing of thermally modified wood. The main peaks that characterize chemical changes during thermal modification are unconjugated C=O stretching at 1724-1734 cm-1 that corresponds to esters, ketones, aldehydes and acids [8]. and C=C benzene ring vibration in lignin 1504-1516 cm-1 [9], [10] as well as C-H deformation in cellulose at 892 cm-1 [10].

The aim of this study is to evaluate chemical changes in hardwood veneers after thermal modification by means of FTIR.

II. MATERIALS AND METHODS

Three low-density hardwood species were used – aspen (*Populus tremula* L.), poplar (*Populus x canadensis* Moench) and birch (*Betula pendula* Roth). Rotary – cut aspen and birch veneers were treated with WTT technology under the previously determined optimal regime 160°C/50 min. The process is described in detail previously in Grinins paper [11]. Rotary-cut poplar and birch veneers 600×600×1.5 mm were treated in four experimental regimes 204°C/2 h, 214°C/2 h, 217°C/3 h, 218°C/30 min in TERMOVUOTO process, which is in more detail described by Sandak [12], although this process was modified – veneers were treated under convective heat regime, between aluminium plates in packs 3 to 12 pieces, which is more alike processes in manufacturing.

Sample size used for obtaining spectra were 20×20×thickness mm; without veneer surface treatment.

ATR - FTIR spectra were obtained using BRUKKER Alpha device with the platinum-diamond prism. Mathematical processing of spectra was made using OPUS 7.5 software. The spectra were taken in a range 2000 to 800 cm^{-1} with spectral resolution 4 cm^{-1}, using 72 repeated scans of each spectrum. Afterwards, the spectra were normalized, using cellulose CH vibration peak at 1030 cm^{-1} as a reference and the baseline was corrected using 62 points and 10 iterations, the influence of CO_2 were excluded. Integration of peak area was made according to R-method built-in OPUS software.

Spectra that characterizes certain treatment regime were obtained by averaging spectra from three samples, measured in three different places of each sample (nine spectra in total).

Spectral results at which absorbance occurs are presented by putting wavelength (cm^{-1}) on the x-axis and absorbance (relative amount of infrared radiation absorbed by sample) on the y-axis.

III. RESULTS AND DISCUSSION

When comparing untreated aspen, poplar and birch spectra, it can be concluded that untreated birch samples have significantly higher absorbance at 1734 cm^{-1}, which reveals the C=O stretching in the non-conjugated carbonyl group [13] depicting initially more acetyl groups in birch wood than in aspen/poplar that coincides with Kocaefe [14]the wood is heated to higher temperatures than those of conventional drying. The wood structure changes due to decomposition of hemicelluloses, ramification of lignin, and crystallization of cellulose. The wood becomes less hygroscopic. These changes improve the dimensional stability of wood, increase its resistance to micro-organisms, darken its color, and modify its hardness. However, wood also might loose some of its elasticity. Consequently, the heat treatment conditions have to be optimized. Therefore, it is important to understand the transformation of the chemical structure of wood caused by the treatment. In this study, the modification of the surface composition of the wood was followed with Fourier transform infrared spectroscopy (FTIR. It indicates that birchwood contains more hemicelluloses with acetylated side groups than aspen or poplar woods. Minor differences between aspen and poplar wood can be observed at 1150 cm^{-1} and 1100 $cm^{-1,}$ which implies minor differences in the content of cellulose in these veneers [8].

The main thirteen peaks that can be seen in ATR-FTIR spectra of veneers in the wavelength range 2000 cm^{-1} – 800 cm^{-1} are listed in Table I.

TABLE I.

FTIR peaks	Characterization		
	Chemical Group	Constituent	Source
895 - 903	C_1-H bending of anomeric carbon	xylan	[13]
1026 - 1032	C-O-C stretching of aliphatic ether bond	xylan, lignin	[13]
1048 - 1051	C-O stretching primary alcohol, arabinoxylans	hemicelluloses	[15], [16]
1108 - 1110	C-O stretching secondary alcohol	cellulose	[15]
1159 - 1166	C-O-C symmetrical vibration C=O in conjugated ester groups (lignin)	cellulose, hemicellulose, lignin	[17], [18]
1231 - 1235	CO-OR stretching of acyl-oxygen bond (hemicellulose) Stretching of the benzene-oxygen bond (lignin) O-H phenolic	hemicellulose, lignin	[13], [19]
1317 - 1322	C-O in carboxylic acids, alcohols, esters in hemicellulose C-H vibrations in cellulose	hemicelluloses, cellulose	[20], [21]
1369 - 1375	C-H bending	cellulose, hemicellulose	[13], [19]
1416 - 1422	C-H Stretching of an aromatic skeleton bending	lignin, cellulose	[13]
1447 - 1463	-CH_3 and -CH_2 unsymmetrical bending Aliphatic C-H bendings	lignin, cellulose	[13], [22], [19]
1506 - 1512	C=C Stretching of aromatic skeleton	lignin	[13], [19]
1590 - 1597	C=C Stretching of the aromatic skeleton; C	lignin	[13]
1732 - 1740	C=O stretching of non-conjugated carbonyl Uronic acid and acety lgroups in hemicelluloses	xylan, hemicelluloses	[13], [22]

The extent of thermal alteration depends on several factors such as the state of the wood specimens, the temperature load and the duration of the treatment [23]. The intensity of the IR radiation absorption peak at 898 cm^{-1} is the lowest for untreated specimens 0.07 but it increases till 0.11 for the veneers treated at the highest treatment temperature. This band is present in the wood spectra due to the β-pyranose ring but it is absent in the spectra of lignin, so it characterizes wood cellulosic structures [22]. The peaks around 1030 cm^{-1} have minor alterations by thermal treatment so the cellulose C-H bond vibration peak at 1030 cm^{-1} was used as a reference in the normalization of spectra.

Aspen wood was treated according to WTT technology only. The moist environment in the WTT chamber favoured degradation of hemicelluloses with carbonyl compounds formation during aspen wood thermal treatment that caused the increased absorption at 1730 cm^{-1} in comparison with the untreated aspen wood samples spectra in Fig. 1. It coincides with the modified samples lowered absorption at 1240 cm^{-1} in Fig. 1. This absorption band is characteristic for acyl-oxygen bond stretching in hemicelluloses esters H_3CCO-OR. It implies to deacetylation of hemicelluloses during thermal modification. The increased absorption of treated samples at 1100 cm^{-1} and 1050 cm^{-1} implies that the content of destruction products has increased significantly.

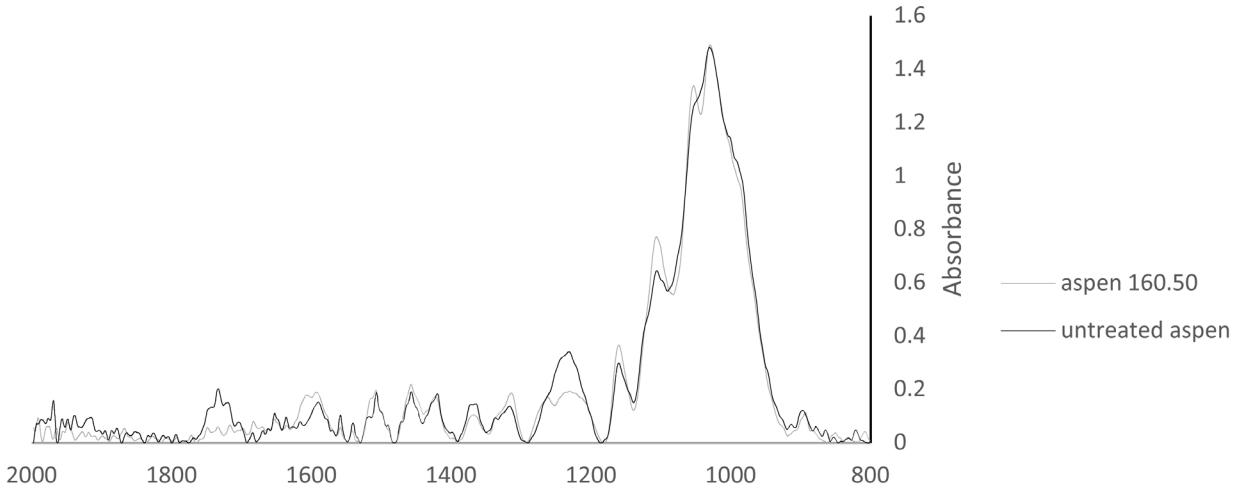

Fig. 1 ATR-FTIR spectra of aspen

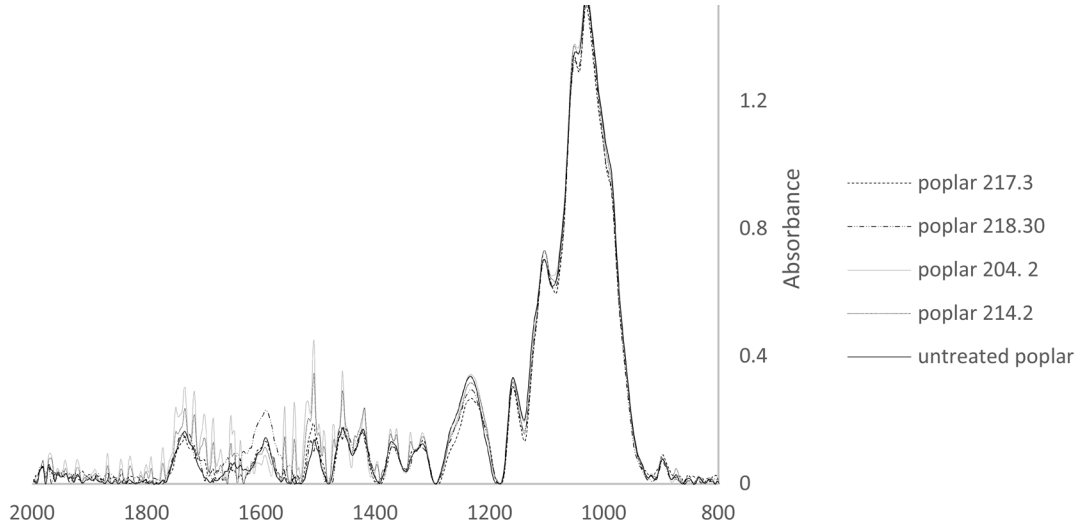

Fig. 2. ATR-FTIR spectra of poplar

During wood thermal modification according to TERMOVUOTO process, wood components gasiform destruction products and water vapour were evacuated from modification environment that decreased their hydrolytic and acid catalysis effect on wood in comparison with WTT technology. The increase of severity of TERMOVOUTO process (204°C/2 h, 214°C/2 h, 217°C/3 h, 218°C/30 min) decreased and slightly shifts to right the absorption band peak at 1230 cm^{-1} of ATR-FTIR spectra of modified poplar wood samples as shown in Fig. 2.

This could characterize cleavage in hemicellulose structure. Disturbance in spectra can be explained with surface roughness, due to larger brittleness of thermally treated poplar wood compared to birch wood.

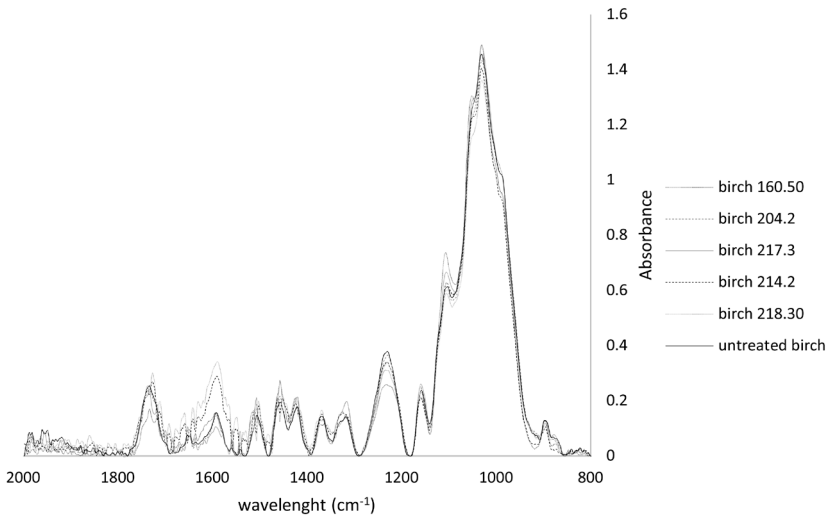

Fig. 3 ATR-FTIR spectra of birch

Birch is the only species of wood in this research that was treated both in WTT and THERMOVOUTO technology. In Fig. 3 there can be seen that alterations in birch wood spectra are the largest at 1580-1588 cm^{-1} highest for birch wood samples treated with 218°C/30 min, with a gradual reduction for 214°C/2 h then 160°C/50 min, then 217°C/3 h and 204°C/2 h. This peak characterizes lignin aromatic ring vibration in aromatic C=C band and this coincides with findings of Ercin [22], where this peak increases with increasing treatment temperature and the relative content of lignin in material increased due to hemicelluloses decomposition. As lignin holds the wood cells together, alteration of its structure can weaken the material. At 1100 cm^{-1} the height of peak increases only for 160°C/50 min regime, which means that alcohols are formed as decomposition products from cellulose.

IV. Conclusions

Treatment regime 204°C/2 h displays very small changes in the ATR-FTIR spectra. Overall, when compared to birch, aspen and poplar display sizable chemical changes in the wood structure. The peak of hemicelluloses at 1740 cm^{-1} and the peak of lignin at 1590 cm^{-1} characterize the severity of the treatment parameters. WTT process causes the most significant changes both in aspen and birch wood. So, regime 160°C/50 min in water vapour is more aggressive than treatments with higher temperatures, but under reduced pressure. To obtain a comprehensive picture about changes in veneers due to thermal treatment, apart from ATR-FTIR spectra subsidiary methods should be used.

Plywood produced from veneers thermally treated according to WTT technology is expected to have less strength than from TERMOVUOTO process produced ones, due to more intense degradation of wood polymer structure.

ACKNOWLEDGEMENTS

The research was carried out within the project P5 "Plywood with improved durability" co-financed by Implementation of Research Program at Latvia University of Life Sciences and Technologies.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 164-167

Study of Overhead Power Line Corridors on the Territory of Pskov Region (Russia) Based on Satellite Sounding Data

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***Abstract*— Overhead power lines (OPL) form the basis of a power grid. Reliable energy supply depends on no-failure operation of these long-length elements of energy infrastructure. More than 12,000 km out of 45,000 km of OPL in Pskov region (Russia) pass through forests. This study investigates the possibilities of using satellite-sensing data to assess the conditions of corridors for OPL with different voltage levels. Authors evaluated compliance of actual data with requirements of national standards. The dynamics of vegetation and local topography based on synthetic aperture radar data and multispectral images were taken into account.**

***Keywords*—GIS, NDVI, overhead power lines, satellite sounding data.**

I. Introduction

Safety and reliability of power transmission systems is an important issue for countries with extensive territory such as Russia. Maintaining the grid infrastructure in proper condition requires various types of monitoring based on different technologies. Legwork with overhead power lines (OPL) as a way of monitoring is still used in many cases, but the economic feasibility of the use of remote monitoring technology becomes more and more obvious.

There are wide range of studies dedicated for different methods and different purposes of OPL remote monitoring. Quite comprehensive review of remote monitoring technologies for OPL contains in [1]. Authors described ways of information acquisition for monitoring of both OPL components and vegetation around them. They discussed satellite and aerial images, laser scanning technology. Many studies are focused on OPL components. Paper [2] describes monitoring system with capacitive sensors for detecting ice accretion on OPL. Such monitoring allows to prevent ice overweight wire breakage. Monitoring of pylon's structural strength is a topic of studies [3], [4]. These studies explore sensors systems and methods of processing obtained data to examine condition of power transmission line poles. Another important components of OPL are insulators. Paper [5] contains feasibility analysis of implementation of RF antenna for online monitoring of outdoor insulators. Partial discharges caused by surface pollution can be negative factor that leads to failure. Surface pollution of insulation as an important factor for monitoring also is described in [6]. Authors measured surface leakage current of disc insulator in laboratory environment.

OPL are spread over large territories with different landscapes and environment. Environmental remote monitoring of OPL is another area for numerous studies. Monitoring of wind speed by fiber Bragg grating anemometer is a topic of [7]. This anemometer does not require power supply for work and is able to transmit signal through optical fiber composite overhead ground wire. Interplay of OPL and bird is described in [8]. Bird strike indicator as a device on wire that allows to get information about bird strikes is a topic of the report [9]. OPL corridors is another area for monitoring. In [10] multispectral satellite stereo images uses to recover 3D-digital elevation model. Detailed review of for OPL corridors monitoring technologies with pros and cons of each technology is given in [1].

Maintaining of OPL corridors is a big issue in Russian electrical power sector. Several years this kind of activity was not sufficiently financed. At the same time the land-use rules was changed to increasing the cost of deforestation. The cost of construction a kilometer of OPL has become comparable to the cost of cutting down a hectare of forest [11]. According to the statistics, about 40% of OPL outages in Russia are caused by contiguity of OPL and vegetation [11]. Such outages occur due to influence of wind, ice accretion and forest fires. In addition to the concept of OPL corridor, which is an empty space around of OPL, an important concept is protection zone of OPL. A protection zone (Fig.1) is a space around OPL where all activities such as building and construction work, agriculture, etc. are limited to prevent electrocution and electromagnetic radiation hazard. Felling of trees in protection zone is also limited by safety restrictions. Distance *h* from outermost to limits of protection zone depends on voltage rating. Distances *h* for different voltage ratings are demonstrated in Table I.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4087

Published by Rezekne Academy of Technologies.

This paper is dedicated to analysis of protection zones, OPL corridors condition of several OPL 330 kV and 110 kV in Pskov region. Analysis is based on satellite sounding data and determination of normalized difference vegetation index (NDVI) inside protection zone.

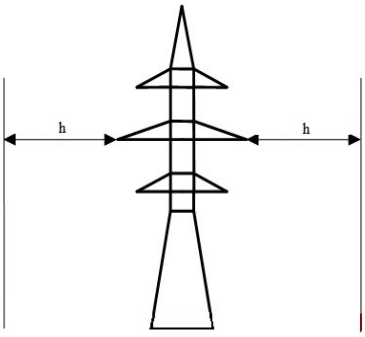

Fig. 1. Protection zone of overhead power line

TABLE I. Distances from outermost to limits of protection zone

Voltage rating, kV	**Distance h, m**
Less than 20	10
35	15
110	20
220	25
330-500	30
750	40
1150	55

II. Materials and Methods

At the moment, the main method of obtaining information about protection zone of OPL in the Russian Federation is a visual inspection conducted by employees of power grid companies. This method has been used for a long time in the electric grid complex and is regulated by technical standards. Significant weakness of the method is the influence of human factor at the stage of collecting, processing and data retention, high labour intensity and considerable time costs, especially when examining hard-to-reach areas of OPL.

In addition to the above methods of collecting information, another cluster of monitoring methods has been intensively formed over the last decades, associated with usage of various technologies of remote sensing data. These methods have high performance, an extensive area of geoinformation collection, provide correct spatial data about parameters of OPL state in digital form and allow to exclude subjectivity at the stage of data collection.

The overgrowing of OPL protection zones with woody vegetation is a significant problem, since the presence of potentially dangerous objects in this area can cause disruptions in the power transmission or even lead to a break in the power lines. The Russian Federation has a huge territory and monitoring the overgrowing of protection zones always is fraught with great difficulties. One of the possible solutions to this problem is the use of remote sensing data. It is less accurate compared with aerial photography in detail and accuracy, but it greatly exceeds in the space of the one-time coverage. Taking into account the capabilities of modern multispectral satellite sensors and the availability of open hubs of data, their use in conjunction with advanced GIS tools allow to identify “risk zones” in large areas in a very short time.

To assess the overgrowth of protection zones, one of the most common and theoretically based vegetation indices — the NDVI index, which is distinguished by a simple method of calculation and rather high accuracy were used. It applies makes it possible to assess the areas of vegetation to be cleared in the protection zone of OPL. In case of doubtful situations, it is possible to check the problematic areas using aerial photography or visual inspection, which in any case, significantly reduces work input.

All stages of data preparation and the creation of vector layers were performed in the QGIS 3.4.

To identify areas of overgrowing of overhead power lines in the territory of the Pskov region, model transmission lines with a voltage rating equal to 110 and 330 kV with a total length of 543.64 km were selected (Fig. 2). Then, in accordance with the standards of protect zone width along all power lines, a buffer zones was created in the vector geo-processing module of the QGIS 3.4. The total area of the protection zone for the lines under study was 2665.11 ha.

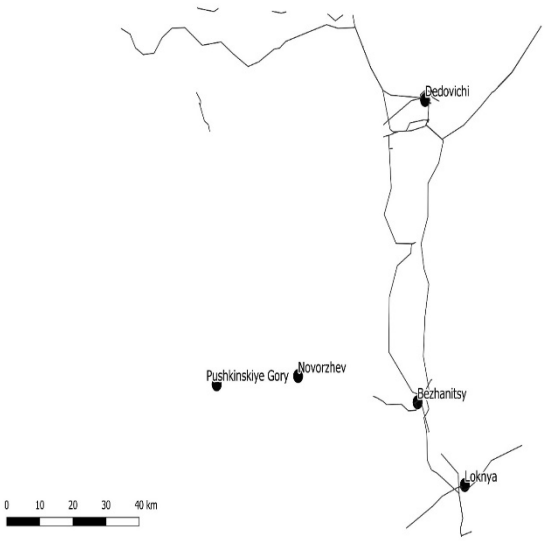

Fig. 2. Configuration of investigated 110 kV and 330 kV overhead power lines in the territory of the Pskov Region

Next, to identify the nature of vegetation from the website of the Copernicus Open Access Hub, a Sentinel-2 satellite image with a minimum cloudiness for June 2018 was obtained. NDVI index was calculated using the “raster calculator” tool in the QGIS program using the formula [12]with potentially important feedbacks to regional and global climate through altered carbon cycle and albedo dynamics. These feedback processes

will be affected by vegetation changes, and feedback strengths will largely rely on the spatial extent and timing of vegetation change. Satellite remote sensing is widely used to monitor vegetation dynamics, and vegetation indices (VIs:

$$NDVI = \frac{NIR-RED}{NIR+RED}, \quad (1)$$

where NIR is the reflection in the near infrared region of the spectrum; RED is reflection in the red region of the spectrum.

For the Sentinel-2 satellite, the near-infrared channel corresponds to band number 8, and the red channel corresponds to band number 4.

After calculating the NDVI index for the study area, the procedure for classifying the state of vegetation by ranges of the index value was performed. As a basic tool for decryption, the classification with training included in the SCP module (Semi-automated classification) was used. After selecting the most successful classification option, all images were converted to vector format and using the QGIS field calculator tool, areas of certain classes of NDVI values in hectares were calculated.

III. Result and Discussion

NDVI estimation is widely used for regional mapping, landscape analysis, resource evaluation, biosystem's area assessment. Such wide implementation can be explained by strong correlation between NDVI and ecosystem productivity. Different types of forests in central part of Russia (from boreal coniferous forests to mixed coniferous-broad leaved forests) identify as NDVI-values on the range between 0.65 and 0.80 [12]with potentially important feedbacks to regional and global climate through altered carbon cycle and albedo dynamics. These feedback processes will be affected by vegetation changes, and feedback strengths will largely rely on the spatial extent and timing of vegetation change. Satellite remote sensing is widely used to monitor vegetation dynamics, and vegetation indices (VIs. OPL corridor segments with such values of NDVI should be under the spotlight of electric grid company. It is important to note that NDVI first of all demonstrates intensity of photosynthesis on investigating area. LIDAR sensing as additional measure to assess forest height can help to determine risk of damage for OPL.

According to classification of NDVI ranges, we determined four main classes for our protection zones (Table II).

Classes of NDVI for protection zones

Class of vegetation	NDVI values	Area, hectares
First class (dense vegetation)	more than 0.65	1012.18
Second class (sparse vegetation)	0.375-0.60	1224.78
Third class (meadows)	less than 0.375	358.8
Fouth class (open water surface)	0.02	69.32

Segments with the first class of vegetation pose significant risk for OPL due to possibility of cross-whipping with short circuit or wirebreak. Periodic field measurements of forest stand height and comparing them with results of NDVI estimation are necessary measure for elaboration and verification of vegetation classes. Systematic comparison will allow improve classification quality and reduce costs of monitoring.

Preliminary assessment of explored fenced off areas shows that 62 % of it belong to non-first class. This fact means that 38 % of explored territory has non-negligible risk of failure accident and need line clearance for maintaining safety and reliability of power supply. Despite that sparse vegetation does not pose such threat to OPL work as dense vegetation does, current Russian regulations prescribe to remove this type of vegetation too. Consequently, 84 % of OPL corridors require clearance to one degree or another.

The disadvantages of presented satellite sounding data analysis include resolution limitation (OPL less than 110 kV due to smaller sizes and distances for corridors and finch off areas require aerial monitoring), necessity of result validation by other methods.

IV. Conclusions

The method for protection zones and forest corridors of OPL monitoring based on satellite sounding data and NDVI estimation was described. It allows to increase the efficiency of corridor clearance activities compare to traditional visual inspection conducted by employees of power grid companies.

Case study with several OPL in Pskov region total length about 543 km was done. It showed that 84 % of OPL protection zones has as dense or sparse vegetation and require clearance activities.

Further work will be focused on long-term dynamics of vegetation in protection zones and investigation of clearance activities influence on vegetation dynamics. It will help to improve OPL maintenance and to reduce its costs.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 168-170

The Possibility of Using Ferromagnetic Sludge Collected During Purification of Water from Spilled Oil Products

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***Abstract*—Among the various methods of water purification from oil pollution, an active magnetic method using powder sorbents with ferromagnetic properties is taking its place. The main components of the sludge are ferromagnetic sorbent, oil and water. The paper discusses some methods of using sludge extracted from water during its cleaning from oil pollution, regeneration and reuse of the sorbent. Particularly, recommendations on the use of sludge as an active fuel additive are given. The possibility of using sludge as a filler for oxygen-flux cutting of concrete and in the production of road-building materials is another demonstrated possibility.**

Keywords—powder sorbents, sludge extraction, oxygen-flux cutting.

I. Introduction

Oil sludge (OS) is formed during the production processes associated with drilling, processing and transportation of oil products. This type of technological waste is very common and represents a great danger to the environment [1,2]. OS is a primarily subject to recycling, although most of them are still subject to disposal. OS is also formed during the spill response of oil products during various accidents and planned cleaning of containers for their storage. OS may vary significantly by its chemical composition and physical properties. This is determined to a large extent by the type of sorbent used in processing technologies. It should be emphasized that the sludge as a whole is quite complex physico-chemical mixtures consisting of petroleum products, metal oxides, mechanical impurities, sand and water [3].

The method of water purification from contamination by oil products using powder sorbents with ferromagnetic properties is effective when working in hard to reach places. When using them, no harmful chemical materials are used [4]. Great possibilities of the method are opening up in connection with the development of new mechanized magnetic devices for the removal of sludge [5]. However, the method is not without flaws, the main of which are relatively low sorption rate and low buoyancy of sorbent. These disadvantages can be eliminated by creating composite sorbents with improved properties [6,7]. The development of recycling technologies and the utilization of ferromagnetic oil sludge (FOS) is also important.

In experimental evaluation of FOS, various methods are used to separate the solid and liquid phases, particularly, by steaming and drying [8.9]. For large volumes, a more complex scheme of splitting the FOS exist using centrifugation and special chemicals. By centrifuging the sludge, one can get up to 10-12 m^3 per hour of purified petroleum product, which can be utilized subsequently as an additive to the fuel [10].

There are known some quite effective ways of utilizing the FOS, in particular, drilling sludge. For example, modified peat, lime, and mineral fertilizers are introduced into waste drilling sludge [11]. All this content is mixed till obtaining a loose mass, stored in piles and covered with a polymer film. Before fertilization in the ground, physical and chemical indicators of the mixture are additionally averaged, and the plot is dug up and then sown with herbs or planted with trees.

II. Materials and methods

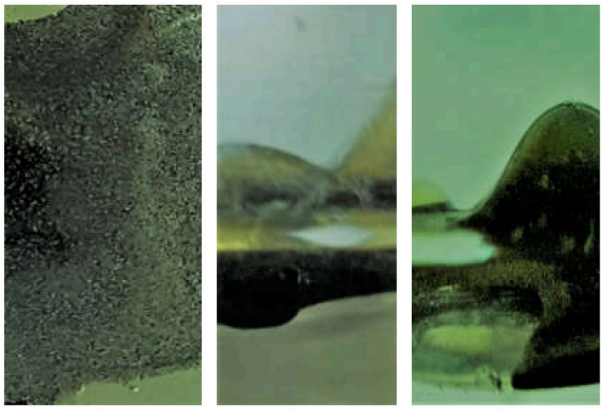
We investigated the FOS obtained when extracting motor oil from water using the developed magnetic technology [7]. Ferromagnetic sorbents are based on fine iron powders (CF) and crushed mill scale (CFO) specified in Table 1.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4177

Table 1 Ferromagnetic sorbents

Sorbent	Iron content, %	Average particle size, microns	Particle shape	Bulk density, g/cm^3
CF_0	97-98	40-50	Spherical	2.05
CF_1	97-98	15-20	Dendritic	1.75
CF_2	75-77	30-40	Dendritic	1.80
CFO_1	70-72	40-50	Petal	2.35
CFO_1	75-78	20-25	Round	2.12

For the research of the sorption process, motor oil was used, which was poured previously on the water surface in the form of a film with a thickness of 0.5-1.0 mm. A thin layer of powder sorbent was scattered on the surface of the spill. The sorption process manifested by the saturation of the sorbent during 5-10 minutes. With longer exposures, the sorbent, together with oil, was formed clots that sank to the bottom of the vessel. With decreasing particle size of the sorbent, its buoyancy increased and the dive slowed down to several hours.



a) b) c)

Fig. 1. Use of ferromagnetic sorbent: powder application (a), sorption process (b, c).

Extraction of sorbents was carried out using magnetic and electromagnetic devices, the effect of which was demonstrated [4,13,14]. When using iron powders up to 20 microns in size, the FOS content after rising out of the water was the following: 20-25% of oil products, 30-35% of water and 30-40% of the solid phase (iron oxides). FOS was dried on the air. In the final product, the water content can be reduced to 3-5%. Periodically, the material should be loosened.

III. Results and discussion

A. Evaluation of the possibility of FOS regeneration

Preliminary tests have shown that the processing of the sorbent in oil, the subsequent drying and calcination can increase its efficiency. This can be explained by wetting effects. To study this issue, experiments were carried out on sorbents made on the basis of iron powder M20 / 80-19 with an average particle size of 30 microns. Engine oil was used as the oil component distributed on the surface of the water. The initial bulk density of the powder sorbent CF_0 was 2.05 g/cm^3, and after calcination it was reduced to 1.90-1.95 g/cm^3. The extraction of the FOS mixture from water was performed using a permanent magnet SmNdB. The sorption degree was estimated by the standard method [14]. Studies have shown that sorption efficiency increases by 10-15% after pressing oil product and heat treatment of the sorbent (Table 2).

Table 2 The results of the reuse of FOS sorbents after regeneration

Specimen	Calcination temperature on air during 30 min, ^{0}C	Residual content of oil product, %
CF_0	-	12-14
CF_1	200	8-10
CF_2	300	4-6
CF_3	400	6-8

The greatest effect was obtained at the calcination temperature 300 ^{0}C.

B. Possible applications of FOS in the production of building materials

One of the most acceptable application for FOS can be additive to the binder in order to improve the quality of the asphalt concrete mix [14]. In our preliminary studies using FOS, pre-building mixture containing sand and crushed stone was heated to a temperature of 200-220 ^{0}C, and then viscous bitumen with a temperature of 140 – 160 ^{0}C was introduced. The mixture was finally stirred. The best results were obtained with the introduction of FOS of the content of 10-15%. This ensured complete enveloping of the material and allowed to save bitumen. In our opinion, FOS can be also used for the production of expanded clay, since the introduction of organic additives helps to reduce the bulk density of clay.

C. The possibility of using FOS for cutting concrete

In the course of the research, it was suggested that FOS can be a good powder filler for oxygen-flux cutting of concrete. This technology is already used to create small-diameter holes in columns, walls and ceilings, and cuttings in old building foundations [15]. The method can be used in road construction.

In this work, an oxygen lance (Fig. 2a) was used for the experiments, which is a steel pipe with an outer diameter of 25 mm, a wall thickness of 0.8 mm and a length of 1.5-2.0 m. The pipe was filled with pre-dried FOS. From a cylinder through the hose connected to the pipe, oxygen was supplied under a pressure of 0.5 kgf / cm^2. At the exit, gas was set on fire. When burning, the spear also melted and a hole is formed in the concrete. It is also possible to use the method for burning holes in metal (Fig. 2b).

a) b)

Fig. 2. Burning of holes using an oxygen powder lance in a 300 mm thick concrete sample (a) and burning holes in a steel strip 20 mm thick (b).

Up to 300 dm^3 of oxygen was required to burn 1 kg of a lance, created in the form of a tube of low carbon steel. A powder lance differs from a rod lance in that iron powder or their mixture with aluminium powder is supplied to the cutting zone. Burning such material causes additional heat. When cutting with an oxygen-flux spear, the oxygen consumption was up to 50 m^3 per hour, and the consumption of dried FOS was 300-500 g/min.

IV CONCLUSION

1. The best indicators of sorption in iron powders with a dendritic particle shape.
2. The calcination of the sludge at temperatures of 300-400 ^{0}C give the opportunity to reuse the ferromagnetic sorbent. When this sorption increases by 6-8%.
3. Sludge with a ferromagnetic sorbent can be used as a filler for gas-thermal cutting of concrete.

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Characterization of Volatile Organic Compounds and Odour Pollution in Atmosphere at Oil and Gasoline Handling and Processing Impact Zone

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***Abstract*–Air quality pollution problem is still one of the crucial points for citizens in Europe for already receiving increasing attention, particularly because of the major European cities 10 and more years. Although the EU's long-term goal is to achieve levels of air quality that do not impact and risks to human health and the environment, many of member states still didn`t reach stated goals. Additionally, to gaseous pollutants, recently specific type of pollution, - odour, seems to become more important. Usually in order to determine pollution levels, national, municipal and private monitoring equipment is used. For this research municipal monitoring site in Riga (Latvia), at Milgravja Street 10, controlling gaseous pollutants (SO_2, O_3, BTX, PM_{10}) and airborne particulate matter, and private monitoring results from Riga, Milgravja Street 16, where odour pollution was obtained, are analysed. Distance between both stations are just 500 m. Measurements at municipal monitoring site is obtained by DOAS and gravimetric sampling, while at Milgravja 16 by photoionization method or so-called "electronic nose". Monitoring results in municipal station show that in 2017 the average benzene concentration was 4,87 ug/m^3, toluene – 8,89 ug /m^3 and xylene – 5,07 ug/m^3, while the odour pollution level does not exceed 5 odour units. In general estimation of pollution averaged annually do not show and explain variability of pollution levels. It`s well known that high BTX and odour pollution episodes occur in shorter periods, thus short term limit values would be useful in order to characterize short term effects on human health and well-being.**

Keywords—air quality, gas analysis, odour.

I. Introduction

More and more scientists are paying attention to research on emissions of different pollutants and odours. Several researchers have conducted odour emissions studies directly in agricultural areas [1] – [3] other researchers have focused on emissions of waste water treatment plants [4] – [6]; others, while industrial emissions [7].

According to public available information, over the past 30 years there has been a tendency to issuing of various judgments, but instead rely on quantitative measurements of odour [8].

In order to perform an economic activity, which is related to air pollution and odour emissions, in conformity with the requirements of regulatory enhancements, the performer of polluting activity (company) must receive a permit issued by the competent authority. Oil Transhipment Company must obtain a category B polluting activity permit depending on level of activity (amount of handled and processed oil products). Before issuing an authorisation, modelling of the distribution of pollutants should be carried out and a draft emission limit for odours should be developed, thereby forecasting emissions of pollutants and odours within and outside the work area of the company [9].

The project for the odour emission limit for company in "Riga-Milgravis" - has been developed taking into account emissions from transhipment of petroleum products (processes) - from transhipment of all products in reservoirs, tankers, road tankers and railway tanks, as well as from storage tanks. The results of the modelling of the distribution of pollutants indicate that the impact of company on air quality does not exceed the limit values specified in regulation No 1290 of MK 03.11.2009. in the area where compliance with air quality standards is assessed [10].

On the other hand, the calculation of the odour distribution shall indicate that the target value of the odour 5 ouE/m^3 specified in regulation 25.11.2014 of the MK No 724 "Regulations regarding the methods for determining odours caused by polluting activity, as well as the procedures for limiting the spread of these odours", shall be not exceeded, where compliance with the target value of the odds in accordance with paragraph 3 of this Regulation [10].

The above points to the fact that a company cannot

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4144

produce concentrations and odours of pollutants, which would affect human health and well-being, while working with maximum load and adverse weather conditions. However, despite this, the national controlling authorities concerned still receive relatively many complaints, in autumn 2017 the number of complaints per day even exceeded 400 [11].

In view of the installation of monitoring stations in the most which continuous measurements of concentrations of pollutants and odour are obtained, the data of the two monitoring stations can then be analysed, the relationship between odour emissions, concentrations of polluting substances, meteorological conditions and the impact of the economic activity of the company on humans may be clarified.

II. Materials and methods

For all company whose performance may require the development of draft odour emission limit projects in the environment, the emission limit projects shall also be based on the direct measurement of odour emissions at the emission sources. Thus, data were obtained, both on actual emissions from the emission source and on the emission source parameters, on the possibility of determining the emissions of odours outside the place of performance of the polluting activity, as well as the possibility of identifying and modelling odours flows at meteorological conditions and the duration of the emissions of odours. The calculation of odour spreading mainly uses the ADMS computer program, which is applicable to the calculation of the spread of air emissions and odours of industrial sources, taking into account the characteristics of the surroundings, i.e. terrain and building, as well as meteorological conditions. In order to identify the emissions of odours from company outside the boundary of the company and potential emissions in residential and public building areas, an analysis of the draft emission limit for odours of Category B polluting activities was carried out.

Data from the air monitoring station of the type of continuous activity installed by the local government, which is located on the Street Milgravja 10, Riga, were used for the analysis and processing of pollutant data. The monitoring station is operated at continuous mode, new measurements averaged for every 10 minutes are collected automatically in the Housing and Environment Department of the Riga City Council via mobile communications and ftp servers [12]. This monitoring station shall also ensure the acquisition of meteorological data, i.e. information on wind speed, direction and air temperature.

The aim of the study is to establish relationship between emissions of air pollutants and odour emissions, as well as the release of volatile organic compounds by nearby located companies, analysis of the continuous measurement data of benzene, toluene and xylene from the DOAS type air monitoring station was carried out in the study. Direct non-validated data were initially obtained, which serves as an indicative assessment of the level of air pollution in the monitoring sites, which are further recalculated in the air quality index and 1 day cut.

Outside the business area, i.e. in the public building area, the company has installed an electrochemical, metal oxide and photoionization detector or "electronic nose". This "electronic nose" is subjected to continuous measurements of the odour concentration. The results of the measurements shall ensure the possibility of obtaining information on the odour concentration, expressed in the odour units (ouE). This monitoring station shall also ensure the acquisition of meteorological data, i.e. information on wind speed and direction.

Data from the two continuous monitoring stations were analysed and compared with each other in MS Excel.

III. Results and discussion

Testing results of accredited laboratories show that from emission sources the odour concentration can be higher than 40000 odour units (ouE/m^3). The results of odour spreading modelling show that the maximum concentration of odours from the location of the polluting activity is not significant, i.e. up to 3,58 ouE/m^3. Such emissions of odours from company are not relevant, although the perception of odours in humans is already from 1unit of odours (ouE/m^3).

Modelling results show that peak odour concentrations are at very low air mass mixing cold and low wind rates, thus identifying the most vulnerable weather conditions for contamination, i.e. stable atmospheric conditions.

Monitoring station for the measurement of continuous odours concentration is installed in the area of the pellet golf area, which is currently the only such type of equipment in the administrative territory of Riga, located in accordance with Republic of Latvia Cabinet Regulation No. 724 „Regulations Regarding the Methods for Determination of the Odours Caused by Polluting Activity, as well as the Procedures for Restricting the Spread of such Odours" in Paragraph 3. The monitoring station shall record actual emissions. According to the data of the monitoring station, the target value of the smell has been exceeded 281 times (hours; the target value of the odour shall be determined for the hour period) in the area of sport and recreation with plants (AS) where the monitoring station is located. In accordance with Cabinet Regulation No. 724, the target value of the odour of paragraph 8, determined for an hourly period (5 ouE/m^3), may not exceed more than 168 hours per calendar year. It is thus apparent that the monitoring station has detected peak of 213 hours (sometimes), as permitted by the regulatory enactments. In this case, there are significant meteorological conditions, i.e. wind direction, since the analysis of wind direction leads to the conclusion that the impact of the oil terminal could have been 183. However, regardless, the target value of odours is exceeded by 15 times (hours) more than permissible. In the analysis of odours emissions, the intensity and duration of odours are essential, so that the five figures "Fig.1" – "Fig.5" reflect the longer-lasting odour episodes with higher odour concentrations.

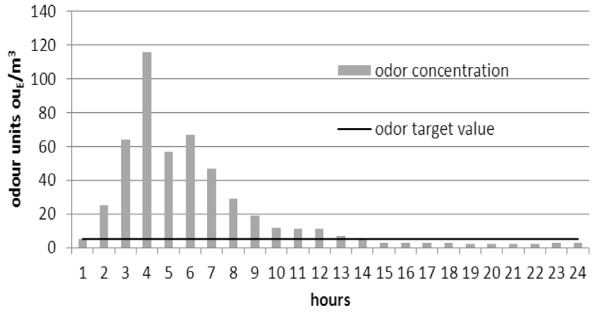

Fig.1. Odour concentration on July 29, 2017.

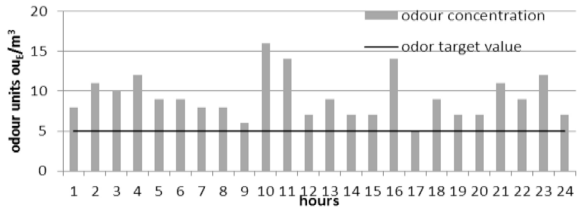

Fig.2. Odour concentration on September 4, 2017.

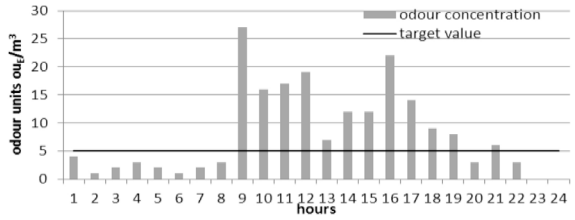

Fig.3. Odour concentration on October 21, 2017.

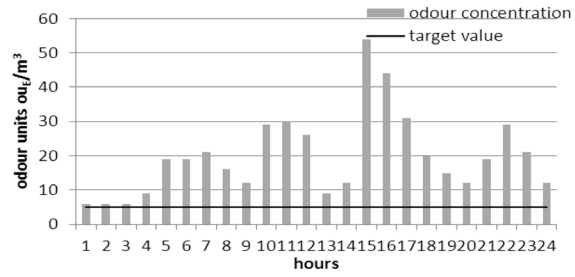

Fig.4. Odour concentration on April 1, 2018.

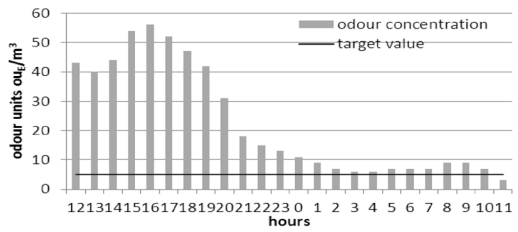

Fig.5. Odour concentration on April 20-21, 2018.

Concentrations of polluting substances, i.e. air quality standards for polluting substances shall be determined at 03.11.2009. Cabinet Regulation No. 1290 "Regulations regarding air quality, according to which the annual average concentration of benzene must not exceed 5 µg/m^3, the target value of toluene week shall be 0,26 mg/m^3. However, the concentration of xylene is not determined by normative measures.

Data from the monitoring station indicate that the average concentrations of the pollutants in the water in 2017 are as follows: benzene concentration was 4,87 µg/m^3, toluene – 8,89 µg/m^3 and xylene – 5,07 µg/m^3.

Although the annual average concentration of benzene in 2017 in Milgravis is lower than in the city centre, the peaks of individual air pollution episodes are more pronounced.

In the analysis of the 2017 data, the largest 1 hour concentration of benzene was observed on 1 August when it reached 97,04 µg/m^3, with a maximum concentration of toluene of 51,11 µg/m^3 fixed on 23 December, while the maximum hourly concentration of xylene was observed on 9 June at 44,22 µg/m^3.

On the evening of September 12, 2017, both the State Environmental Service and the State Fire and Rescue Service received complaints from more than 400 residents over a short period of time (a few hours interval) about disturbing smells from several districts of Riga, i.e. Sarkandaugava, Milgravis and Vecmilgravis [11]. Therefore, Fig.6 summarises the information from the two monitoring stations located in Milgravis, both concentrations of pollutants and odour emission concentrations.

Data from monitoring stations do not indicate increased odour emissions or concentrations of pollutants, although benzene, toluene and xylene concentrations exceeded 5 µg/m^3 in individual hours. During this period there was a SPC wind at a speed of up to 2 m/s, which means that due to meteorological conditions, true emissions from oil terminals could not be identified.

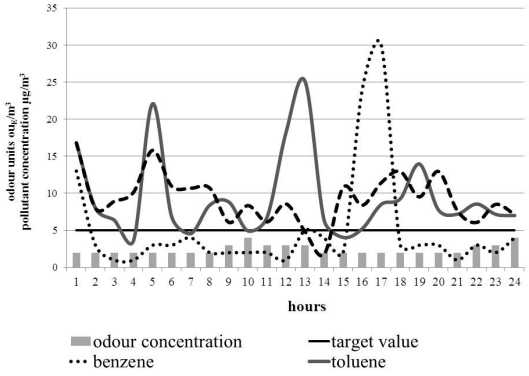

Fig.6. Odour and pollutants concentrations on September 12, 2018.

Although performers of polluting activities, perform the development of draft odour emission limit projects, perform modelling of the odour concentration, as well as the State Environmental Service, when issuing permits for polluting activity, shall determine the conditions regarding the operation of plants in conformity with the requirements of regulatory enactments, regardless of which there are problems with the emission of odours in individual districts of Riga. The assessed draft emission limits for odours and the results of modelling the odour concentration shall indicate the hours in the annual cut of the average and maximum concentration, as determined by regulatory enactments. Calculated emissions in

emission limit projects are less than actually in nature.

The above does not indicate that non-compliant emission limit projects are being developed for the performance of polluting activities, the problem is that odour emissions are assessed on an annual basis, but the activity of companies or the work area does not operate for the full annual cycle, i.e. the number of hours per year is significantly lower. By offsetting working hours in the annual section, even when no polluting activity is carried out, the concentration of odours will be reduced by analogy. Similarly, the average concentration of the hour may also meet the requirements of the regulatory enactments in cases where there has been a strong smell for 30 minutes and the smell has not been at all or has been minimal for 30 minutes. It is logical that, within 30 minutes, even serious health problems may arise for a particularly sensitive group of people, so it is necessary to think about both spatial planning and legislative developments.

If the emission limit projects developed also show the actual maximum possible emissions as well as the total actual emissions of several companies, this would not solve the problem in the areas affected by the odour of petroleum products, i.e. significant measures should be taken to reduce odour emissions. This does not mean that it is necessary to shutdown firms in order to preserve the quality of the environment, but the economic situation in the country must also be promoted, but a new regulatory framework is currently needed to carry out polluting activities, which would require stricter requirements to install polluting gas collection plants.

IV. CONCLUSION

The results indicated that concentrations of pollutants are not always high during periods when odour emissions are higher. The results obtained show that odour emissions exceed the number of hours when the odour concentration is above 5 ouE/m^3. On the other hand, the annual average concentration of odour shall not exceed 5 ouE/m^3, nor shall emissions of pollutants be within the limits of regulatory enactments.

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Load-Carrying Capacity Increase of Arch-Type Timber Roof

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***Abstract*—Possibility to increase load-carrying capacity of arch-type timber roof of multifunctional public building with the span equal to 60 m was analysed. Three-hinged segment arches with the rectangular glued cross-sections are considered as the main load-carrying structures in the transversal direction. Freely supported purlins with the massive rectangular cross-sections are considered as the main load-carrying structures in the longitudinal direction. The dependences between height of the arches, it bays and distances between the bracing members strengthening top and bottom zone of the arches cross-sections so as relative materials consumption and specific load-carrying capacity of the arches were obtained as the second power polynomial equations. Height of the arches and it bay changes within the limits from 10 to 30 and from 2 to 9 m, correspondingly. The distances between the bracing members strengthening top and bottom zone of the arches changes within the limits from 2 till 10 and from 4 till 16 m, correspondingly. The arch-type timber roof was considered under the action of the load combination which include structural dead weight, drifted and undrifted snow loads and wind loads. The relative materials consumption of the arches was determined as a relation between the dead weight of the arch to it span and changes within the limits from 24 till 114 kg/m. Glued and solid timber with strength classes GL24h and C24 are considered as materials of arches and purlins, correspondingly. The specific load-carrying capacity of the arches was determined as a relation between load –carrying capacity of the arche and volume of structural materials. Specific load-carrying capacity of the arches changes within the limits from 0.23 till 0.83 kN/m/t in the case, if purlins are taken into account. It was shown, that the rational from the point of view of materials consumption and specific load-carrying capacity height of the arche, it bays so as the distances between the bracing members strengthening top and bottom zone of the arches are equal to 15, 7.5, 5 and 15 m, correspondingly. Corresponding values of relative materials consumption and specific load-carrying capacity are equal to 24 and 0.23 kN/m/t. The depth and width of the arche cross-section were equal to 1617 and 318 mm, correspondingly.**

It was shown, that strengthening of the arches cross-section by the steel bars of strength class B500 and carbon fibre reinforced plastic tape Sika Crbo Dur S512 enables to increase load-carrying capacity of the arche by 10.20 and 9.48%, correspondingly. But common use of the steel bars together with the carbon fibre reinforced plastic tapes enables to increase load-carrying capacity of the arche by 18.89%.

Keywords*—glued laminated timber, relative materials consumption, specific load-carrying capacity, three hinged segment arch.

I. Introduction

The problem of limited raw material and energy resources can be solved by decreasing the structural dead weight, increase of span and durability of load carrying structures so as by the replacement of non-renewable structural materials by renewable ones [1] – [3]. Production of the most widely used structural materials concrete and steel is responsible for from 5% to 8% of global greenhouse gas emissions and requires about 4% of global energy use [4]. Replacement of reinforced concrete and steel structures by the timber ones is one of the modern tendencies in civil engineering. Timber is a renewable structural material, which can be grown and as it grows, it consumes carbon. Timber structures are friendly for environment. Using of timber structures enables to decrease impact on the planet. Structural members from glued laminated timber and other timber-based materials are widely used for one-storey and multi-storey buildings [4]. Timber as a structural material has a potential for substitution of concrete and steel in its major applications.

Arch-type timber structures take a special position among timber framework structures due to its shape and internal forces distribution in the major load-carrying members. Three-hinged arches are the most widely used static scheme for the long-span timber structures due to the increased compliance of timber in comparison with the steel and reinforced concrete. Sport stadium Majuro is an example of arch-type timber roof, where the main structures in the transversal direction are three hinged arches with span equal to 60 m (Fig.1.).

Two-hinged static schemes used for the structures with the short-spans in the case of glued cross-sections or for the long-span lattice arches [5] – [8]. Arch-type timber roof of Hakona hall is an example of the roof, where the main load-carrying structures in the transversal direction are lattice arches with the span equal to 86 m (Fig.1.).

So, framework of multifunctional residential building with three-hinged arches with the glued laminated rectangular cross-sections and span equal to 60 m, was considered as an object of investigation. Using of the glued laminated timber cross-sections enables to increase

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4056

fire resistance of the timber arches in comparison with the lattice ones [6]. Decrease of the structural dead weight enables to increase effectiveness of the structural solution for long-span structures [2]. Possibility to decrease structural dead weight and increase the load-carrying capacity of arch-type timber roof is the aim of current investigation. The aim should be obtained by the evaluation of rational from the point of view of materials consumption geometrical parameters of the arch-type timber roof and by the increase of specific strength of the major load-carrying structural member's materials. Increase of the specific strength of the major load-carrying structural member's materials can be obtained by strengthening of the arch's glued laminated rectangular cross-sections.

Fig. 1. Arch-type timber structures: (a) of sport stadium Majuro; (b) of Hakona hall [8].

II. Approach to the solution of the problem

A. Structural solution of the arch-type timber roof

Framework of multifunctional residential building with three-hinged segment arches with the span and chamber equal to 60 and 10 m, correspondingly, was considered as an object of investigation. Lateral stability of the arches so as overall stability of the timber framework was provided by the system of bracings including transversal bracings trusses so as the vertical bracings. Purlins, which are placed in the longitudinal direction, working as the load-carrying members and bracing members at the same time (Fig. 2.).

Glued timber with strength class GL24h was considered as a material of glued rectangular arches cross-sections. Solid timber of strength class C24 was considered as a material of purlins and members of bracings.

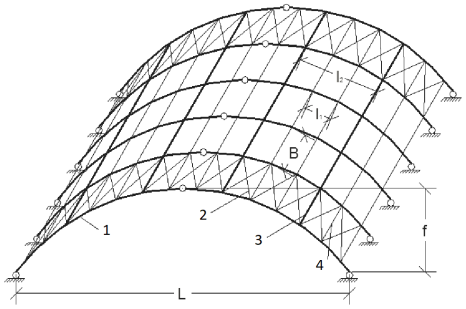


Fig. 2. Structural solution of considered arch-type timber roof: 1 – three-hinged arch; 2 – transversal bracing truss; 3 – vertical bracings; 4 – purlins; B – bay of arches; l_1 – distance between the purlins; l_2 – distance between the vertical bracings; f – camber of arches; L – span of arches [8].

B. Method of analysis

Rational from the point of view of materials consumption height and bay of the arches so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections were determined for the arch-type timber roof. The response surface method and full factorial design were used to solve the problem. The numerical experiment of type y=34 was realised [9]. Where y is amount of the considered variants of the arch-type timber roof, 3 is amount of levels for each considered variable and 4 is amount of considered factors. So, the 81 variants of the arch-type timber roof were analysed. The height and bay of the arches so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections were considered as four variables and signed f, B, l1 and l2, correspondingly. Relative materials consumption (G) so as specific load-carrying capacity of the arches (G_1) were considered as parameters of optimization. The relative material consumption was considered as a relation of the structural dead weight to the span of the arch, measured in kg/m. The specific load-carrying capacity of the arches was found as a relation of load-carrying capacity of the arch to the total volume of all timber structures, measured in kN/m/m^3.

All 81 variants of the arch-type timber roof were analysed by the using of software RFEM 5 at the action of permanent and variable loads (Fig.3.). Planar models for considered variants of the three-hinged arches were treated. The dimensioning and check of cross-sections of the arches, purlins and members of the bracings was carried out basing on the requirements of EN 1995-1-1. The arches, purlins and elements of the bracing system were considered as the members subjected to compression with the bending, flexure and axial loading, correspondingly. Lateral stability of the arches was checked by the formulas (1)-(2) in the case, if maximum normal stresses acting in the cross-section of the arch due to the bending moment are smaller, than the maximum normal stresses acting due to the compressive force [10], [11].

$$\frac{\sigma_{c,0,d}}{k_{c,z}\, f_{c,0,d}} + k_m \ \frac{\sigma_{m,d}}{f_{m,d}} \le 1 \qquad (1)$$

$$\frac{\sigma_{c,0,d}}{k_{c,y}\, f_{c,0,d}} + k_m \ \frac{\sigma_{m,d}}{f_{m,d}} \le 1 \qquad (2)$$

Where: $\sigma_{m,d}$ and $\sigma_{c,0,d}$ are maximum normal stresses acting in the cross-section of the arch due to the bending moment and compressive force, correspondingly; $f_{m,d}$ and $f_{c,0,d}$ are the design resistances of timber in bending and compression, correspondingly; $k_{c,y}$, $k_{c,z}$ are factors, which should be determined by the equations (6.25) and (6.26); km is a factor, equal to 0.7 for rectangular sections.

Lateral stability of the arches was checked by the formula (3) in the case, if maximum normal stresses acting in the cross-section of the arch due to the bending moment are bigger, than the maximum normal stresses acting due to the compressive force [10], [11].

$$\left(\frac{\sigma_{m,d}}{k_{crit}\, f_{m,d}}\right)^2 + \frac{\sigma_{c,0,d}}{k_{c,z}\, f_{c,0,d}} \le 1 \quad (3)$$

Where: k_{crit} is a factor which takes into account the reduced bending strength due to lateral buckling; other designations as for formulas (1) and (2).

The dependences of relative materials consumption and specific load-carrying capacity of the arches on the height and bay of the arches so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections were obtained as the second power polynomial equations [9]. Equation (4) was written for the case, when relative materials consumption was considered as a parameter of optimization.

$$G = b_0 + b_1 f + b_2 B + b_3 l_1 + b_4 l_2 + b_{12} fB + b_{13} f l_1 + b_{14} f l_2 + b_{23} B l_1 + b_{24} B l_2 + b_{34} l_1 l_2 + b_{123} fB l_1 + b_{134} f l_1 l_2 + b_{234} B l_1 l_2 + b_{124} fB l_2 + b_{1234} fB l_1 l_2 + b_{11} f^2 + b_{22} B^2 + b_{33} {l_1}^2 + b_{44} {l_2}^2 \quad (4)$$

Where: G is relative materials consumption; b_i, b_{ij}, b_{ijk} – coefficients; other designations are the same as in Fig. 3.

Equation for the case, when specific load-carrying capacity of the arches was considered as a parameter of optimization, has the similar form. Rational from the point of view of materials consumption height and bay of the arches so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections were determined for the arch-type timber roof by the system of equations (5):

$$\begin{aligned}
\frac{dY}{df} &= b_1 + b_{12}B + b_{13}l_1 + b_{14}l_2 + b_{123}Bl_1 + \\
&+ b_{134}l_1l_2 + b_{124}Bl_2 + b_{1234}Bl_1l_2 + 2b_{11}f \\
\frac{dY}{dB} &= b_2b_{12}f + b_{23}l_1 + b_{24}l_2 + b_{123}fl_1 + \\
&+ b_{234}l_1l_2 + b_{124}fl_2 + b_{1234}fl_1l_2 + 2b_{22}B \\
\frac{dY}{dl_1} &= b_3 + b_{13}f + b_{23}B + b_{34}l_2 + b_{123}fB + \\
&+ b_{134}fl_2 + b_{234}Bl_2 + b_{1234}fBl_2 + 2b_{33}l_1 \\
\frac{dY}{dl_2} &= b_4 + b_{14}f + b_{24}B + b_{34}l_1 + b_{134}fl_1 + \\
&+ b_{234}Bl_1 + b_{124}fB + b_{1234}fBl_12b_{44}l_2
\end{aligned} \quad (5)$$

Where designations the same as for equation (4).

System of equations (5) was written for the case, when relative materials consumption was considered as a parameter of optimization. The obtained results then were analysed and corrected by the inspection.

III. Evaluation of rational geometrical parameters of arch-type timber roof

The segment three-hinged arches were considered under the action of permanent and imposed loads (Fig.3.). The permanent load includes dead weight of the roofing, elements of bracings and arches. Structure of roofing include corrugated steel sheets BALEX number TR50260 POSITIVE with thickness in 0.5 mm, layer of heat insulation with thickness in 180 mm, density in 140kg/m3 and layer of hydro isolation.

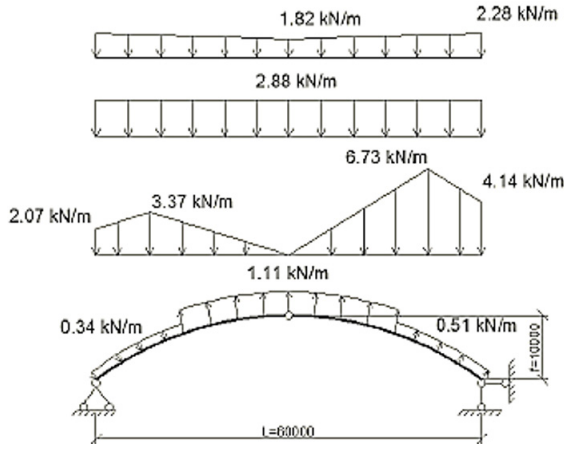
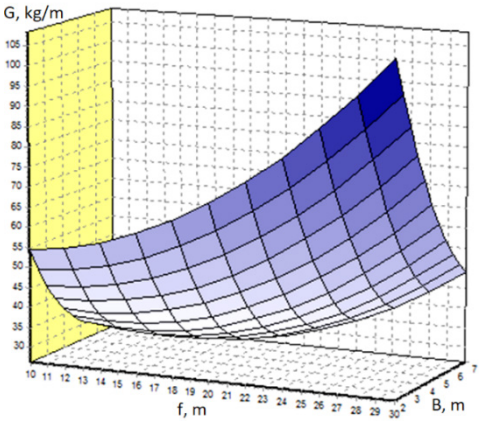


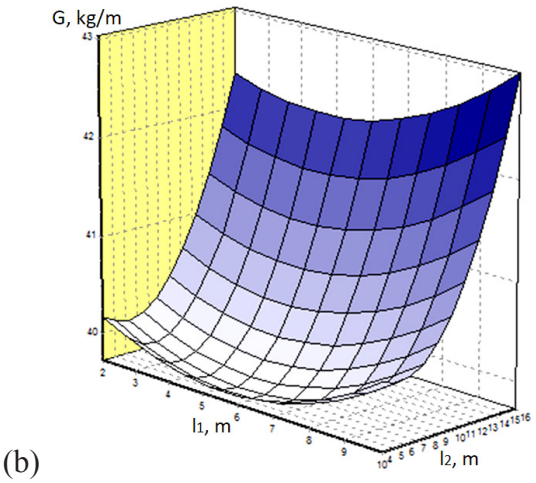
Fig. 3. Design scheme of three-hinged segment arche loaded by the permanent and imposed loads: a) – permanent load; b) – undrifted snow load; c) – drifted snow load; d) – wind load; The loads intensities are given for the bay of arches equal to 2 m [8].

Imposed loads are presented by the wind and snow ones. Permanent load has nonlinear distribution by the horizontal projection of the segment three-hinged arche and its intensity changes within the limits from 1.82 to 2.28 kN/m. The snow and wind loads were determined for Riga climatic conditions [12]. The snow load includes two variants – undrifted snow load and drifted one. Intensity of undrifted snow load is equal to 2.88kN/m, but for drifted snow load it intensities changes within the limits from 2.07 to 6.73 kN/m. Intensities of the wind load are equal to 0.34, 1.11 and 0.51 kN/m for zones A, B and C, correspondingly. The boundaries between zones A and B so as zones B and C is placed on the height 0.7f, which is equal to 7 m. The wind pressure in zones B and C is negative (Fig.3.).

The height and bay of the arches so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections changes within the limits from 10 to 30m, from 2 to 9 m, from 2 to 10 m and from 4 to 16 m, correspondingly. The dependences of relative materials consumption and specific load-carrying capacity of the arches on the height and bay of the arches so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections, are shown on Fig. 4 and 5, correspondingly.



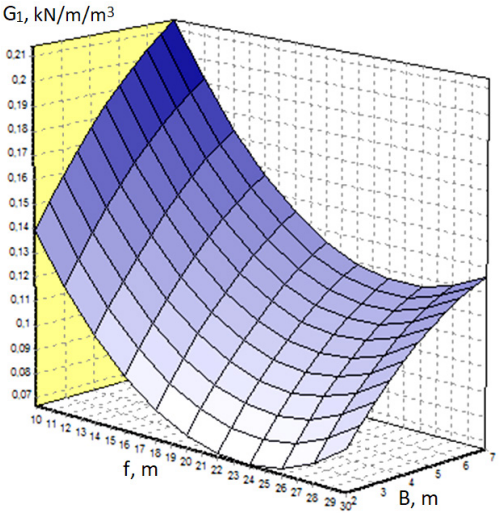
(a)



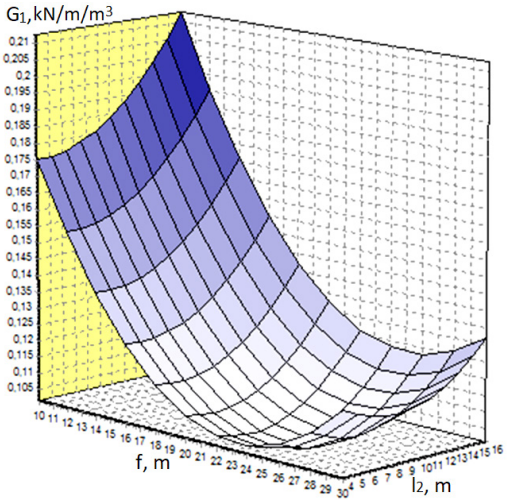
(b)

Fig. 4. The dependences of relative materials consumption (G): (a) as a function from the height (f) and bay (B) of the arches; (b) as a function from the bayes (l_1) of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections (l_2) [8], [13].

The relative materials consumption changes within the limits from 24 to 114 kg/m. The specific load-carrying capacity of the arches changes within the limits from 0.06 to 0.38 kN/m/m^3 at the same time.



(a)



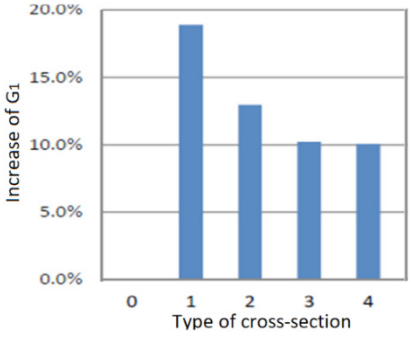
(b)

Fig. 5. The dependences of specific load-carrying capacity of the arches (G_1) (a) as a function from the height (f) and bay (B) of the arches; (b) as a function from the from the height (f) and bay of the bracing members providing lateral strengthening of the bottom parts of the arches cross-sections (l_2) [8], [13].

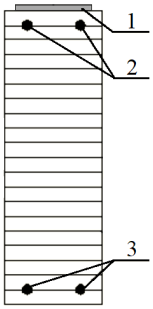
The using software EdaOpt [13] obtained the dependences shown on the Fig. 4 and 5. It was stated, that the rational from the point of view of materials consumption and specific load-carrying capacity of the arches, it height and bay so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections are equal to 15, 7,5, 5 and 15 m, correspondingly. Corresponding values of relative materials consumption and specific load-carrying capacity of the arches are equal to 24 kg/m and 0.38 kN/m/m^3. Three-hinged segment arch for the estimated best variant has glued laminated rectangular cross-section with depth and width equal to 1617 and 318 mm, correspondingly.

IV. Load-carrying capacity increase of arch-type timber roof

Possibility to increase specific load-carrying capacity of the considered arch-type timber roof by the increase of specific strength of arches structural materials was analysed. Structural material of the arches was glued laminated timber with strength class GL24h. The increased specific strength was provided by cross-section strengthening by two steel bars with diameters in 22 mm, placed both in the top and bottom zones of cross-section. The fibre reinforced plastic tapes with width and thicknesses equal to 150 and 1.4 mm, correspondingly, placed in the top part of cross-section only. Steel of grade B500 with point of yielding in 420 MPa, was considered. The carbon fibre reinforced plastic tape Sika Crbo Dur S1514 so as glass fibre and aramid fibre reinforced plastic tapes with tensile strengths equal to 3100, 896 and 557 MPa were considered as the strengthening materials [8]. Transformed section method and software RFEM 5 was used for analysing of arch-type timber roof. The roof with the evaluated in the previous chapter rational from the point of view of materials consumption and specific load-carrying capacity of the arches, its height and bay so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches, was considered under the action of permanent and drifted snow load. Specific load-carrying capacity increase for different variant of the arch cross-section strengthening is shown on Fig. 6.



(a)



(b)

Fig. 6. G_1 increase for different variant of the arch cross-section strengthening (a): 0 – without reinforcement; 1 – steel bars both in the top and bottom zones and carbon fibre reinforced plastic tape in the top zone; 2 - steel bars both in the top and bottom zones and glass fibre reinforced plastic tape in the top zone; 3 - steel bars both in the top and bottom zones and aramid fibre reinforced plastic tape in the top zone; 4 - steel bars both in the top and bottom zones. (b) reinforcement placement for variants 1, 2, and 3: 1 – fibre reinforced plastic tape; 2 – steel reinforcement in the top zone; 3 – steel reinforcement in the bottom zone [8].

It was stated that the maximum increase of specific load-carrying capacity of the arch-type timber roof was equal to 18.89%. Specific load-carrying capacity grows from 0.38 kN/m/m^3 to 0.45 kN/m/m^3. It was obtained for the case, when the steel bars both in top and bottom zones strengthened the cross-section and the carbon fibre reinforced tape strengthened the bottom zone. But the specific load-carrying capacity of the arch-type timber roof grows by 10.20% when the cross-section of the arch was strengthened by the steel bars both in the top and bottom zones [8].

V. Conclusions

Rational from the point of view of materials consumption geometrical parameters of the arch-type timber roof with the span equal to 60 m were evaluated. It was stated, that the rational from the point of view of materials consumption and specific load-carrying capacity of the arches, its height and bay so as bays of the bracing members providing lateral strengthening of the top and bottom parts of the arches cross-sections are equal to 15, 7,5, 5 and 15 m, correspondingly. Corresponding values of relative materials consumption and specific load-carrying capacity of the arches are equal to 24 kg/m and 0.38 kN/m/m^3.

Possibility to increase load-carrying capacity for arch-type timber roof was considered. It was stated, that specific load-carrying capacity of the arch grows by 18.89% in the case, when the steel bars both in top and bottom zones strengthened the cross-section of the arch and the carbon fibre reinforced tape strengthened top zone.

Acknowledgments

The research leading to these results has received the funding from Riga Technical University, Faculty of Building and Civil Engineering Grant “DOK.BIF/18”.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 180-186

Ecology of Polylepis spp Forests, and Proposal for Its Conservation in the Andean Region of Tacna, Peru

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***Abstract*— The forests of *Polylepis* (queñoales) is one of the most important Andean forest ecosystems and with the greatest impact due to human activities. The objectives of the study were to determine the distribution and diversity of queñoa forests in the Andean region of Tacna, Peru. With this information, We propose the restoration and conservation plan for the *Polylepis* spp. For this purpose plots of 500 m2 were established. The sampling was simple random, taking a population census in each of the sample units in the 4 provinces (Jorge Basadre, Tacna, Tarata and Candarave). The total evaluation area was 27,491 hectares.**

The presence of two *Polylepis* species was identified. *Polylepis rugulosa* Bitter was registered in 9 districts with an altitudinal range of 3050 to 4226 m.a.s.l. in 6 life zones. *Polylepis tarapacana* Phil is distributed in the provinces of Tarata and Tacna within 3 districts. *P. tarapacana* occurs in an altitudinal range between 4230 and 4750 m.a.s.l. in 5 life zones. The tall and diameter of tree were variable for two species. The human impact for *P. rugulosa* was recorded: Not Intervented (76%), Semi Intervening (21%) and Intervened (3%). For *P. tarapacana* it was: Not Intervented (77%), Semi Interventions (21%) and Intervened (2%). According to the data gathered, the conservation plan is proposed, consisting of 5 guidelines: 1) education, 2) communication and capacity building, 3) conservation and sustainable management, 4) policies and regulations, and 5) research and monitoring.

***Keywords*—Ecology, high Andean forests, queñoa, southern of Perú.**

I. Introduction

The forests of *Polylepis* present a great scenic beauty and landscapes, species of flora and fauna specialist of these forests make them unique ecosystems in the world [1]. The distribution of *Polylepis* species is eminently South American and its distribution is restricted to mountainous areas in the Andes [2]. In [3] argue that the center of diversification would be located in the southern area of the Andes and the greatest diversity of species (18 species) is distributed between 3000 and 4000 meters above sea level. These forests are strongly impacted by human activities, with fire and erosion being the main factors [2].

According to [2], the number of species of the genus *Polylepis* is 26, of them, 14 species are distributed in Peru and reports three endemic species. In [4] report four endemic species for Peru. Later, [5] concluded the existence of 19 native species for the genus Polylepis, increasing to five the number of endemic species for Peru. Peru has the highest number of queñoa species (19 species) followed by Bolivia with 13 species [3].

The Andean region has particular environmental characteristics such as precipitation, temperature, altitude, among other factors that have influenced the development of a plant community adapted to these conditions, found in it species of great value are these forest, shrub and herbaceous; likewise, it is a promising area of resources, mainly water resources [6]. The surrounding populations make use of these resources indiscriminately due to the increase of the population which demands a greater consumption of this resource, forest products and the expansion of the agricultural frontier. The importance of conserving queñoa forests is increasingly visible. In [7] mention that these forests are vital for biodiversity and hydrological functions taking into account the current increase in anthropogenic pressure that they are suffering, causing fragmentation, deforestation and loss of biodiversity.The objective of the study was to evaluate the current state of the *Polylepis* forests (queñoas), and we proposed the following specific objectives: 1) determine the area of queñoa forests, 2) determine the density and population structure; and, 3) to determine the affectation of the forests by the anthropic influence, and 4) to propose a plan of conservation of the forests of queñoas in the Tacna region.

Material and methods

Study area

The department of Tacna contains four provinces. The forests of Polylepis are distributed at an altitude between 3400 and 5000 m.a.s.l. The study area includes part of the four provinces of the Tacna region, such as:

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4105

a) Jorge Basadre includes the districts of Locumba, Ilabaya and Ite. The evaluation was carried out in the farming communities of Santa Cruz, which is located in the district of Ilabaya.

b) Candarave is divided into six districts: Candarave, Cairani, Camilaca, Curibaya, Huanuara and Quilahuani. The evaluation was carried out in Camilaca (Quebrada Pantara) and Candarave (skirts of the Yucamani Volcano, Hiltajavira and Colpapampa).

c) Tarata has altitudinal levels that fluctuate between 4200 and 5000 msnm and the assessment areas were located in the districts of Susapaya, Estique Pueblo, Tarucachi, Sitajara, Ticaco and Tarata.

d) Tacna has an area of 16076 km². The altitudinal extremes are the Tutupaca volcano, 5815 m.a.s.l., the snow-capped mountains of Chupiquiña, 5788 m.a.s.l. and Barroso, 5742 m.as.l. The place of study is located in the high Andean area of the district of Palca, in the province of Tacna, ranging from 4200 to over 5000 m.a.s.l. A cold climate predominates in the mountain range, intense cold and in some cases snowed.

Procedure

Form and delimitation of the plots

The method of sampling by parcels was used, establishing a plot of 20m x 25m (0.05 ha) for each zone. Each plot was located randomly throughout the forest and delimited with the help of stakes, raffia and compass [8].

Collection and identification of samples

Conventional techniques were used for the treatment of botanical samples [9] - [10]. The botanical samples were identified in the Herbarium Vargas (CUZ) of the National University of San Antonio Abad of Cusco.

Density and population structure

We proceeded to count all the individuals within each plot with the help of a Garmin GPS [8]. The counting of adult individuals, saplings and latizales was carried out; For this, a metal metric tape was used: a) brinzales, from 0 to 30cm, b) latizales, > 30cm up to 1m, and c) adults, > 1m.

Diameter and height of the tree

The DAP (diameter at breast height) was measured at 1.5 m towards the slope and the side closest to the ground, with the help of a tape measure [11].

To obtain the total height of the trees; the direct estimation was made, it was measured from the soil to the top of its crown or crown with the help of a metallic tape [11].

Anthropogenic factors

The guide provided by the Regional Government of Tacna [12] was used: a) Not intervened (good physical condition, vigorous leaves and no anthropic impact), b) Semi-intervened (slightly damaged, there are few dry leaves), and c) Intervened (broken, cut, dried, burned and dead trees).

II. RESULTS AND DISCUSSION

The presence of *P. tarapacana* in Tacna is not more controversial. On the other hand, the presence of *P. rugulosa* is debated. In [13], it is explained that the distribution of *P. rugulosa* includes southern Peru and northern Chile as opposed to *P. subtusalbida* (Bitter) where its distribution is recorded in Cochabamba and Potosí in Bolivia, in studies of [5] and [7], in the distribution of *P. subtusalbida* (Bitter) indicate that this species is found in Tacna and in southern Peru. On the other hand, in [14] conclude that there are differences between these species, the results of the present study shows that the other species found in Tacna is *P. rugulosa* Bitter.

Density and population structure

P. tarapacana presented higher density of trees (1420 indiv./Ha) in Cerro Purupuni, followed by Cerro Anatajave and Cerro Iscachancara and Huayllapujo and Camauta, and the lowest density was recorded in Condorpico and Quebrada Chillhuani and Quebrada Huañucucho with 400 indiv./ Ha (Table 1).

Regarding the population structure, the latizales surpasses 50% of the individuals in Huayllapujo and Camauta, Chiluyo Chico, Qda. Queñuta and Paucarani, being the highest percentage registered in Paucarani. The seedling record is much lower compared to latitudes and adult individuals. Of the 11 sectors evaluated, 4 forests present a record greater than 50% of adult individuals. The registry of adult individuals is higher in Cerro Juqhure (Kallapuma), representing 84% of the total registered individuals, being lower in Paucarani (11%) (Table 1).

P. rugulosa showed higher density of trees (2420 indiv./Ha) in Cerro Timilla - Apacheta, followed by Yucamani Volcano and Huiltajavira Annex with 1880 indiv./Ha and 1720, respectively. The lowest density was registered in Queñoaplaza with 220 indiv./Ha and Cerro Paquercara with 389 indiv./Ha (Table 2).

Regarding the population structure, of the 13 sectors evaluated, none of the sectors exceeds 50% of latizales. Regarding samplings, two sectors surpass 50% (Cerro Paquercara and Anexo Huiltajavira) and the evaluation in 8 sectors exceeds 50% of its composition by adult individuals. Cerro Paquercara is a forest in recovery since up to 11% of individuals of the total registered individuals were recorded (Table 2).

According to the registry, *P. tarapacana* presents young forests with greater presence of latizales (48%), followed by adults with (45%) and saplings with only (7%).

TABLE 1. DENSITY AND POPULATION STRUCTURE OF *P. TARAPACANA* FORESTS

Province	District	Sector	Nº *	Density**	Latizales		Brinzales		Adults	
					Nº	(%)	Nº	(%)	Nº	(%)
Tarata	Ticaco	Cerro Purupuruni	71	1420	23	(32)	6	(7)	42	(60)
	Tarata	Cerro Juqhure (Kallapuma)	37	740	5	(14)	1	(2)	31	(84)
		Cerro Antajave and Cerro Iscachancara	70	1400	32	(46)	5	(7)	32	(46)
		Huayllapujo y Camauta (near to Coracorani)	70	1400	40	(58)	9	(13)	20	(29)
		Chiluyo chico	48	960	27	(56)	5	(10)	16	(33)
Tacna	Palca	Quebrada Queñuta	45	900	33	(73)	0	(0)	12	(27)
		Paucarani	29	580	25	(89)	0	(0)	4	(11)
		Condorpico	20	400	6	(30)	0	(0)	14	(70)
		Quebrada Chillhuani and Quebrada Huañucucho	20	400	9	(45)	2	(10)	9	(45)
		Cerro Curicurini and Quebrada Choroveco	25	500	8	(32)	4	(12)	15	(56)
		Cerro Pupusane and Quebrada Picanani	49	980	24	(49)	1	(2)	24	(49)
		TOTAL	**484**	**--**	**232**	**--**	**33**	**--**	**218**	**--**

* Individuals / plot. ** Number of individuals / Ha estimated based on field data.

TABLE 2. DENSITY AND POPULATION STRUCTURE OF *P. RUGULOSA* FORESTS

Province	District	Sector	Nº *	Density**	Latizales		Brinzales		Adults	
					Nº	(%)	Nº	(%)	Nº	(%)
Tarata	Estique	Cerro Paquercara	19	380	3	(16)	14	(73)	2	(11)
	Tarucachi	Quebrada Nuñamayane and Cerro Yaurimojo	81	1620	20	(25)	2	(2)	59	(73)
	Sitajara	Cerro Chuñave and Cerro Huarahuarani	82	1640	32	(40)	23	(28)	27	(32)
	Ticaco	Cerro Chujovilque and Cerro Chajracape	81	1620	17	(21)	3	(3)	61	(75)
	Tarata	Queñoaplaza	11	220	2	(18)	2	(18)	7	(64)
	Susapaya	Cerro Taipesirca	32	640	3	(9)	0	(0)	29	(91)
		Cerro Timilla – Apacheta	121	2420	59	(49)	14	(12)	48	(39)
		Cerro Tancan	58	1160	8	(14)	16	(29)	34	(57)
		Cerro Yocata	24	480	4	(17)	8	(33)	12	(50)
Jorge Basadre	Ilabaya	Santa Cruz de Ilabaya	52	1040	10	(19)	10	(19)	32	(62)
Candarave	Camilaca	Cerro Pantara	39	780	5	(12)	17	(44)	17	(44)
	Candarave	Anexo Huiltajavira	86	1720	14	(16)	21	(24)	51	(59)
		Volcan Yucamani	94	1880	29	(25)	34	(2)	31	(73)
		Caserio Colpapampa and Quebrada Galluta (near to Huiltajavira)	47	940	10	(40)	11	(28)	26	(32)
		TOTAL	**827**	**--**	**216**	**--**	**175**	**--**	**436**	**--**

* Individuals / plot. ** Number of individuals / Ha estimated based on field data.

In Quebrada Queñuta, Paucarani and Condorpico sectors, there are no seedlings showing signs that there is no recruitment of new individuals. *P. rugulosa* presents a higher percentage of adults (51%), followed by latizales (27%) and saplings (22%). These forests are being altered and can be reduced in a short time because there would be no reproductive individuals.

Height and diameter of the trees

P. tarapacana has the highest altitude in Cerro Juqhure (Kallapuma) in Tarata, followed by Quebrada Chillhuani and Quebrada Huañucucho (Palca). The coefficient of variation shows less variability in Paucarani, Cerro Chiluyo Chico, Cerro Antajave and Cerro Iscachancara, Condorpico, Cerro Curicurini and Quebrada Choroveco. The forest of the Juqhure hill (Kallapuma) has the highest average height (1.68m), with the lowest record in Huayllapujo and Camauta with 0.83m (Table 3).

P. rugulosa presents the highest average height in Caserio Colpapampa and Quebrada Galluta in the province of Candarave, followed by the sector of Cerro Taipesirca in the province of Tarata. The coefficient of variation shows less variability in Cerro Taipesirca (Tarata) and shows greater variability in Cerro Pantara of the province of Candarave. The forest of the hill Caserio Colpapampa and Quebrada Galluta has the highest average height (1.62m), with the lowest record at Cerro Paquercara with 0.29m. In this forest, only two adult

individuals were registered, with the highest proportion of saplings being recorded (Table 4).

Regarding the height of *P. tarapacana*, a great variability was observed within the plots sampled, varying individuals from 0.1 m the smallest tree in the district of Tarata in the sector Huayllapujo and Camauta and 3 m the largest in the district of Tarata, Juqhure sector. The results indicate that the variation depends on the presence of saplings (new individuals) and in others only of the latizales (juvenile individuals). In [15], they conclude that in forests of *P. tarapacana* trees have been found from one to seven meters high, contrary, [1] mentions that these forests do not exceed 2m high. [13] reported that trees of *P. tarapacana* are trees between 5 and 10m. [16] mention that they are shrubs that measure from 1 to 4 meters high. The Regional Government of Tacna [12] concludes that in the high Andean zone of Tacna the trees of this species require 73 years to reach their biological maturity. The trees of *P. tarapacana* have an average of 80 years, being the longest of 137 years.

TABLE 3. HEIGHT OF *P. TARAPACANA* FORESTS

Province	District	Sector	Mínimum (m)	Máximum (m)	Average (m)	Coefficient of variation
Tarata	Ticaco	Cerro Purupuruni	0,15	2,50	1,22	0,46
	Tarata	Cerro Juqhure (Kallapuma)	0,30	3,80	1,68	0,40
		Cerro Antajave y Cerro Iscachancara	0,20	2,20	1,15	0,53
		Huayllapujo y Camauta (cerca a Coracorani)	0,10	1,90	0,83	0,51
		Chiluyo chico	0,10	1,90	0,89	0,55
Tacna	Palca	Quebrada Queñuta	0,40	1,70	0,91	0,37
		Paucarani	0,33	1,27	0,68	0,33
		Condorpico	0,31	2,30	1,21	0,52
		Quebrada Chillhuani y Quebrada Huañucucho	0,30	2,60	1,24	0,51
		Cerro Curicurini y Quebrada Choroveco	0,18	2,10	1,14	0,52
		Cerro Pupusane y Quebrada Picanani	0,30	1,85	1,02	0,36

TABLE 4. HEIGHT OF *P. RUGULOSA* FORESTS

Province	District	Sector	Mínimum (m)	Máximum (m)	Average (m)	Coefficient of variation
Tarata	Estique	Cerro Paquercara	0,10	0,80	0,29	0,68
	Tarucachi	Quebrada Nuñamayane y Cerro Yaurimojo	0,00	2,50	1,25	0,43
	Sitajara	Cerro Chuñave y Cerro Huarahuarani	0,12	3,40	0,95	0,85
	Ticaco	Cerro Chujovilque y Cerro Chajracape	0,00	2,50	1,25	0,43
	Tarata	Queñoaplaza	0,18	2,60	1,24	0,62
	Susapaya	Cerro Taipesirca	0,53	3,10	1,61	0,31
		Cerro Timilla – Apacheta	0,15	3,60	1,01	0,53
		Cerro Tancan	0,10	3,10	1,36	0,73
		Cerro Yocata	0,12	2,60	1,14	0,74
Jorge Basadre	Ilabaya	Santa Cruz de Ilabaya	0,15	2,50	1,18	0,54
Candarave	Camilaca	Cerro Pantara	0,18	4,20	1,46	0,95
	Candarave	Anexo Huiltajavira	0,10	4,00	1,30	0,70
		Volcan Yucamani	0,10	5,20	1,12	1,07
		Caserio Colpapampa y Quebrada Galluta	0,15	5,00	1,62	0,83

P. rugulosa showed great variability within the evaluated plots since trees were registered from 0.1m in the Estique district (Paquercara sector), Susapaya (Cerro Tancan sector), Candarave (Yucamani Volcan sector) and 5m, the greater height, in the district of Candarave, sector Caserio Colpapampa and Quebrada Galluta. [15] conclude that individuals of *P. rugulosa* measure between 3 and 5m in height. Studies carried out by [17] [18] describe heights between 3 and 10m. [16] mention that it is a shrub that reaches heights between 2 and 5m. [19] reports averages of 1.10 to 2.43m in height. The records of this study show that average heights would belong to secondary or recovery forests given the use and exploitation of these species as combustible material made by local people.

Regarding the diameter of the trees of queñoa (DAP), it is evident that the individuals of *P. tarapacana* with greater average were registered in Cerro Juqhure (Kallapuma), Cerro Antajave and Cerro Iscachancara, Chiluyo Chico, Quebrada Chillhuani and Quebrada Huañucucho with 0,10m; it is recorded according to the coefficient of variation that the results between zones are variable because in many cases within the plot the DAP (0 cm) was not measured, thus obtaining broad results, as shown in Table 5. In most of the evaluated sectors, the

trees branch at a low altitude, and no data can be obtained at chest height (Table 5).

The highest averages of *P. rugulosa* were recorded in Quebrada Nuñamayane, Cerro Yaurimojo, Cerro Chujovilque and Cerro Chajracape with 0.08m. It is recorded according to the coefficient of variation that the results between zones are variable, in the areas of Cerro Taipesirca, Cerro Timilla-Apacheta, Queñoaplaza with 0.5; 0.5 and 0.94 respectively, have less variability with respect to Cerro Chuñave and Cerro Huarahuarani, Santa Cruz de Ilabaya, Yucamani Volcano with 2.4; 2.0 and 2.0 respectively.

On the other hand, the highest rank was registered in Queñoaplaza and Cerro Chuñave and Cerro Huarahuarani (Tarata) with 0.50m respectively; This is because in many cases, within the plot, the DAP (0 cm) was not measured, obtaining broad results as shown in Table 6.

The DAP of queñoas is variable. In the study, it was not possible to register enough tall individuals since the measurement method implies a recording at a height of 1.5m. [12] recorded diameters between 0.4 and 0.6m reaching this range in an approx. 40 years for *P. tarapacana*. In the case of *P. rugulosa* this range varies between 0.02 and 0.42m.

TABLE 5. DIAMETER OF THE TREES OF THE *P. TARAPACANA* FORESTS

Province	District	Sector	Mínimum (m)	Máximum (m)	Average (m)	Coefficient of variation
Tarata	Ticaco	Cerro Purupuruni	0,30	0,00	0,30	0,03
	Tarata	Cerro Juqhure (Kallapuma)	0,00	0,10	0,03	1,33
		Cerro Antajave and Cerro Iscachancara	0,00	0,10	0,02	2,00
		Huayllapujo and Camauta (near to Coracorani)	0,00	0,00	0,00	0
		Chiluyo chico	0,00	0,10	0,002	5,00
Tacna	Palca	Quebrada Queñuta	0,00	0,00	0,00	0
		Paucarani	0,00	0,03	0,002	3,50
		Condorpico	0,00	0,05	0,007	1,42
		Quebrada Chillhuani and Quebrada Huañucucho	0,00	0,10	0,01	3,00
		Cerro Curicurini and Quebrada Choroveco	0,00	0,08	0,01	2,00
		Cerro Pupusane and Quebrada Picanani	0,00	0,03	0,002	4,00

TABLE 6. DIAMETER OF THE TREES OF *P. RUGULOSA* FORESTS

Province	District	Sector	Mínimum (m)	Máximum (m)	Average (m)	Coefficient of variation
Tarata	Estique	Cerro Paquercara	0,00	0,40	0,04	3,00
	Tarucachi	Quebrada Nuñamayane and Cerro Yaurimojo	0,00	0,47	0,08	1,50
	Sitajara	Cerro Chuñave and Cerro Huarahuarani	0,00	0,50	0,05	2,40
	Ticaco	Cerro Chujovilque and Cerro Chajracape	0,00	0,47	0,08	1,50
	Tarata	Queñoaplaza	0,00	0,50	0,17	0,94
	Susapaya	Cerro Taipesirca	0,01	0,11	0,04	0,50
		Cerro Timilla – Apacheta	0,00	0,10	0,02	0,50
		Cerro Tancan	0,00	0,16	0,03	1,30
		Cerro Yocata	0,00	0,16	0,04	1,00
Jorge Basadre	Ilabaya	Santa Cruz de Ilabaya	0,00	0,18	0,01	2,00
Candarave	Camilaca	Cerro Pantara	0,00	0,16	0,03	1,30
	Candarave	Anexo Huiltajavira	0,00	0,15	0,03	1,30
		Volcan Yucamani	0,00	0,21	0,02	2,00
		Caserio Colpapampa y Quebrada Galluta	0,00	0,34	0,05	1,40

Anthropogenic factors

For both species, the results are similar. The anthropic factor for *P. rugulosa* is categorized as: Not Intervented with 660 individuals (76%), Semi Intervening with 181 individuals (21%) and Intervened with 29 individuals (3%). For *P. tarapacana* it is categorized as: not intervened with 369 individuals (77%), Semi Interventions with 102 individuals (21%) and Intervened with 11 individuals (2%).

The forests of *P. tarapacana* are in a good state of conservation, due to the fact that in the evaluation sectors the percentage was higher than 90% in most of the plots. In Cerro Antajave and Cerro Iscachancara, the percentage is 11% of individuals not intervened. The forests of *P. rugulosa* are in a regular state of conservation, records show that the majority of sectors are in the range of 50% to 75% of category not intervened. In the Semi-Intervened category, ranks between 10% and 38% are presented.

Local people graze cattle (mainly cows) that feed on the saplings. During this action, mechanical damage is generated by the movement of animals and people. The soils are poor and adverse climatic conditions are known at these altitudes that affect the viability of the saplings.

In Tacna it has been observed that of the adult individuals they present some degree of anthropic or natural impact such as felling, burning, overgrazing, defoliation by the phenology, plague or disease. The main anthropic influences are due to the indiscriminate felling of trees, burning and livestock activity [1]; some use it to provide energy to the mines [6], and as a medicinal use, in our case there were clearings, burning, food for their livestock and especially the destruction of the new individuals as the roads of the settlers go through the middle of these forests [19]. Other studies indicate that certain seasons of the year burn these forests in order to fertilize the land [20], on the contrary in previously done studies it was evidenced that they cut and instead put another type of tree (eucalyptus, molle) [19]; being impacted not only the queñoas but the accompanying flora and fauna that in many cases are endemic to this type of forest and would not survive another ecosystem and would perish in time [21]. The opening of roads contributes to the fragmentation of habitat and the contamination with solid waste that besides polluting the soil distort the aesthetic harmony of the landscape. It can be considered that logging and grazing are the main activities that accelerate the degradation process of the forest and areas of influence [22].

Understanding the structure and composition of forests is the key to achieving an adequate management and restoration of these ecosystems. The forests of this area form very heterogeneous landscapes, with a high biological diversity, in which the alterations due to human activities have played a determining role. There is still limited information on what factors have shaped the structure and current composition of the forests, and how the species found respond to environmental stress, particularly in their early stages of development, which can be the key to understanding their dynamics and response to changes environmental.

One of the fundamental bases of the sustainable management of the forests is the maintenance of the natural regeneration. This form of management requires that species regenerate naturally to maintain their populations and ensure the future productivity of the forest [23] - [24].

III. CONCLUSIONS AND RECOMMENDATIONS

On basis of the data gathered, we established next conclusions:

- Two species of queñoa are distributed in Tacna: *P. tarapacana* and *P. rugulosa*.
- *P. tarapacana* had a lower density than *P. rugulosa*.
- The height of queñoas is variable. The forests of queñoa showed are forests in process of natural restoration.
- The diameter at breast height showed that trees of queñoa are younger and small. It means that forests are growing or initiating a resilience process.
- The main human activities affect the population structure of queñoa forests are: grazing, burning, provide energy to mines, reforestation (with other species) and opening of roads.

Our recommendation about a conservation plan for queñoa forests are:

1. Education: to design a programme about alternative education with intercultural focus (local governments), to improve environmental education programme (Ministry of Education and local units), and to incorporate a special chapter about the importance of queñoa forests in formal education (Ministry of Education).
2. Communication and empowerment of local populations: to design accessible ways for communication through focus groups, to create a network of social communicators (bilingual), to design a programme about environmental citizen, to publish research about the importance (both social and economic values) of queñoa forests for population (rural and urban) including ecosystem services.
3. Conservation and sustainable management: to develop biological inventories about diversity associated, to identify priority areas for restoration and conservation, to promote use of sustainable energy, to design a programme of ecotourism (communitarian rural tourism) for improving incoming of villagers, and to implement a programme of agroforestry.
4. Policies and regulations: to establish regulations of national, regional and local about the protection of queñoa forests, to promote protection of forests by companies through to subsides, incentives or social responsibility mechanisms.
5. Research and monitoring: to map the priority areas to conservation; to assess the economic value of biological resources associated; to study the phenology, taxonomy, and biomass of queñoas; to study the effects of climatic change about queñoa forests; to compilate the traditional knowledge of villagers; and, to realize research about social importance of those high Andean forests.

ACKNOWLEDGMENTS

Juan Pablo Franco León provided advice during the collection, data analysis and drafting of the manuscript. Alfredo Tupayachi Herrera (Herbario Vargas - CUZ) provided taxonomic information and complemented the research work. Alejandro Murillo Calisaya and Avelino García Lévano accompanied and supported the activities of information gathering in the field.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 187-191

Modelling of Strass-stain State in Epicentral Zone of Strong Earthquake

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***Abstract*—This article describes the results of modeling the stress-strain state of the epicentral earthquake zone, which occurred on December 26, 2003 in the southeast of Iran in the province of Kerman (Bam), before and after the formation of the fault. It is shown that the main earthquake shock is located in the zone of high intensity of stresses, and the formed fault traces this zone on the surface and corresponds to its extent. Aftershocks are localized in the area of the maximum released stress intensity after the formation of the fault. Stress release stimulates the discharge of accumulated tectonic stresses in the subsequent aftershock process. The results obtained can be useful for deterministic approach to assessment and prediction of seismic hazard, as well as for geophysical observations clearly suited for the goal of predicting strong crustal earthquakes in continental regions.**

Keywords*—epicentral earthquake zone, tectonic stresses, modelling, stress-strain.

I. Introduction

A strong earthquake with M_w and seismic moment $6 \div 9\text{-}10^{18}$ occurred in the southeast of Iran on December 26, 2003. The epicenter of the earthquake was located near the town of Bam in the province of Kerman. The ancient town of Bam, whose population was more than 100 thousand people, was practically demolished at the moment of main shock, and the number of victims exceeded 30 thousand people. The epicenter of the earthquake was located at a depth of 10 km [1]. On the surface, cracks were found tracing the direction of the formed gap 18-20 km long. After the earthquake in the vicinity of Bam, a network of seismic stations was set up (Figure 1), which registered more than 1,000 aftershocks M> 2.7. This allowed us to outline the main area of aftershock activity (about 25 km in length and 7 km in width) stretched in the meridional direction [10]. Hypocenters of aftershocks were localized at depths from 6 to 20 km. At the same time, most aftershocks were concentrated within the seismogenerating layer of the earth's crust with a thickness of 5 to 15 km. [9].

The nearest to the town of Bam tectonic fault (Bam fault) is located 4 km east of the town, its length is about 50 km (Figure 1). In the northwest there is a system of meridional faults (Gowk fault). Based on the analysis of the mechanism of strong shock and GPS data, the regional field of tectonic stresses is characterized by the dominant pressure stresses of submeridional orientation [10]. The confinement of strong earthquakes to faults in crystalline foundation suggests that tectonic faults, as an area of destruction of the geological medium [6, 7, 8], lead to the formation of a local non homogeneous stress-strain state (SSS) in the Earth's crust.

A contemporary view on tectonic faults is related to the dispersed geological material therefore they can be represented by a model (giant blocked tectonic melanzh [11]. The presence in such a homogeneous massif of similar dispersion zones, the elastic modulus of which is substantially lower than that of the surrounding massif, leads both to the formation of anomalous local zones of high stress intensity, which initiate the development of a fault in a focus of tectonic earthquake [2, 3]. Formation of a fault leads to a change in SSS in the epicentral zone. In this case, regions of dropped stresses immediately adjacent to the new fault arise together with regions of increased stresses (at the termination points of a fault) exceeding the stresses that existed before the seismic event.

Modeling the stress-strain state in the epicentral zone of the December 26, 2003 Bam earthquake made it possible to distinguish an abnormally high area of stress intensity, which correlates with the stretch zone and the length of the predicted fault formed as a result of the earthquake. In this case, strong aftershocks with M> 5 are in the region of high stress intensity preceding the formation of the main shock (rupture). The localization of aftershocks epicenters and the mechanisms of shocks with $M \geq 2.7$ suggest that they are associated with the zone of ejected stresses, after the main shock.

The obtained results confirm the hypotheses of "nonlinear elasticity" of geological medium, where the model of SSS of the epicentral zone assumes an "instantaneous" release of stresses in the initially elastic medium, but the real process goes on with a certain delay in the aftershock activity time interval. In this connection, the possibility of forecasting the area of a strong tectonic earthquake in seismically dangerous regions according to the results of SSS modeling of rock massifs destroyed by systems of tectonic faults, acquires practical significance.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4119

II. Seismotectonic position of the epicentral zone of the December 26, 2003 Mw 6.6 Bam earthquake

To the north and south of the city of Bam within a radius of 70 - 80 km over the past twenty years, several strong earthquakes M> 6.0 were recorded, associated with active fault zones of meridional orientation (Nayband - Gowk - Sabzavaran system) [10]. The 2003 earthquake turned out to be unexpected, since historical data only testify to several earthquakes located north of the city, and instrumental observations are limited to sufficiently remote seismic stations [1]. The parameters of strong earthquakes were instrumentally determined on June 11, 1981 (Mw 6.6) and July 28, 1981 (Mw 6.6). These earthquakes and the March 14, 1998 strong earthquake (Mw 6.6) are associated with tectonic activity of the extended fault of submeridional orientation (Gowk fault) [1, 10] (Figure 1). According to GPS-observations, the right lateral displacement along the fault is ~ 6 mm / year.

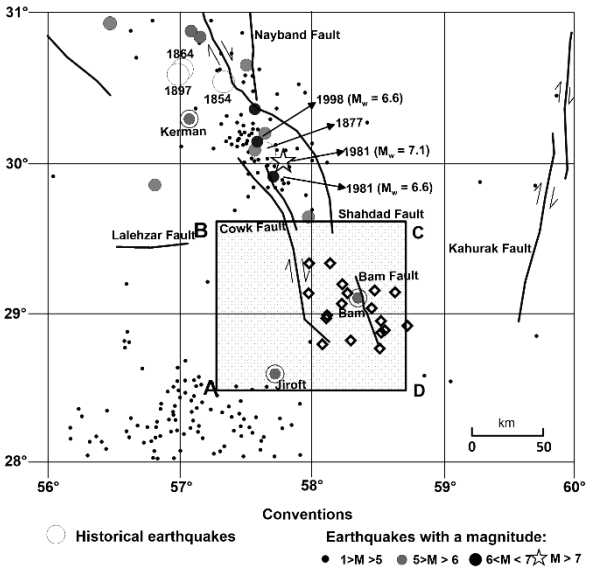

Fig.1. Structural-tectonic scheme and epicenters of strong earthquakes in the area of the city of Bam (Iran). ABCD - the area of the simulation of the SSS of the epicentral zone of the earthquake on 26.12.2003

9 seconds after the main shock, a strong aftershock (Mw = 6.5) with an epicenter located south of the main shock was recorded [10]. Three days after the main shock, a network of mobile seismic stations was set up to record subsequent aftershocks. Figure 2 shows the area of aftershocks development 25 km long and 7 km wide (Figure 2). Aftershocks were registered at depths of 5 to 15 km, with maximum density in the "layer" from 9 to 12 km. The spatial distribution of aftershocks and crack systems on the surface suggest a submeridional orientation of the plane of the newly formed cracks, shown in Figure 3 taking the data into account. Figure 3 also shows the horizontal projection of P-axes in the epicenters of registered aftershocks and the position of a newly formed crack [9, 10]. These data are used to model the epicentral zone of the December 26, 2003 earthquake.

The GPS/GLONASS observations in Iran, mechanisms of strong earthquake epicenters north of the city of Bam and aftershocks after the December 26, 2003 earthquake give grounds to assert the prevailing pressure stresses in the Bam area with an axis oriented in the range 0-10 ° relative to the meridian.

III. Simulation results of the December 26, 2003 earthquake epicenter

The external field of tectonic stresses (border conditions) for ABCD square (see Figure 1) was given by the following values: σ_{yy} = -30 MPa, σ_{xx} = -10 MPa. The modulus of crystalline basement rocks elasticity E = 8x103 MPa, the modulus of elasticity of fault zones of the dispersed medium is two orders lower than E = 8x10 MPa, the Poisson's ratio μ = 0.25.

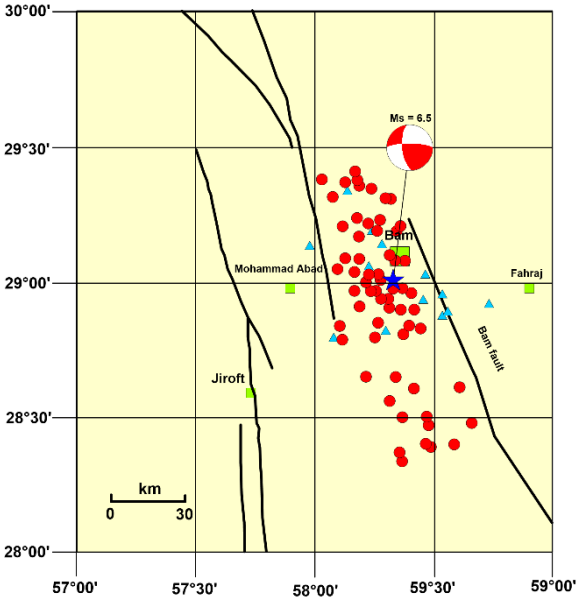

Fig. 2. Map of epicenters of aftershocks of the Bamsky earthquake on December 26, 2003.

Figure 3 shows the map of stress intensity distribution prior to the December 26, 2003 earthquake. High stress intensity zones are allocated on it, which could be associated a priori with possible zones of initiation and development of the fault. Moreover, the zone of high intensity of stresses between the Bam fault and Gowk fault about 75 km long, oriented in the meridional direction has three extremes and is more preferable in forecast evaluation of the possible development of seismotectonic process.

The distribution map of stress components σ_{yy} (Figure 4) has roughly the same morphology-an extended zone of high σ_{yy} values between the Bam and Gowk faults that extends north and the high σ_{yy} region at the southern end of Bam fault. Within the framework of the model, it has to be expected that abnormally high pressure stresses stimulate the start of destruction in the earthquake epicenter and the subsequent spreading of the fault.

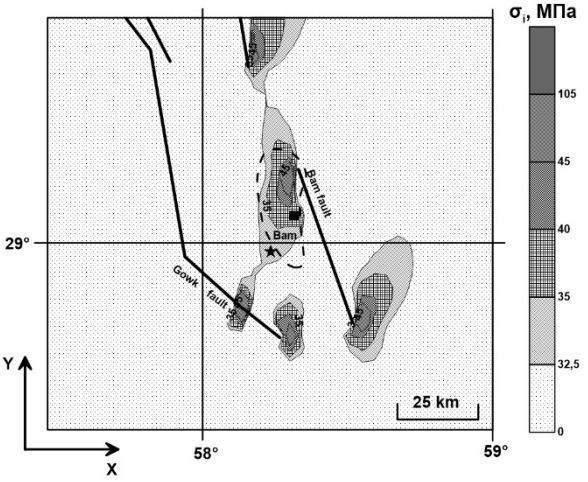

Fig. 3. Stress intensity map σ_i before the earthquake.

From considerations of distraction mechanism (the Mohr-Coulomb model), it would be logical to expect that the fault began from the area of maximum pressure stresses σ_{yy} and the minimum values σ_{xx}, under these conditions the probability of a fault in the form of a shear is extremely high.

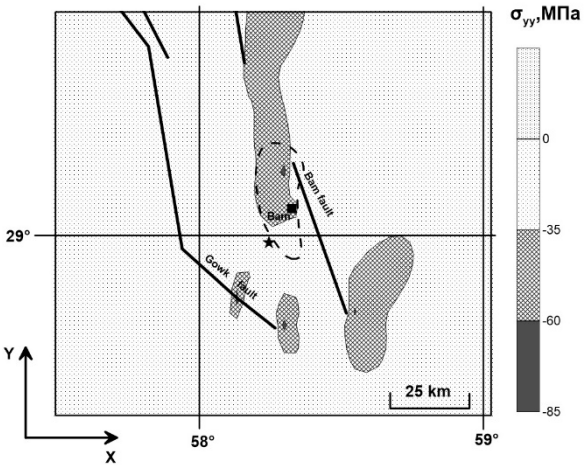

Fig. 4. Stress map σ_{yy} before the earthquake.

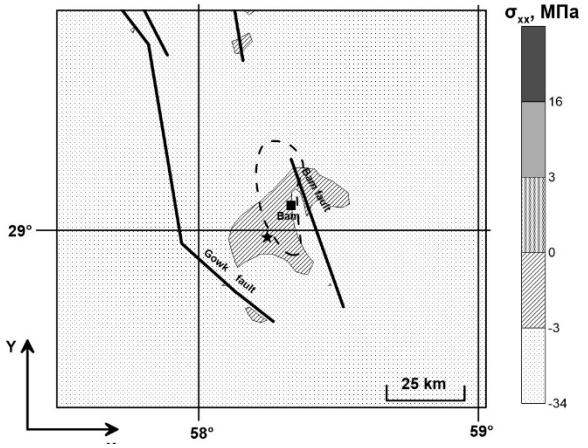

Fig. 5. Stress map σ_{xx} before the earthquake.

Figure 5 shows the stress tensor σ_{xx} component map before the earthquake. In the central part of the ABCD quadrant, a zone of anomalously low stresses (lower than 2 MPa, at background values of 10 MPa) is identified in the center of the region between Bam fault and Gowk fault. The σ_{xx} stresses are transformed into strain stresses.

Figure 6 shows the map of stress components ratio σ_{yy}/σ_{xx}. It can be seen that at the initial background value $\sigma_{yy}/\sigma_{xx} = 3$, in the central zone between the faults this value exceeds background values by 6 or more times.

On the maps (Figures 3-7), the epicenter of the main shock is indicated by a star. The epicenter of the main shock is associated with an extended zone of high stress intensity (Figure 3). Similar results were obtained earlier when simulating SSS of epicentral zones of strong earthquakes in India and Turkey [2, 5]. At the same time, the epicenter of the main shock falls in the area of high σ_{yy} values at the minimum σ_{xx} values, evolving into strain stresses (Figure 6).

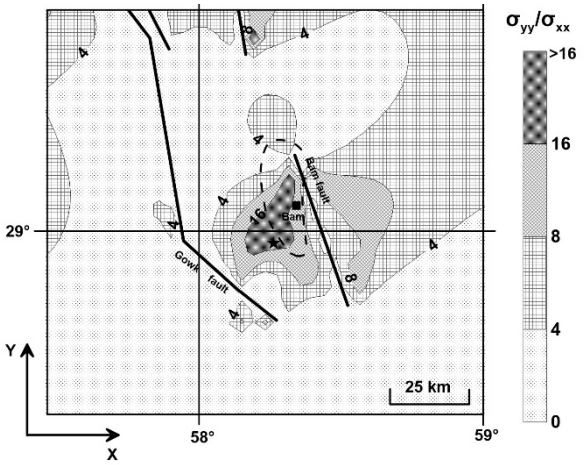

Fig.6. Map of relations æ (σ_{yy} / σ_{xx}) before the earthquake.

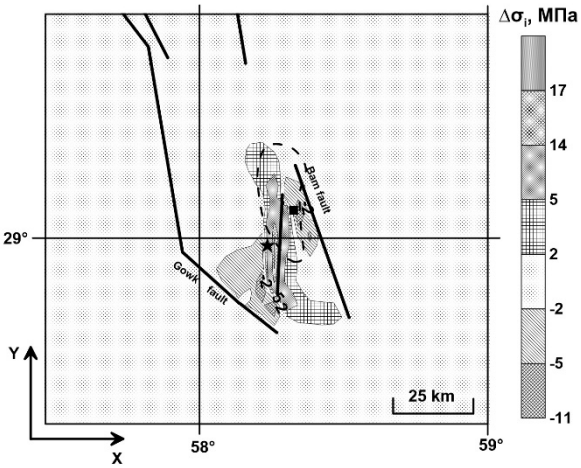

Fig. 7. Map of stress intensity difference ($\Delta\sigma_i$.) Before and after earthquake.

Using the results given in [10], the contour of the aftershocks area is indicated on the σ_{yy}/σ_{xx} ratio map, the position of which is determined with an error not exceeding 2 km.

From this area of maximum stresses, the fault propagates in a submeridional direction and, from the analysis of cracks formed on the surface, probably occupies the position between the Bam and Gowk faults, as shown in Figure 3 by a dotted line. In Figures 3 - 7 the area of aftershocks localization of is indicated by a dotted line. In Figure 4, this area corresponds to the zone of maximum stress intensity, which includes the epicenter of the main shock. In Figure 5, the aftershocks area coincides with the area of maximum pressure stresses σ_{yy}, which apparently determines the mechanism

of aftershocks in this zone. The correspondence between the aftershocks area and the area of minimum pressure stress σ_{xx} is shown in Figure 6.

Formation of a new tectonic rupture (dotted line in Figures 6 - 7) leads to a change in SSS of the epicentral zone. Relaxation of "secular" accumulated stresses occurred as a result of aftershock process. A drop of stresses in the area of a new fault stimulated this process. The cluster of aftershocks, as shown above, is localized in the area of high intensity of stresses preceding the earthquake, and the mechanisms of shocks corresponds to the condition of submeridional pressure, as shown in Figures 3 and 4.

Figure 7 shows the stress intensity difference map $\Delta\sigma_i$ before and after the earthquake. In the area adjacent to the proposed fault, the level of stress intensity becomes significantly lower than the previous level before the formation of the fault. At the same time, new zones of increased stress intensity arise. It can be seen that the zone of epicenters of aftershocks is localized mainly in the zone of the dropped stress intensity.

The method used to calculate SSS of the epicentral zone (elastic formulation of the problem) assumes that "secular" static stresses drop completely in the area of a new fault (adequate tectonic fault) in the process of its "conditionally instantaneous" propagation. The energy of the dropped secular stresses is within 10x16 – 10x17 J. Under real conditions, only a part of static secular stresses can "conditionally instantaneously" drop - the dropped energy of deformation, during the earthquake, does not exceed first percent of the dropped energy calculated by [2]. The real "non-linear elasticity" of the geological medium holds it in the process of aftershock activity, because time is required for a drop of static stresses. Aftershocks epicenters as elements of elastic properties weakness of the geological medium lead to a new stress state of the epicentral zone due to a change in its physico-mechanical characteristics in a much larger volume, compared with the volume of dispersed geomaterial of an emerging new tectonic fault.

IV. CONCLUSION

It follows from the foregoing that:

1. The epicenter of the Bam earthquake in Iran, which occurred on December 26, 2003, is located in the area of anomalously high stress intensity, obtained from the data of SSS modeling of the epicenter area.
2. It can be assumed that the "starting point" (the hypocenter of the December 26, 2003 earthquake) is associated with the stress state of the geological medium when high meridional pressure stresses σ_{yy} cause destruction of the geological medium at minimum pressure stresses passing into stretch stresses σ_{xx}.
3. The results of SSS modeling in the area of the source of December 26, 2003 earthquake correspond to the mechanism of the main shock source obtained from seismic data.
4. Orientation of the "plane" of the fault and its length are adequate to the zone of high stress intensity obtained as a result of SSS modeling of the Ms 6.9 earthquake of December 26, 2003 epicentral zone.
5. The strong aftershocks that followed after the main shock are localized in an abnormally high stress intensity zone preceding the main shock.
6. After the formation of tectonic fault, SSS of the epicentral zone changed. There are areas of intensity drop adjacent to the newly formed fault in the area of increased stress intensity.
7. The zone of epicenters of aftershocks (including more than 1000 events) with a length of 26 km and a width of 7 km is localized in the zone of high intensity of stresses preceding the main shock. In this zone, after the earthquake (i.e., after the newly formed fault), the stress intensity decreased substantially as a result of the development of the subsequent aftershock process.

The results of SSS modeling of the epicentral zone of the Mw 6.6 strong earthquake in Iran of December 26, 2003, are adequate to the SSS modeling results of the epicentral zones of two strong earthquakes in India [3]. Summing up the results of the presented article and the specified works, it is possible to assert:

1. SSS modeling of epicentral zones of strong crustal earthquakes in continental regions allows us to retrospectively identify regions of localization of epicenters of possible strong earthquakes.
2. The length of local stress intensity zones is adequate to the extension of the formed fault and can serve as a predictive criterion for the magnitude of a possible tectonic earthquake.
3. Formation of a new tectonic fault leads to a change in SSS of the epicentral zone, - regions of resetting the "static" stresses and local areas of their increase arise, which are associated with epicenters of subsequent strong aftershocks.

Thus, the analysis of the results of modeling the Mw 6.6 earthquake epicentral zone of December 26, 2003 in comparison with seismological data gives hope for the possibility of predicting the location and energy of a possible maximum earthquake in seismotectonic environment, similar to the Bam area in southeastern Iran.

The work was performed as part of research works on the state task of the Ministry of Science of the Russian Federation

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 192-197

Research on Properties of Composites Based on Magnesium Binders

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***Abstract*—the research is devoted to composites based on magnesium binders, which is very perspective building material in the modern construction industry. Magnesium based binders have better compatibility with organic fillers comparing to traditionally lime binder cement [1]. In this investigation two magnesium-based binders are used, such as magnesium chloride and magnesium sulphate. The aim of this study is to investigate the physical, mechanical and durability properties of composites based on magnesium binders, such as density, compressive strength, thermal conductivity and capillary water absorption, and to obtain magnesium binder that could be used to produce foamed concrete. This can be done by improving the composition of the mixture. In this framework properties of magnesium binders are analysed and how these binders can affect to the properties of magnesium based composites.**

***Keywords*—magnesium binders, magnesium oxychloride and sulphate cement.**

I. Introduction

Since the building domain has obsessed a significant role of the energy consumption in recent years, the demand for efficient construction has become more important. Nowadays the building sector in regular covers up to 40 % of all energy. A lot of industrial activities, factories and also building cause environmental pollution and CO_2 emission. High level of these emissions caused by manufacturing of building materials and low energy of buildings are the main reasons for promoting the greenhouse gas. On this account increasingly is paid attention to environmentally friendly construction materials that accomplish requirements of high-level energy efficiency [2].

The European Union has announced several public documents and guidance for the purpose of reducing pollution and CO2 emissions, for example the Paris Agreement in 2016 [3]. The main objective of the directive EU2010/31/EU is to limit the amount of emissions by 20 % till 2020 [4] and of the Energy and Climate framework 2030 by 40 % till 2030 [5].

In addition, besides the most significant environmental inflecting factor the Global Warming Potential, there are other factors that should be considered – toxicity, acidulation etc. Manufacturing of building materials affects the environmental a lot because of multitude amount use of raw materials and energy intensity [3] [5] [4]. Therefore there is a need for additional efforts to reach all objectives. So even more all new buildings are required to become as nearly zero-energy [6]. Thereby buildings have high energy performance and use of renewable energy sources. [7]

It is also important to note that one of more widely used building materials all over the world is cement. Despite the good qualities of it, there are a lot of undesirable consequences. It must be understood that cement accounts up to 94% of CO_2 emissions and the main of energy consuming processes is directly the production. [8]

Thereby there is consumed a lot of raw materials and there is a need to find a way to reduce energy consumption. One of the solutions could be the use of magnesium binding materials. [9]

Due to the low calcination temperature the magnesium based cements can bring environmental benefits. So there are different types of MgO based cements and the most typical are – Magnesium Phosphate cements, Magnesium Silicate cements, Magnesium Oxychloride cements and Magnesium Oxysulphate cements. Magnesium based cements are suited for prefabricated construction, roadwork and other fields. These cements would rather use MgO then CaO (involves more than 60 % of Portland cement). Whereas the chemical compositions of these two are very different, it is not so simply to change the raw material for Ca-based cements. [10][11]

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4157

A. Magnesium Oxy-Chloride cement

Magnesium Oxy-Chloride cements is indicated by MOC and relies on water reaction between MgO and MgCl2. So the chemical formula of raw materials is MgO + MgCl2 [12]. It is also known as Sorel cement, as it was first announced by Sorel in 1866. Sorel cement is characterized by high strength, bonding and quick setting, also it is hard, fire proof so it could be used for heavy floorings because of relatively light weight [13] [11].

Despite that MOC binders have been used less for flooring in the last decade because of doubt about sensitivity to water damage and also high costs. But the topic about fire resistance is getting more actual, as there is another interest about uses. That's way there is another application nowadays – production of boards containing wood fibres and perlite, overlayed by glass cloth. These boards have look of chipboard and ability to withstand nails and screws. Since there are used MgO and a low temperature during production, almost always they are indicated as "eco" products or carbon-neutral. [11] [14]

The compressive strength is about 120 – 140 MPa. The coefficient of thermal expansion is low and chemical formulas for compounds are $3Mg(OH)_2 \cdot MgCl_2 \cdot 8H_2O$ (phase three) and $5Mg(OH)_2 \cdot MgCl_2 \cdot 8H_2O$ (phase five) [12]. Normally it is assumed for cements to calcinate magnesium at 800 – 1000 °C, but the temperature of calcination is about 700 °C [11]. At higher temperatures of calcination releases a less reactive MgO or dead burned. Whereas MgO reacts with MgCl, so it is unable for CO_2 to be absorbed through carbonation and because of this the less CO_2 is created [15].

B. Magnesium Oxy-Sulfate cements

Magnesium Oxy-Sulphate cements are indicated by MOS and in general are similar to MOC, but the main difference is that $MgSO_4$ is used instead of $MgCl_2$ [11]. The chemical formula of raw materials MgO + $MgSO_4$, but for compounds – $3Mg(OH)_2 \cdot 3MgSO_4$ (phase three) and $5Mg(OH)_2 \cdot MgSO_4 \cdot 2H_2O$ (phase five) [12].

These types of cements obtained interest thanks to that magnesium sulphate is less hygroscopic than magnesium chloride. And it was proven to have better resistance to atmospheric effects. However, magnesium oxysulphate cements have fewer applications and available literature is limited comparing to MOC cements. Owing to the limited solubility of $MgSO_4 \cdot 7H_2O$ (at room temperature), it is more complicated to form MOS cements. [11] [16] [17]

The main application of magnesium oxysulphate cement is production of lightweight insulating panels that contain impregnative wood shavings. There is an option to produce several types of panels with different uses and they are suitable for construction, public and residential buildings etc. [10]

II. Materials and methods

A. Used materials

All magnesium – based binders were obtained experimentally in a laboratory setting using the main components as follows:

Magnesium oxide – in this research caustic magnesia as main binding agent was used, being made by calcination of magnesite ($MgCO_3$). The used magnesium oxide is produced by "RHI AG Ltd", Austria. The properties of the material are as follows: 73.0% MgO, 4.0% CaO, 4.0% SiO_2, 3.0% Fe_2O_3, 1.0% Al_2O_3, size distribution 90% < 30 μm and calcination temperature 750°.

Magnesium chloride hexahydrate, produced in Germany and containing 47% $MgCl_2$ was used as brine solution (with proportions 1:1 salt: water by weight) and also magnesium sulphate was used as brine solution (with proportions 1:1 salt: water by weight) to produce mixtures.

Natural, washed sand was used as a filling component. Sand with fraction size 0-1.0 mm and supplied by "Sakret", Latvia was used.

Pozzolanic additives – microsilica (MS) or silica fume was used. MS with fine particles (1μm – 15 nm) works as the supplementary cementing material [18] and improves the water resistance of binding material [19].

B. Mixtures

In this experimental study mixtures with MgO/sand ratio 0.5 were produced, the amount of $MgCl_2$, $MgSO_4$, metakaolin (MK) and MS was variable (see data in table 1). Experimental mixes 1-6 were produced using $MgCl_2$ and three of these mixes (4-6) were produced adding MS additive. Using $MgSO_4$, the compositions A-F were made. Three of these compositions (D-F) were also produced by adding MS.

In this experimental study, foam concrete compositions were also prepared without adding sand. These mixes were made by pre-foaming technology where magnesium-based binder was mixed with beforehand prepared foam (synthetic foaming agent PB-Lux was used). The ratio of monopotassium phosphate and MgO 0.8 and $MgCl_2$/MgO 0.67 was used.

TABLE I. MIXES OF MAGNESIUM BINDER

Designations of mixes	Ingredients (weight proportions of the MgO)							
	Sand 0-1 mm	MgO	$MgCl_2$	MS	Water	$MgSO_4$	K_2PO_4	PB-Lux
1	2	1	0.67	0	0	0	0	0
2	2	1	0.5	0	0.17	0	0	0
3	2	1	0.33	0	0.33	0	0	0
4	2	1	0.67	0.07	0	0	0	0
5	2	1	0.5	0.07	0.17	0	0	0
6	2	1	0.33	0.07	0.33	0	0	0
A	2	1	0	0	0	0.67	0	0
B	2	1	0	0	0.17	0.5	0	0
C	2	1	0	0	0.33	0.33	0	0
D	2	1	0	0.07	0	0.67	0	0
E	2	1	0	0.07	0.17	0.5	0	0
F	2	1	0	0.07	0.33	0.33	0	0
I	0	1	0	0	0.55	0	0.80	0.80
II	0	1	0.67	0	0.10	0	0.13	0.80

C. Testing methods

The test of compressive strength was performed using semi-automatic testing machine "CONTROLS". The force was applied with a constant speed (0.05 MPa/s). Samples (six pieces of each series) with dimensions 50x50x50 mm were subjected to the test and were stored at the temperature 15-20°C and relative humidity level ~90-95%. The parameters of compressive strength were determined both in dry and wet condition of the magnesium-based samples, so the softening coefficient was determined (1):

$$K = \frac{R_{wet}}{R_{dry}}, where \quad (1)$$

R_{wet} – compressive strength of specimen cured in water during the hardening, MPa;

R_{dry} - compressive strength of dry specimen, MPa (RH 90-95%, temp. 15-20°C).

According to the methodology of the standard LVS EN 722-11 the test of capillary water absorption was performed. Specimens were immersed in water in the depth of 5 mm. To keep the water level even across the entire cross-section of the sample, the spacers under the specimens were used (see Fig.1).

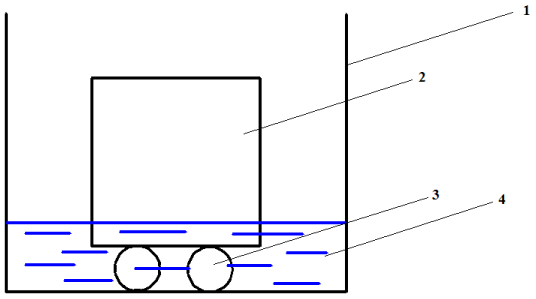


Fig. 1. Scheme of capillary water absorption test, where: 1 – container, 2 – testing specimen, 3 – spacers, 4 – water level.

During the test masses of the samples were periodically controlled and determined after 10, 15, 20, 30 minutes and 1, 24, hours (from the beginning of this test).

The coefficient of capillary water absorption C was calculated by (2):

$$C = \frac{m_s \quad m_d}{A_s}, where \quad (2)$$

- mass of the specimen after the process of water soaking (g);

- mass of the specimen after the process of drying (g);

– cross area of the specimen surface immersed in water (dm^2).

According to standard EN 12667 guidelines, test of thermal conductivity was performed. For determination of the coefficient of thermal conductivity, heat flow measurement device 'Laser Comp's heat flow meter instrument FOX 600'was used.

The Bio-Fourier law, where the heat flow, the coefficient of thermal conductivity and temperature gradient are combined (3), is the main operating principle of the measuring equipment:

$$q = \lambda\left(\frac{dT}{dx}\right), where: \quad (3)$$

where:

q - heat flow through the sample (W/m^2);
λ - the coefficient of thermal conductivity (W/mK);
$\left(\frac{dT}{dx}\right)$ temperature gradient of flat surface (K/m) [20]

The thermal conductivity test was performed on samples that were produced by pre-foaming mixing technology. Magnesium-based specimens – plates with dimensions of 315x320x31.30 mm and 305x305x43.80 mm (the thickness was determined by heat flow meter; accuracy 0.01 mm) were used during the test. The settings of the test were as follows: 0°C at the upper (cold part) and 20°C at the lower metal plate (warm part), making temperature difference of 20°C.

The water/binder ratio was calculated:

$$water/binder = \frac{0.5MgCl+H_2O}{MgO+MS+0.5MgCl}, where \quad (4)$$

MgCl - amount of magnesium chloride (kg);
MgO - amount of magnesium oxide (kg);
H_2O - amount of water (*l*);
MS - amount of microsilica (kg);

III. Results and discussion

A. Density and compressive strength

The data on the density and compressive strength (7 days) from produced magnesium chloride (1-6) and magnesium sulphate (A-F) binder mixes are summarized in the graph (see Fig.2).

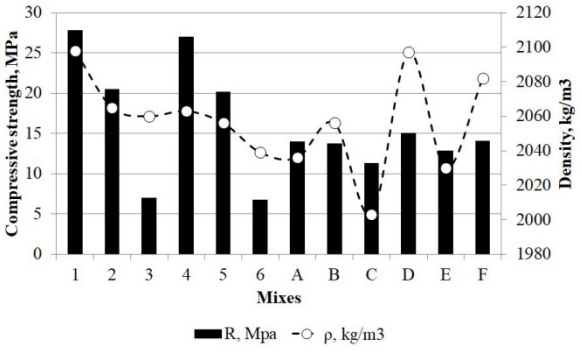


Fig. 2. Results obtained from the density and compressive strength (7 days).

Results show that using higher amount of magnesium chloride increases compressive strength 1.9 times comparing to adequate amount of magnesium sulphate. The opposite view are with data of 50% of magnesium chloride amount that shows 62% lower value of compressive strength comparing results to adequate amount of magnesium sulphate.

It also can be concluded that decreasing ratio of magnesium chloride decreases value of compressive strength

from 27.8 MPa to 7 MPa. Similar tendency have mixes with magnesium sulphate - decreasing ratio of magnesium sulphate decreases value of compressive strength from 14 MPa to 11.3 MPa.

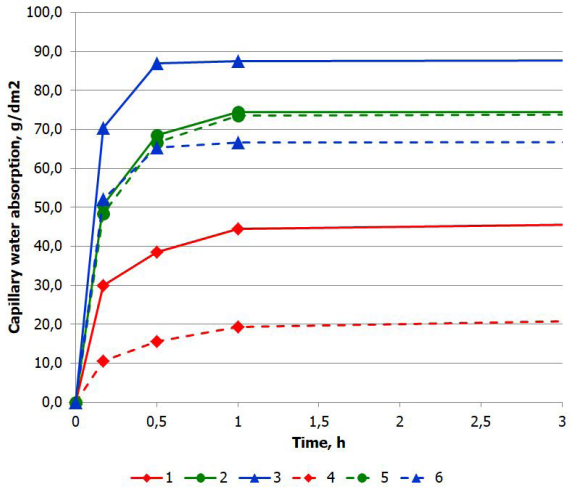
B. *Capillary water absorption*

The data on the capillary properties obtained from produced magnesium chloride binder (see Fig. 3 A) and magnesium sulphate binder (see Fig. 3 B) mixes are summarized in the graphs.

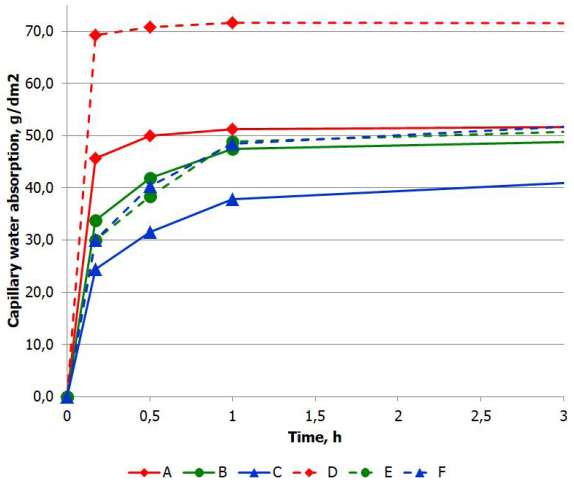
Obtained results show that decreasing magnesium chloride up to two times increases capillary water absorption from 30 g/dm^2 in average to 75 g/dm^2 during the time of three hours.

It also can be concluded that role of using microsilica fume depends on used magnesium type - decreases capillary water absorption up to 2.3 times in magnesium chloride case (comparing to results of higher amount of $MgCl_2$ and 75% of amount of $MgCl_2$), while using magnesium sulphate doesn't affect such an important difference. Microsilica has fine particles (1μm – 15 nm) and it ensures compact packing of used ingredients. It helps to increase water resistance of the specimens.

Results show that significant is used ratio (used weight) of magnesium chloride. For example, higher amount of magnesium chloride decreases capillary water absorption up to 6 times comparing to 50% of amount of magnesium chloride.



A



B

Fig. 3. Results obtained from the capillary absorption test (first 3 hours, designations of mixes 1-6 and mixes A-F see in table I).

Coefficient of thermal conductivity

The data on the thermal conductivity obtained from produced magnesium phosphate mixes (mixes with phosphate, magnesium oxide and foaming agent; mixes with phosphate, magnesium oxide, magnesium chloride and foaming agent (*PB Lux*), see Table 1).

Results show that decreasing amount of water and monopotassium phosphate decreases value of coefficient of thermal conductivity from 0.101 W/mK to 0.093 W/mK (mixes I and II).

C. It also can be concluded that use of magnesium chloride decreases value of coefficient of thermal conductivity.

Water/binder-compressive strength

The data about water/binder ratio (4) and compressive strength of 7 days, a graphic relationship is created (see Fig. 4).

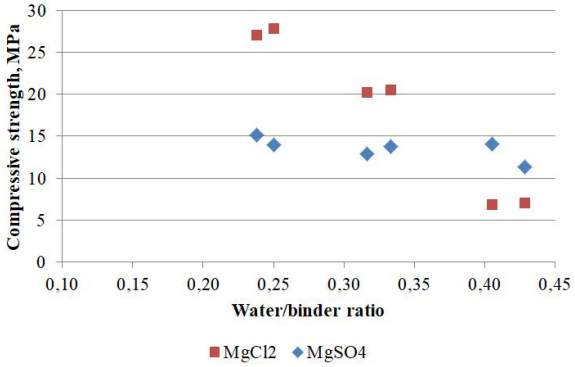


Fig. 4. Corelation between water/binder ratio and compressive strength.

Obtained results show that use of magnesium chloride obtains higher values of compressive strength from 38% up to 49% comparing to use of magnesium sulphate.

It also can be concluded that compressive strength depends on used water/binder ratio. Mixes with higher amount of magnesium binder are with lower values of water/binder ratio than mixes with 50% amount of magnesium binder.

In summarizing the data about magnesium binder amount and compressive strength of 7 days, a graphic relationship is created (see Fig.5).

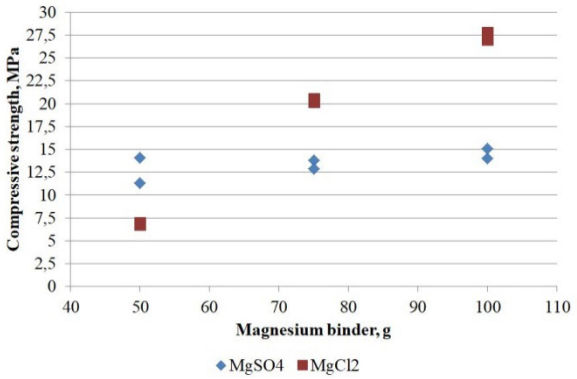


Fig. 5. Corelation between magnesium binder (g) and compressive strength.

Obtained results show that graphic of compressive strength is ascending by using higher amount of magnesium chloride comparing to use of magnesium sulphate.

It also can be concluded that effectiveness of magnesium chloride decreases when $MgCl_2$:MgO ratio is lower than 0.5. Results show that use of 50% magnesium sulphate increases compressive strength from 6.9 MPa to 12.7 MPa.

D.

Softening coefficient-compressive strength

In summarizing the data about softening coefficient and compressive strength of 7 days, a graphic relationship is created (see Fig.6).

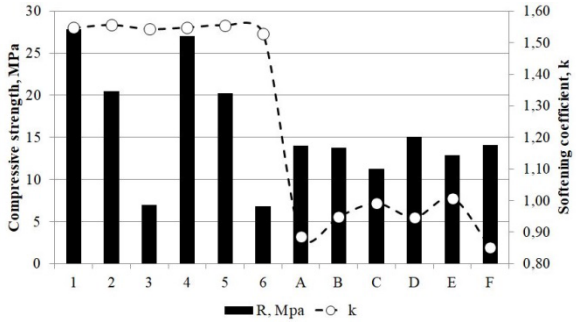


Fig. 6. Corelation between softening coefficient and compressive strength.

Obtained results show that compressive strength is ascending by using higher amount of magnesium binder type (chloride or sulphate).

IV. It also can be concluded that value of softening coefficient is higher by using magnesium chloride (in range 1.53 to 1.56) comparing by using magnesium sulphate (in range 0.85 to 1.01).

Conclusions

1. The use of $MgCl_2$ allows achieving higher values of compression strength, comparing to the use of $MgSO_4$ (approximately from 38% to 49%).

2. The use of $MgCl_2$ ensures about 56% lower values of capillary water absorption (comparing data of compositions with100g and 50g of $MgCl_2$).

3. Adding MS to mixes with $MgCl_2$ reduces water absorption values, but for the compositions with $MgSO_4$ it almost did not affected values of water absorption. The values of water absorption of $MgSO_4$ mixes are 18%-68% lower comparing to compositions where $MgCl_2$ was added.

4. The values of compressive strength of compositions with $MgSO_4$ are not affected by water/binder ratio, but for the mixes where $MgCl_2$ is added, the values of compressive strength decrease with increasing the water/binder ratio.

5. Decreasing amount of water and monopotassium phosphate ensures lower value of coefficient of thermal conductivity from 0.101 W/mK to 0.093 W/mK (mixes I and II).

The financial support of European Regional Development Fund project Nr.1.1.1.1/16/A/007 „A New Concept for Sustainable and Nearly Zero-Energy Buildings" is acknowledged.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 198-203

Entrepreneurial "Blue" Practices for Sustainable Development and Resources Efficiency

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***Abstract*—The article considers smart solutions for our contemporary sustainable development. The achievements of nature and physics provide innovative opportunities for changing the economy, creating new jobs and added value, and optimizing the resources used. The entrepreneurial way to do this is the blue economy which uses technological innovations based on the perfection of ecosystems where nothing is lost. The proposed practices along with our environment build sustainable models with the help of which business regains its competitive position.**

Keywords—blue economy, entrepreneurial practice, resources efficiency, sustainable development.

I. Introduction

We live in an unsustainable economic, social and environmental world. Among the reasons that led to the disrupted balance in the socio-ecological system are the mechanical means and technologies used. Environmental deficiencies are symptoms of a continuing crisis in resource provision.

One of the challenges for achieving sustainable development is the creation of new jobs. This could be achieved by using the diversity and perfection of ecosystems and their species. Nature and ecosystems inspire us to change our patterns of production and consumption.

The greatest opportunities for job creation will come from recreating the perfection of ecosystems where nothing is lost. Nature, in all its glamor and diversity, solves many of the challenges to sustainable development in a smart and unexpected way. If we discover the chemistry, processes, structures, and design that life has been developing and testing for millions of years, we will get a lot of new solutions.

II. EXPOSITION

Blue Economy offers solutions that are both environmentally friendly and economically beneficial to society. Unlike green economy, which requires considerable financial investment, blue one is looking for a balance. In the entrepreneurial blue practices presented, waste products are used as raw materials, thus reducing costs and harmful emissions for the environment.

Blue economy is built on the following basic principles:

- Satisfying basic human needs with the ones around us
- Using nature-inspired innovations
- Generating jobs and social capital
- Opportunities for realizing entrepreneurial ideas that can achieve more with less
- Generate processes from nature with multiple benefits for society
- Making maximum use of energy and resources to develop sustainable business and reduce the cost for the end user

Specific Principles [1].

In nature everything is recycled. What appears at first sight to be a waste is in fact a raw material ("food") for a subsequent cycle. For example, the dead leaves falling from the trees turn into soil that feeds a new tree. Such insights can be applied to today's linear production systems, transforming them into closed-loop systems where the limited resources are optimally used and the waste stream is eliminated.

- The solutions are laid down in the laws of physics - everything is related to temperature (t) and pressure (p).
- Natural systems transfer substances, energy and materials - there is no waste. Every (sub) product is a resource for something else.

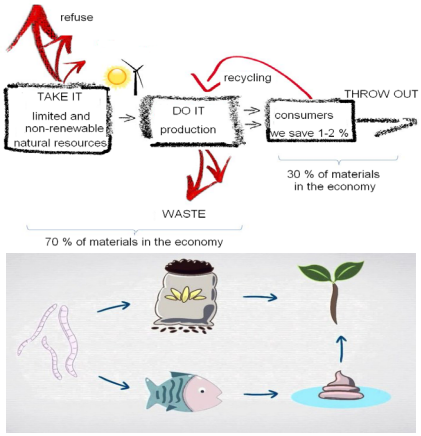
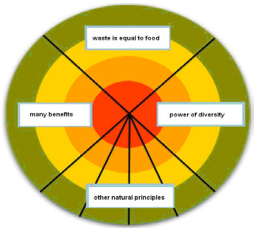


Fig.1. In nature, waste means food

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4114

- Nature evolves from several species to a rich diversity.
- Gravity is the main source of energy - solar energy is a secondary renewable source.
- Water is the main solvent/diluter! - there is no need for complex chemical and toxic catalysts.
- The constant in nature is the change - innovation is constantly happening.
- Nature responds to its basic needs and then develops from sufficiency to abundance - today's patterns of production and consumption function on the basis of resource shortages!
- In nature, everything is biodegradable - everything is a matter of time.
- In the natural systems everything is bound and evolves to a symbiosis.
- In nature, water, air and soils are common - they are many and are free.
- Natural systems share risk - it is this risk that is a motivator for innovation.
- In nature, negatives turn into positives - problems become opportunities!



- Nature is looking for large-scale savings - a natural innovation brings various benefits to everyone.
- Nature looks for the optimal in all elements.

According to the UN forecast, the population of the planet will increase by nearly 2.5 billion inhabitants by 2050. To provide food, Fig.2. Lessons from nature housing and infrastructure to the growing number of inhabitants, new technologies will be needed.

Construction industry has been looking for innovative materials for years to solve problems such as low energy efficiency and better living comfort. [2] One of the most advanced solutions is the use of natural building materials based on hemp and lime. The hemp brick wall has heat insulating properties that exceed several times the performance of the brick and concrete walls at the same thickness, which means that the same building area has a larger living area. Hemp bricks and lime-hemp plaster maintain constant levels of relative humidity in the building, absorbing any condensation. They prevent the formation of mold and create a qualitatively different environment in the room they surround. Hemp walls accumulate heat and evenly distribute it throughout the room. Therefore, in such rooms it will be warm even at low external temperatures. The advantages of hemp concrete are:

- Naturally refractory, waterproof and resistant to termites, pests and mold;
- Long-lasting (weather-resistant);
- Low thermal conductivity (R = 4.2 for a wall of a thickness of 300 mm);
- Dense structure, providing air permeability;
- Hygroscopic material, acting as a buffer for temperature and humidity fluctuations;
- Low carbon footprint;
- Fully recyclable and suitable for reuse;
- Hemp concrete is an elastic material. In case of deformation, uniformly arranged microcracks are formed, which are closed when lime and atmospheric moisture interact.
- Buildings filled with hemp concrete can be demolished without heavy mechanization and serious contamination.

Concrete from hemp is very diverse, as it can be used for walls, floors, roofs, etc. When used as an outside wall, it takes up water and moisture without causing decay or damage to the material.

Fig.3.. Concrete from hemp - the supreme material for eco-construction [3]

Life on our planet is an immense source of answers and solutions to the most urgent issues facing human species. The new paradigm that looks at the natural world in quest of innovation and sustainable design is biomimicry. The word comes from the Greek *bios* (meaning *life*) and *mimesis* (meaning *to imitate*). Biomimicry examines the place of every living being in the complex network of relationships and conditions and looks for its applications in the social and economic environment of our lives. It is connected with taking different technologies from nature and using them to create new things. Examples of innovative technologies are:

- Tunnel drilling machines copy earthworms. Similarly, drilling machines "eat" the ground as they continually move forward, leaving behind a large tunnel.
- Shinkansen high-speed trains in Japan have not only copied the shape of the kingfisher when it penetrates into water, but they also copy their coating which makes them less noisy.

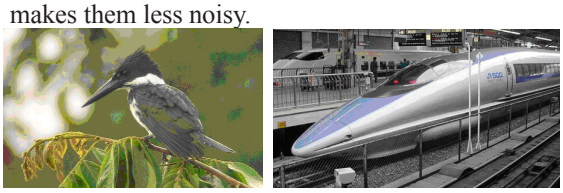


Fig.4.The bird (a) *and the high-speed train* (b)

Imitation of predatory birds for the design of more cost-effective modern aircraft. They have twisted wings. This amendment was introduced as a result of the observation of birds' flights and it could decrease the consumption of kerosene by 20%.

Nature is our mentor - it is a source of information and inspiration for creativity and ecological design, for the functioning of economic systems based on limited resources for homes that are heated and cooled on their own.

Termites construct mounds that maintain a constant internal temperature due to their structure and interaction with the environment. Architect Mick Pierce uses Termite's principles to design a business building in Hara-

re, Zimbabwe, which is passively cooled. A $ 35 million building saves 10% of the cost in advance and since it is not necessary to buy an air conditioning system. The multi-storey building is heated and cooled only by natural air currents. The economic benefits of this new system are exceptional. Unlike nearby buildings, rents are cheaper due to energy cost savings.

Fig.5. Termitary (a) and Eastgate Business Center (b)

Humpback whales have jagged leading edges. When they swim, water passes through their protrusions and forms a lot of vortices. In this way, whales get a greater lifting force that allows them to tilt their fingers at a great angle without losing their speed, and the protrusions reduce resistance. Researchers apply this principle in making more efficient water turbines. WhalePower develops blades for wind turbines using the same physical characteristics to make its invention quieter and more reliable in winds.

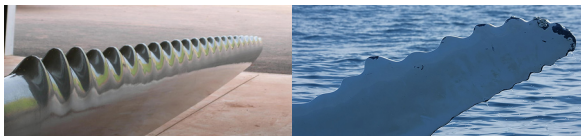


Fig.6. Flipper of back whal (a) and wind turbine blade (b)

Diversity in nature provides strength and various benefits. The most fascinating aspect is people's ingenuity with their ability to use the peculiarities of the surrounding landscape to his advantage. The masterpiece of engineering was the well-organized agriculture run by the Aztecs. They skillfully built ingenious floating gardens, which were small rectangular areas of fertile arable land floating on the shallow lake in the Valley of Mexico. Workers wielded sticks to each other to form giant rafts stretching over 90m in length and 30m in width. They then collected mud from the pond and piled it on a raft to achieve a soil cover. The rafts were fastened to the lake with ropes attached to mayow trees planted nearby. Between the floating gardens there were channels that allowed the canoes to pass. Water management was vital to ensure good harvest during the year. The Aztecs developed a complex drainage system that includes dams, sluices and canals. The entire garden network stretched over 22,000 acres in the lake. They cultivated crops with which they fed the vast population.

Fig.7. The ingenious floating gardens of the ancient Aztecs . http://back2nature.rocks/

To create sustainable and productive systems to meet human needs and harmoniously integrate people and land, permaculture is applied. [6] It is a set of methods for sustainable land design. It is based on ecological and biological design principles for human habitats and productive farming systems, maximally resembling natural ones - ecological processes of plants and animals, their food cycles and climatic factors. The elements in the system are considered together with the interactions between them, and the products of one element being a resource for another. In a typical permaculture system, work is minimized: waste is turned into resources, productivity and yields increase and environment is restored. Eco-friendly development approaches can be applied to any environment and scale - from urban residential complexes to rural houses, from small farms to large regions. Permaculture design is based on the care of the earth and people, providing access to all the resources needed for human existence.

According to the UN forecast, the population of the planet will increase by about 2.5 billion inhabitants by 2050. To provide food, housing and infrastructure to the growing number of inhabitants, new technologies will be needed. One of these technologies is vertical aquarium-based farms using LEDs of a specific wavelength to intensify crop growth.

At present, about 80% of the planet's land on which food products can be grown (vegetables, fruits, grains, meat, dairy products, etc.) is actively processed. The remaining 20% of potential arable land will not be enough if existing technologies are used to feed the growing population on earth. One of the possibilities for solving this problem is the vertical urban farms for the production of vegetables and fruits. Vertical farms are built where the users of the produce (vegetables and fruits) are located, and on a small area on many floors (racks), production is produced all year round with artificially created parameters: light, nutrient environment, temperature, humidity, ventilation, etc. Thus, annual output per unit area can be increased tens of times, with a significant reduction in production cost and a guaranteed daily supply of fresh vegetables and fruits with almost zero transport costs.

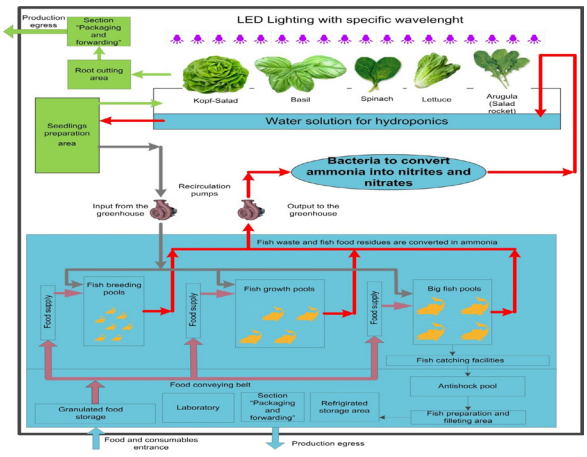


Fig.8. Technological scheme of aquaponics (LEDGROW Engineering Ltd.)

The greenhouse differs from what has been known so far due to the specific illumination of the crops provided by LED strips of a precise radiation pattern and strictly fixed duration of illumination associated with the biological lifecycle of the plants being grown.

High automation of processes reduces the need to employ a large number of additional employees. The greenhouse is adapted to operate under different

climatic conditions: temperatures from -300C to + 550C; humidity from 40% to 90%; rain, snow and more. The electricity supply to the greenhouse is provided by the power distribution network of the area, by solar panels (autonomous power supply) or by both sources (optimization and reserve of power supply). Water supply is provided by the water supply network.

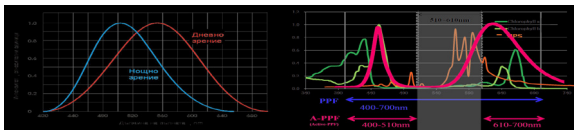


Fig.9. *Visible human wavelength (a) and required absorption spectrum for plant growth (b)*

The processes in the growth room are realized automatically. For this purpose, the following automated systems have been designed and built:

- Access control system with automatic scanning of the access conditions (chip, card, fingerprint, passage sensors)
- Climate control system for climate control in the room
- Lighting system to ensure the proper illumination of the plants and that in the work rooms.
- Pump station that controls the water flows from the fish pond to the greenhouse and its water basins and vice versa - from the greenhouse to the fish basin;
- Parameter control system of the nutrient aqueous solution.

Within the second stage swimming pools are envisaged for fish breeding. This stage is a major knot in the process and converts the technology from hydro to aquaponics. Aquaponics combines aquaculture and hydroponics: Fish waste provides an organic food source for plants and plants appear a water filter. Aquaponics also has a third component: microbes and composting red worms. Microbes and worms convert ammonia (from fish waste) into nitrate, and nitrates (and solid waste) into a vermicompost (a compost produced from some kind of worms), a source of plant food. While hydroponics does not solve many of the problems of traditional farming (such as weeds, the amount of water required, insects in the soil, other pests that feed on leafy vegetables, mainly fertilizing and composting methods), it still needs "careful application" and "human-made nutrients". Aquaponics only needs fish (along with careful observation). Aquaponics is also a safer way to grow food.

The method of building a farm that combines crop (farm crops) growing and fish breeding in an interconnected cycle (mutual exchange) has been known since ancient times. The name "aquaponica" has been suggested by scientists from the University of the Virgin Islands as a result of years of research. This name reflects the combination of two progressive technologies: "hydroponics" - growing plants not in soil, but in aquatic environment and "aquaculture" - growing fish, crabs, shrimps, mussels, etc. in a well-organized system. A number of observations and later experiments have shown that plants can only be grown in an aquatic environment without the need for soil. At the same time, if fish are kept in the aquatic environment, a double effect is obtained: the waste from fish breeding appears to be an excellent nutrient medium for plants submerged in the aquatic environment. Furthermore, plants are an excellent filter, leaving the waste from fish on their roots and thus purifying the water in the pool. Plants are fed by products extracted from living organisms (potassium, nitrogen and phosphorus compounds, carbon dioxide, etc.) and naturally purify and enrich with oxygen the aquatic environment. The production process eliminates the use of chemical fertilizers and the need for their dosing and soil treatment. The chemical process of treatment and purification occurs naturally in a closed loop and does not require the use of synthetic chemicals. Aquaponics imitates the natural water circle in nature.

The symbiosis between growing plants and fish in a common aquatic environment unexpectedly leads to intensification of plant and fish growth, resulting in a closed ecosystem. Another feature of hydroponics (a constituent part of aquaponics) is that plant cultivation does not require land and its farming, and plants grow in the aquatic environment. This makes possible the development of the greenhouse in a vertical direction and the plants themselves are grown in vertically spaced water channels. Thus, a unit of land is multiplied by a larger production. The combined cycle of growing plants and fish is always more effective than split farming and gives a larger amount of market output from plants and fish.

Purifiers and a mechanical filter system are used to treat water from solid waste and particulates. Denitrification in "aquaponics" occurs naturally - a balanced activity of plants and bacteria and only in extreme cases it requires additional cleaning with expensive carbon filters.

Areas in the fish breeding department are made up of modules whose size is typified and is determined by the type of fish grown and the amount of desired end-of-day catches. The modular building of the room allows you to breed and grow different types of fish according to the needs of the market in different modular pools. It is permissible to mix different populations if there is non-conflict cohabitation.

We will also look at some practical ideas for achieving a sustainable urban environment.

New research and technological advancement allow farmers to find new ways to grow food as effectively as possible. In some cities, such as Chicago, green roofs are even part of the city's common sustainable plan. Specifically in Chicago there are about 359 roofs with vegetation.

Fig.10. *Chicago Botanic Garden's McCormick Place West Rooftop Garden*

Per unit area, field yields are often larger than areas grown under traditional methods. Roof farming not only provides fresh food to the cities but it also reduces energy cost of buildings and contributes to cleaner air.

In addition, roof farming helps society by providing jobs and giving people a new category of public spaces (places to communicate). In addition, roof farms keep rainwater (diverting drainage water from sewage systems) and focus on food production, thus eliminating the need to transport fresh food from a neighborhood to a neighborhood.

Many views on nature in cities draw attention to the importance of the link between green and blue infrastructure in densely populated areas. Successful people-to-people reconnection will have a positive impact on their values and will ensure the protection of ecosystem services.

Rich natural diversity gives birth to unique entrepreneurial opportunities that become the backbone of modern economics. Bulgarian youth offer an innovative concept of an eco-restaurant built and furnished with natural and recycled materials. [4] The restaurant generates the electricity needed for its operation through solar panels and purifies the water used by means of a special system. The restaurant serves dishes prepared exclusively from natural products supplied by local producers. Young entrepreneurs also organize monthly educational eco-courses in the restaurant. They also offer home delivery with cyclists.

Another entrepreneurial idea of young people is to create a gym with appliances that allow the energy of mechanical movements in the course of training to be stored and turned into electricity. A large dashboard will be placed in front of the gym, which will show the amount of electricity generated by customers during the month and will calculate how much CO2 emissions are saved through their involvement. The most active exercisers who use these devices will receive special discounts.

The idea of eating our own waste sounds disgusting and repulsive. In nature, however, this is a natural process: the "waste" of all living organisms is broken down into organic compounds that feed the soil and plants, and they in turn feed us humans. The French architectural company "Chartier-Corbasson" uses this "organic" metaphor to construct a building from panels made on site from the plastic waste collected and separated by its inhabitants. According to Jetson Green, a popular American blogger for sustainable construction, the creators of the "growing" building have calculated that plastic waste collected over a year would be enough to complete the building's facade.

There are various ideas and approaches for developing intelligent solutions. The Eastern and Western coasts of the United States offer several indicative practices for "intelligent" urban management systems in action. For example, in San Jose, Calif., also known as the Silicon Valley capital, Intel has sponsored an urban network of sensors to collect data on air quality, noise pollution and traffic flows. Thus, in case of accident, the responsible municipal authorities can quickly respond, redirecting traffic and timely sending information to residents so that they can decide to use different modes of transport (such as cycling instead of driving).

To the east, New York could boast of a massive program to improve the energy efficiency of municipal housing, which uses intelligent energy-saving technology and thus saves valuable financial resources in the city's treasury. Intelligent Urban Systems are underway in the continental part of the United States. To live in a sustainable way, we need to focus on practices that pay close attention to how we consume resources rather than to the development of technology.

Fig.11. Sketches of the London Organic Skyscraper project. Photos: *Shutterstock, Chartier-Corbasson*

The production of the world's blue economy is currently estimated at around EUR 1.3 trillion and is expected to double by 2030. Bulgaria, together with the Mediterranean and Black Sea countries, is involved in building a cluster network as part of European development projects of the maritime industry, aimed at stimulating the "blue" economy. [5] Investing in "blue" projects is becoming an important driver of prosperity and job creation in coastal areas. The participants are committed to solving the most pressing problems of the world's water areas. The European Commission proposes a transition to an economy based on better design, recycling and reuse of products that will contribute to cleaner oceans.

The seafaring and maritime sectors provide jobs for 5.4 million people now and contribute a total gross value added of around € 500 billion a year. By 2020, they should increase to 7 million people and nearly 600 billion euros respectively. Coastal and maritime tourism is the largest sea-related sector in terms of gross added value and employment and is projected to increase by 2-3% by 2020, according to a study by the European Commission. Within a 10-year period - from 2010 to 2020, cruise tourism is expected to create 100,000 new jobs. With a total budget of € 6.5 billion for the period 2014-2020, the European Maritime and Fisheries Fund supports EU coastal communities to develop their economies, create new jobs and improve the quality of life on European shores.

The market realization of technology for energy generation from waves and tides will be improved by reducing technology costs. According to expert estimates, the total annual turnover in marine mineral resources is expected to increase practically from zero to 5 billion in 2020 and to 10 billion in the period up to 2030. By 2020, the blue "Biotechnology must start supplying mass markets for cosmetics, food and pharmaceuticals, chemicals and biofuels. The Coordinator of the European "blue" economy is the island state of Cyprus. The trend is to build the island as a European Center of Excellence in Marine Research, Innovation and Technology. The future innovation and technology center of excellence will

stimulate Eastern Mediterranean partnerships in scientific and business research in the blue economy sectors such as maritime transport, coastal and marine tourism, aquaculture development, energy sector.

"Blue" growth is a modern multi-faceted framework based on the main axes of sustainable development - economy, society, environment, and partnership. Under the "Blue Career Center" project on the Eastern Mediterranean and the Black Sea, the first European Qualification Center for blue graduates is being built. It will be located in Cyprus with offices in Bulgaria, Greece and Romania. Its goal is to increase employment in key blue sectors in the region, such as maritime transport and shipping, shipbuilding and ship repair, cruise and sea tourism, aquaculture, offshore oil and gas exploration. The center will attract young people to train, qualify and retrain them thus preparing them to become prospective "blue" specialists. The goal of another Blue NET project is to create a network of sea clusters for "blue" growth in the Mediterranean, Adriatic, Ionian and Black Seas. In this way, cooperation between maritime clusters in the field of research, innovation and competitive growth of enterprises directly linked to European maritime policy and the "blue" economy will be promoted.

III.CONCLUSION

Nature has been perfectly designed for billions of years. As we learn lessons from nature, we can reform our society by making it richer and more varied, more beautiful, and cleaner. The future of limited resources has urged lots of leading corporations to turn to teams of biologists and designers to find the solutions they want in the natural world. According to the *cradle-to-swing* model, if designers integrate the intelligence of natural systems, such as substance cycling and vastness of solar energy, they will be able to create products, production systems, buildings, even regional plans which could help nature and industry co-exist without interfering each other. Our current consumption and waste generation system can become a source of products and services that are both environmentally, socially and economically useful. By rediscovering our industrial systems and approaches, we can stimulate innovation that provides sustainable development and prosperity.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 204-209

Eco-Innovative Solutions for the Processing of Technogenic Mineral Resources

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***Abstract*—The inorganic wastes and residues formed during the production and operation process are valuable technogenic minerals, the rational treatment of which can reduce the amount of non-renewable natural mineral resources.**

The relatively low reuse of technogenic mineral resources is currently associated with specific characteristics of these resources. They have a wide and multiplex diversity in composition and structure, and hence a wide, uneven range of physical and chemical properties that require a complex approach to assessing the potential for developing each resource. In addition, it is necessary to evaluate the ecological and energy efficiency, technical feasibility and economic efficiency of the processing of these resources in comparison with the production of natural mineral substances from traditional technologies. A methodology for the evaluation production of potentially new goods from technogenic mineral waste is proposed. Parameters such as multifunctionality of new products, energy and resource saving, lifetime increase, reduction of negative impact on the environment, maintenance or improvement of production quality compared to original quality are taken into account. The basis for the analysis of these possibilities and methodology of assessment of eco-energetic efficiency to justify the usefulness of mineral wastes processing are given. Possibilities of using this approach for the development of mineral waste from construction and demolition recycling technologies for the production of composites, binders, fillers and monolithic structures are shown.

Keywords—mineral waste, waste managment, recycling, ecoefficiency , ecoindicators,product properties.

I. INTRODUCTION

It is known that significant part of waste produced in the industry have inorganic nature [1,2] In our previous investigations [3,4] we declared that all solid waste which are inorganic in the terms of chemistry are mineral waste. They include: the remnants of the construction and repair, debris , byproducts of mining , construction and demolition waste, glass and glass- use industrial waste , ceramic waste, combustion waste, and so on .

Mineral waste compared to organic waste is less susceptible to natural degradation processes. Consequently, it does not fit into the natural process of substance circulation in ecosystems and its volume is constantly increasing. At the same time, since these substances are less exposed to chemical and biochemical transformations, they are often not harmful to the environment (except for the specific waste group - classified as hazardous waste); Main effect of them are the passive pollution of the territory and their ineffective disposal into the dumpsites. However, all these mineral wastes have retained virtually unchanged the components from which they were made, as well as partly the original structure and physical properties, and thus potentially have been used either directly or after the relevant processing to serve as raw material for the production of new products by replacing natural raw materials - hence reducing the intensity of depletion of non-renewable resources and the amount of landfilled waste to be disposed of. [5] All these wastes should therefore be considered as technogenic minerals and valued at the same level as natural resources.

There are two main reasons for this situation - first and foremost, the technologies for extraction and processing of natural resources were built, developed, equipped with the relevant techniques and materials - and became traditional and economically efficient. Secondly, the composition, structure and condition of technogenic resources are very uneven, complex, variable, so the properties are not permanent. Their volumes and formation sites are also variable and subject to a variety of random factors. As a result, traditional mineral resource processing technologies cannot be technically or economically profitable for the processing of techno resources. You need your own specific approach to the development of recycling technologies for these resources. [7, 8.9,].

In the .European Waste Classification[10] according to Regulation no. 849/2010 all the waste are divided into two groups: non-hazardous and hazardous and 51categories. Of these categories, mineral resources include: metallic wastes (0.61.0.62.0.63), glass wastes (0.71), mineral waste from construction and demolition (1.21), combustion wastes (1.24), soils (1.26), mineral wastes from waste treatment and stabilized wastes (12.8, 13), other mineral wastes (1.22.1.23.1.25). Waste such as discarded equipment (0.8), vehicles (0.81), battraries and accumulator wastes (0.841), mixed and undifferentiated materials (102) may also be partly related to mineral resources. The group recycable wastes (0.6.0.7) is not very precise in terms of composition

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4050

because consists mainly from metal and glass . Analyzing the total quantities of non-hazardous waste produced from 2010 onwards, the European Union shows that it is gradually increasing, but the growth is not high - in just 6 years it was only about 5%.(fig.1)

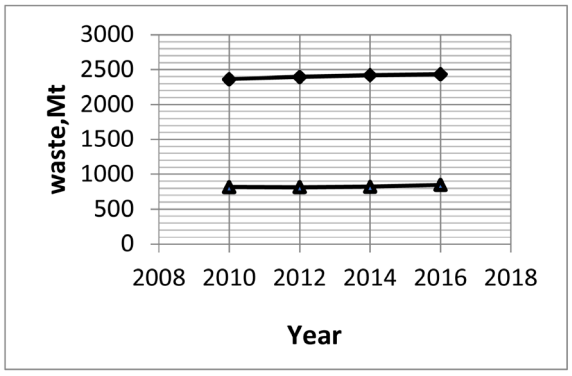


Fig.1.Volumes of nonhazardous wastes in EU generated ◆ and recycled ▲

The recycling of waste is around 38% of the total amount of waste produced. This means that the remaining 62% or around 1600 Mt of waste is collected annually in the environment. The total amount of non-hazardous waste in Latvia increased from 1430.2 kt in 2010. up to 2466.4 kt in 2016 - more than 1.7 times (Fig.2) [6].

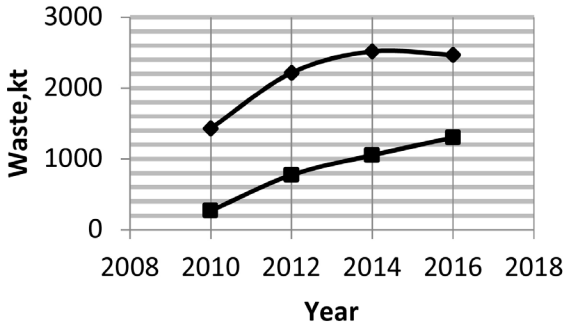


Fig.2.. Volumes of nonhazardous wastes in Latvia generated ◆and recycled ■

But must be mentioned that the percentage of recycled waste in 2016 increased also -from 19% to 53% of the total.

II. MATERIALS AND METHODS

In our research, we paid attention to mineral waste, which is currently not recycled or recycled in very limited quantities. These are: mineral waste from construction and demolition, combustion wastes, soils, other mineral wastes. (fig.3)

Their total volume generated in 2016 in the European Union, achieved 1609 Mt, in Latvia consequently- 486 kt (66% and 20% of the total non-hazardous waste respectively) (tab1).

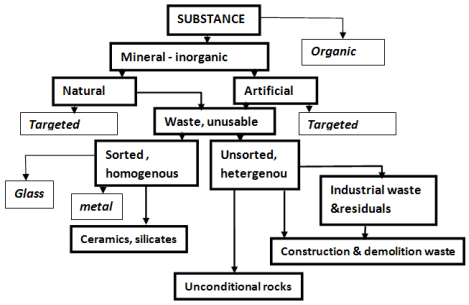


Fig.3. Mineral technogenic resources .In bold blocks – analysed wastes.

It should be understood that in order to obtain a high-quality eco-innovative product with better qualities (at least not lower, but better upcycled) than for the former product , with high-value (hightech) characteristics, a serious phase of raw material research is obligatory - using modern hardware and research methods. resulting from processing .

Otherwise, the product obtained as a result of waste processing will be uncompetitive and unsuitable to use.

Therefore, the comparison of techno-mineral waste recycling methods and the quality of the obtained product and the justification of the optimal variant is needed. Currently there are a number of indicators of ecological, economic, energy efficiency evaluation and calculation methods of different directions [12,13, 14]. The paper analyzes them and adapts to the conditions of mineral waste recycling.

TABLE 1 Mineral waste generated in EU and Latvia (2010-2016)

Year	Country	Total hazardous + non-hazardous,	Total non-hazardous	Mineral wastes from construction and demolition	Soils	Combustion wastes	Other mineral wastes	Total 5+6+7+8+9
1	2	3	4	5	6	7	8	9
2010	EU ,Mt	2,460	2,364	328	420	111	742	1601
	Latvia, kt	1,498	1,430	144	0	153	31	328
2012	EU, Mt	2,491	2,395	329	406	122	781	1638
	Latvia, kt	2,310	2,214	396	31	174	30	631
2014	EU, Mt	2,515	2,420	306	459	115	754	1634
	Latvia, kt	2,621	2,517	571	9	45	29	654
2016	EU ,Mt	2,535	2,435	335	485	112	677	1609
	Latvia, kt	2,533	2,466	387	13	46	40	486

III. RESULTS AND DISCUSSION

Thus, the process of developing mineral waste recycling methods and technologies should consist of the following stages:
1.Justification for recycling need
2.Setting a recycling target
3.Technological and physical research of mineral resources
4.Evaluation of the physical effects on the formation of minerals and new properties.
5.Designing of the experiments, conducting experiments and testing the obtained material
6.Assessment of technical feasibility, ecological and economic efficiency of processes.
7.Development of a Production Technology Pilot Project.

Let us look at each of these stages. In the initial **1. stage** phase must be answered the question - is there a need for some sort of action on these wastes or would it be best to simply dump it into a landfill or otherwise integrate it into the environment.

For example, if they are not a hazardous waste group they can be used in the reconstruction of mechanically degraded areas,changing relief, in building engineering objects (embankments, roads, dams). The need in recycling of mineral waste is related to
-Danger to the environment and man,
-Large volumes and continuous growth of waste,
- Economic disadvantages and environmental hazards for landfill storage,
- Valuable components or useful properties of this waste,
-Inadequacy with any use variant directly without prior processing.

The information obtained in the first stage is used in the **stage2** to formulate the recycling target. It may be directed to:
(a) waste itself, the need to eliminate or reduce (regulate) its quantity;
(b) the production of a predetermined product from this mineral waste.
In the first case, further research is related to a broad assessment of possible uses of mineral resources and a reduction in their volume. In the second case, the studies are performed within a narrow range of potential product design characteristics.
In the **Stage 3** the research methodology is set according to the goals formulated in the second stage. If the task is to avoid the total volume of the mineral waste, it should be taken into account that the mineral waste is a resource and that it is necessary to find the most useful way of avoiding it by obtaining the maximum benefit from it. This means that in this case also a complex analysis of this substance is required - to determine the macro-composition, mineral and chemical composition, structure and state parameters, physical and chemical properties.
At all stages of the study, the results should be evaluated using the available data base on the physical, chemical properties, structure and composition of existing analogue materials. Research may be interrupted at any stage if the compliance of the properties of the mineral waste with any existing and used material is found [15]. If the task is to use this mineral resource to produce a predefined product, the research program consists of the following steps:
- Precisely defines the essential requirements and properties to be met by the final product (according to existing analogues).
- mineral properties are studied
- Compliance or non-compliance of these properties is determined.

The main task of **Stage4** is to determine, on the basis of the physical effects database, the possible physical fields and processes that could result in the creation of a set of required properties corresponding to the intended use of the recycled resource. [16]
• Experiment planning is being carried out in **Stage 5**. The aim of the experiments - to check the results of the selected physical effects, to obtain samples of the final product, to evaluate the conformity of their properties to the properties of the planned reference material. Stage 6 specifies the technologies and regimes for the potential treatment and recycling of the mineral resource and analyzes them according to the criteria of ecological, technical feasibility and economic efficiency. The most mineral wastes are not biodegradable and can not be used as a fuel for thermal energy . Their processing must be based on changing physical properties of materials by mechanical , thermal treating or using other physical fields such as electromagnetic, acoustic, nuclear radiation, thermo-chemical , biochemical , mycrobiological processes.

In all cases, it is necessary to identify the types of potential exposures to which the material may be exposed and the possible outcomes of this exposure (tab.2).

The only determining factors for the change of material properties are their composition, structure and condition at different levels - from submicroscopic to macroscopic. External physical and chemical fields are the means by which these parameters can be changed. Thus, all types of exposure to minerals that determine the possible changes in the physical fields of a mineral can be divided into 4 groups:
1.Changes in energy status.
2. Changes in link strengths between the different structural elements of the substance at different scales.
3. Changes in phase condition (including state of aggregation).
4. Changes in composition (including chemical).
Practical tasks of mineral processing are in many cases directly related to the last process. In turn, they can be divided into the following types of activity:
1. Extraction of useful components from the original mineral mass
2. Separation of inappropriate, harmful components from the original useful mineral mass.
3. Combining different components into a single composite material to produce the product with the required properties.
The construction and demolition waste in many cases consists of a mixture of such different components: concrete,

reinforced concrete, clay bricks, silicate bricks, glass, metal, soil admixtures, organic materials (plastic, wood). Assessing the feasibility of rational use of these wastes begins with determining their aggregate composition. The best way to use is when the raw material is the least exposed to the processing, but at the same time the quality of the final material is the best of the available variants and its producing technology has the least negative effect on the environment- princips most quality – less losses (MQ-LL).. This means that mineral waste can only be used directly if its use is in line with the MQ-LL principle. Recycling starts from a basic stage - pre-preparation of a mineral resource that includes operations:

Primary sorting by composition - metal, glass, organic, and by components size: (granulometric composition). Modern materials processing technologies allow to effectively implement these waste preparation works, incl. separation of iron reinforcement from reinforced concrete structures [17]. As a result of the pre-preparation, an intermediate product is obtained which is more even in the composition and structure than the primary waste . Iron and glass components can already be used in traditional waste recycling technologies. Organic compaunds may be subjected to incineration, resulting in heat energy, or exposed biological recycling for biofuel production.

The mineral part of the waste according to the size of the components and their composition may in turn be used in different ways.

1. Monolithic pieces - according to their composition as:
- just elements for New Building Structures, Bs
- additional elements to create macrocomposite structures.Mbs

2. Dispersed material as a
-filler for cement FCe
-filler for composite FCo
-binder Bi
-adsorbent Ad
-heat insulation Hi
- alloy (fusion) - sintering, vitrified material Fu

TABLE 2

Physical, Chemical and Biological Field Effects which are Perspective for Mineral Waste Processing

Action nature	**Processes**	**Physical effects, changes in composition, state, structure, properties**
Mechanical	Disintegration	Structure, granulometric composition, strength, specific surface, fluid permeability, reactivity
	Consolidation (compacting)	Density, strength, elasticity, permeability, chemical reactivity
	Separation (sorting, rinsing, dusting))	Homogenization, homogeneity in composition, structure, properties
Hydraulic	Dissolution	Formation of solutions, release of soluble and insoluble components
	Hydrolysis (solvolize)	Formation of new chemical compounds
	Hydration (solvation)	Formation of new compounds (hydrates, solvates)
	Extraction	Extraction of components
Thermal	Dehydration	Water is released from the material
	Thermomechanical Destruction	Disintegration (changes in structure, granulometry, and all related properties)
	First-order phase transitions (changes in physical state, melting, vitrification)	Melt formation - changes all properties incl. structure, composition, density, porosity
	Second-order phase transitions (polymorphic transformations)	Changes of crystalline structure and all properties
	Sintering	Changes in strength and elasticity parameters, porosity, permeability, density, humidity changes
	Reduction-oxidation reactions	Changes in chemical composition, formation of oxides, release of components
Electro-magnetic	Electrothermal Heating	All effects according to thermal effects
	Electrolysis	Partitioning in components
Chemical	chemical synthesis reactions	New substance formation
	Chemical decomposition reactions	New substance formation
	Replacement and exchange reactions	New substance formation
Microbiological	Microbial leaching (bioleaching)	Release of chemical elements

The properties of the product to be designed and the physical fields to be used for their production are listed in Table 3

An assessment of the ecological, economic and social efficiency of the selected process for the recycling of mineral waste can be done using developed methods for assessing the eco-energy, socio-efficiency of production -BASF's Eco-EfficiencyAnalysis Methodology [20],

Delft University of Technology [21,22] and others. The recycling of waste should be aimed at the development of recycling technologies, the use of which gives the final product with a quality not less than the quality of the original product - the upcycling principle now predominantly practiced in place of the "downcycling" principle when a product with a lower value is obtained at each subsequent processing stage compared to previous quality [23,24] During analysis process we divided the evaluation criteria into two groups - the first characterizing the production area - recycling of waste, the second - the quality of the product obtained. In the first group we included 4 indicators - energy consumption -E, gas emissions- G, water consumption - L, secondary waste- W

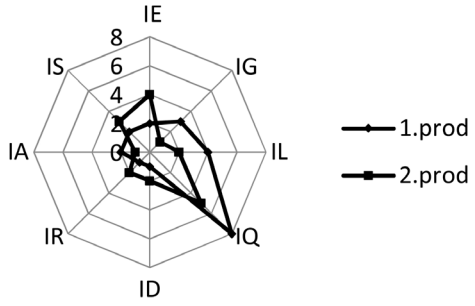
TABLE3

THE DEFINING CHARACTERISTICS OF THE FINAL PRODUCT TO BE DESIGNED AND THE PHYSICAL PROCESSES OF THEIR FORMATION

Intended product	**Key Features**	**Physical Fields and Processes Used**
Building details, blocks of monolithic waste (Bs)	Geometric dimensions, shape, strength, frost and moisture resistance	. Mechanical, hydraulic treatment, heating.
Composite constructions of macroelements (Mbs)	Geometric dimensions, shape, strength, frost and moisture resistance	Mechanical, hydraulic treatment, heating.
Cement Filler (Fce)	Degree of dispersion, adhesion, adsorption, specific surface and surface energy, strength	Mechanical treatment (shredding, sieving), surface activation
Filler for composite materials FCo	Degree of dispersion, adhesion, adsorption, specific surface and surface energy, strength	Hydraulic processing, thermal, mechanical (pressing),electromagnetic fields
Binder Bi	Chemical composition (CaO, SiO_2, Al_2O_3, Fe_2O_3) Degree of dispersion, adhesion, adsorption, specific surface and surface energy, strength	Mechanical treatment (shredding, sieving), surface activation
Adsorbent Ad	Specific surface, adsorption	surface activation, crushing,-milling
Heat insulation Hi	Thermal properties λ, α, c, porosity, pore structure, humidity	Thermal treatment, mechanical compacting
Alloy	Melting, sintering, vitrification temperature and energy, specific heat capacity	Thermal efficacy
sieving, Gr	Components difference in particle size	Mechanical treatment
Separation in Physical Fields	Components difference by physical properties (density, elasticity, magnetic, electrical, thermal)	Relevant Physical Fields
Melting, Me	Componens difference by melting point	Thermal efficacy
Extraction, Ex	Components difference in solubility in different solutions and at different temperatures	Hydraulic efficacy, also with heat fields
Biological extraction .Bex	The ability of the components to be exposed to microorganisms	Microbiological effects
Formation of chemical compounds) .Ch Rādīt vairāk Rādīt mazāk	Chemical activity in different fields	Effects of chemical fields, including thermal reactions

In the second group was included the integrated properties of the produced product as durability of the product - D, compliance with the product's quality criteria rate - R, range of applications (its amplification) - A, product safety - S.

All these indicators are converted into dimensionless proportions. In addition, the indicators of the first group are calculated as the ratio of the value of the parameter to be evaluated for the traditional production of the product to the same new production parameter: IE = E0 / EM, IG = G0 / GM, IL = L0 / LM, IQ = Q0 / QM product is attributed to the quality criterion of the traditionally made product: ID = DM / D0, IR = RM / R0, IA = AM / A0, IS = SM / S0 As a result, the efficiency of the new products from the techno-minerals is higher, the larger is each of these indicators. Figures less than one indicate the inefficiency of the new process or production according to this indicator.. By displaying these indicators in the diagram, the total efficiency indicator will be proportional to the corresponding field of the limited area (Fig.4).



The choice of weight coefficients should be based on the degree of hazard to the environment caused by the recycling of techno-waste and the importance of the quality of the product obtained. If the calculation $\Phi \leq 1$, the selected processing technology is not useful. With regard to the assessment of the construction waste recycling process and the efficacy of the final product, the following weightings may be recommended, taking into account existing experience: E = 0.6, G = 0.8, L = 0.4, W = 0.3, D = 0.7 , R = 0.9, A = 0.4, S = 0.6.

Coefficients may be specified and adapted to the recycling of a particular waste and production. At present, programs [25,26,27] have been developed that enable the use of a comprehensive database for calculating the indicators needed to assess the eco-efficiency of the relevant technological processes throughout the production life cycle.

IV. CONCLUSION

Industrial mineral waste according to its composition, structure and physical properties is a valuable resource that can be effectively used as a source of natural primary resources in many cases, thereby reducing the use of natural resources, increasing energy and eco-efficiency in the production sector. But this is achievable if, on the basis of resource physical and chemical properties exploration and acquantance with the possibility of physical processes acting on the material to obtain the required quality

product, the optimum technology of processing the resource is developed. In this case, it is possible to obtain technologically valuable, high quality eco-innovative end products with high added value. This means that the most important stage in solving the problems of mineral waste utilization is the in-depth study of physical processes and field interaction with substances and the implementation of a rational technological process according to the obtained results.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 210-215

Intelligent, Innovative and Sustainable Industry in Bulgaria – Prospects and Challenges

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***Abstract*—The report analyzes industrial transformation through smart and sustainable growth, as well as building a culture of innovation in a new digital age. Innovative enterprises from Bulgaria are presented with their respective modern organizational structures and forms of innovative cooperation between them - Sofia Techpark, Trakia Economic Zone, Technological Park at the Technical University of Gabrovo. The barriers to innovation development of SMEs in Bulgaria are outlined. An example of a high technology center funded under the EU Operational Programs is presented. Answers to questions such as: what are the role of the innovation centers in the innovation ecosystem in Bulgaria; how to stimulate the transfer of talent between university and business; how the market for innovation of the future changes; why deliteracy is a factor of success; how to support innovation and digitization; what are the European policies in the field of innovation and digitization?**

Keywords*—innovation, new organizational structures, technological development, smart industry, transfer of innovation.

I. Introduction

The percentage of innovative enterprises in Bulgaria is low - only 16% of all enterprises in industry. This is all the more relevant for SMEs. This is also confirmed by the data included in the Innovation Scoreboard developed by the European Commission. Bulgaria lags significantly behind the EU average levels by a number of indicators [6, 8]:

- low R & D expenditure - 0.5% of GDP;
- low share of innovative enterprises receiving public support for innovation - 0.8%;
- low degree of commercialization of the Bulgarian research activity;
- low level of cooperation between business and research institutions and universities - 10%;
- low share of innovative SMEs cooperating with other SMEs - 3.1%;
- low share of SMEs performing organiza-tional innovations - 11%;
- low exports of high-tech products - 3.3%.

In Bulgaria relatively the most innovative are the sectors of "Computer Technologies", "Engineering and consultancy activities", "Financial intermedia-tion".

SMEs strive to achieve results through innovation activity by increasing the quality and diversification of the product mix. Gradually realize the role of competitive advantages of a higher rank and, above all, of their innovative solutions, related to the reduction of the cost of raw materials and energy efficiency [2].

In Bulgaria, the creation of new knowledge and the transfer of the existing one takes place in several directions:

- participation in international research pro-grams and partnerships between business, scientific circles and public administration;
- transfer of innovation through direct and foreign investment;
- international trade co-operation;
- transfer of knowledge and innovative prac-tices through local business contacts with foreign partners through contracts such as suppliers, subcontractors, distributors, etc.;
- exploiting the potential of the local inno-vation system.

The conclusions of the Lisbon European Council are aimed at: maximizing the benefits of innovation in research at national and EU level as well as creating a favorable environment for the emergence and development of an innovative business. EU innovation trends are: encouraging research that is turning into innovation; increasing the deployment of new technologies by enterprises; encouraging investment in innovation; creating technological "valleys"; increa-sing the importance of the service sector; directing innovation to environmental protection, etc.

The knowledge economy requires strong science and highly qualified specialists. The share of scientists in enterprises in the Republic of Bulgaria is the lowest among all surveyed countries [6].

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4188

Here is where we can look for answers to the following questions:

- what is the role of the innovation centers in the innovation ecosystem in Bulgaria;
- how can the transfer of talent between universities and business be stimulated;
- how the innovation market of the future will change;
- why de-literacy is a factor for success;
- how innovation and digitization are supported;
- what are the European policies in the field of innovation and digitization;
- where are the centers of science and technology in Bulgaria?

II. Explanation

The *modern organizational structures* is built on the basis of the project organization with a dynamic organizational structure [1]. When we have large and complex projects with a long duration in time we create so-called clean design structures. With in them, all management functions are executed, from planning to controlling, the involved specialists are directly subordinated to the project manager, as well as the resources for the implementation of the project.

The *design structure* depends on the size of the project group. It should be noted that the *matrix structures* are characterized by the simultaneous use of functional and target elements. To perform certain tasks, target groups are created, involving specialists from the functional departments of the organization. *Matrix organization* is a flexible and dynamic structure. There is an opportunity for regrouping the resources by changing the environment and creating conditions for creative expression of the specialists. In the high-tech industries, the so-called *"structures of the future"*. As such, the *orchestrated structure*, which has a limited practical application, can be mentioned. Its main elements are [1]:

- "orchestra" - a person in the organization who acts as a coordinator of the actions of the operational and innovation loop;
- executive groups - innovators work on them;
- sponsors (guarantors) - their task is to "push" innovation and order new ideas.

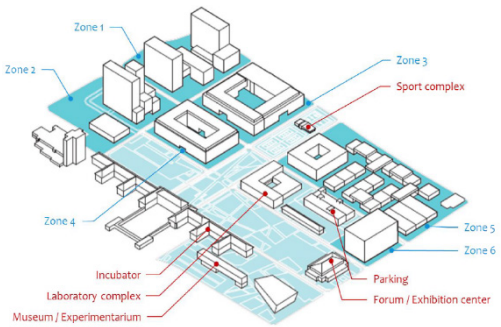

Fig. 1. Sofia Techpark

Examples of these types of new organizational structures are the Sofia Techpark (Fig. 1) and Trakia Economic Zone (Fig. 2).

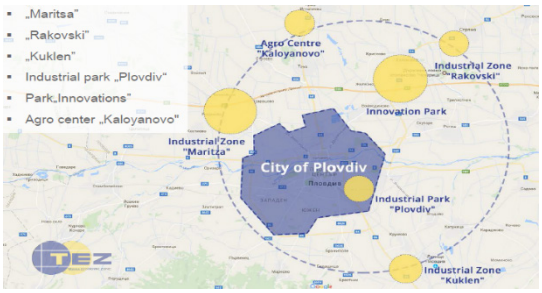

Fig. 2. Trakia Economic Zone (TEZ)

The *information and communication infrastructure* covers the storage and transmission environment of information and knowledge. At the macro level, it includes national and local fixed and wireless voice and data networks and user access devices. At the micro level, key features of the information and communication infrastructure are the availability of intercompany computer and communication networks, software applications and protocols. It should be noted that despite the rapid and homogeneous development by 2016 the information and communication infra-structure in the Republic of Bulgaria lags behind the average level of the new EU member states. The pro-duction activity carried out in Bulgarian SMEs does not require well-developed ICT. These enterprises are still peripheral equipment but not network commu-nication. The share of enterprises with IT systems for operational management of production is small. For most businesses in Bulgaria, the internet remains the only means of communication and much less used for online marketing or e-commerce. This trend in 2016 has rapidly changed in the direction of increase. In order to assess the ICT activity in the European Commission, they monitor the indicators: working in high-tech areas and exporting these products as part of total exports; selling new products for market and new products for companies; working in medium-high-tech and high-tech industries.

According to the Organization for Economic Cooperation and Development (OECD) classification, high-tech industries are those for the production of: drug substances and products; office and electronic computing; radio, television and telecommunication equipment; aircraft and spacecraft and their engines [3].

The index for the export of high-tech products measures the country's technological competitiveness, the ability to realize the results of the research and the realization of the international markets. It is important to note that by this indicator Bulgaria is equal to the average for the EU countries. Over the last 5 years, the share of R & D spending in the mid-high-tech and high-tech sectors of industry amounted to approxi-mately 80% of the total cost of industrial research and innovation costs. The indicator for ICT investments as a percentage of total costs reflects the fundamental specificity of the knowledge-based

economy, the driver of present and future productivity improve-ments. These investments include equipment, services and software. In order to enhance the role of ICT in the innovative economy in the country, the following measures should be taken to:

- development of ICT infrastructure with access to e-services by society;
- reengineering the network of the state administration;
- ensuring high information security by building an effective information environ-ment and interaction standards;
- setting up centers of excellence in the field of ICT;
- building and supporting technology plat-forms in the ICT field;
- promoting a public-private partnership for more investment and innovation in the ICT sector.

Innovative forms of cooperation implemented in Bulgaria - Business Incubators [4]. The incubator is a complex multifunctional complex that performs a variety of innovative services and can be located in one or several buildings and works on the principle of synergy (Figure 3).

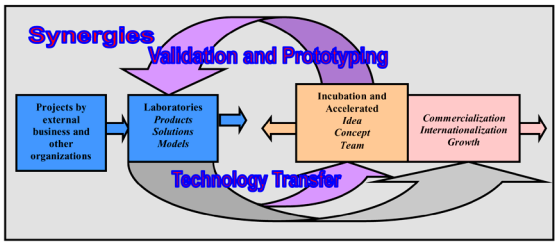

Fig. 3. Principal scheme of Incubator work by Sofia Techpark

There is an opportunity to significantly reduce the costs of a start-up entrepreneur as a result of the renting of a work space, the necessary equipment and a wide range of highly qualified consulting and information services on all aspects of entrepreneurial activity. Payment of the services provided, including the rent of the premises, the use of the equipment and servicing belonging to the incubator is at moderate prices as a result of the participation of the government, the local authorities, the large organizations and universities involved in the financing of the incubator's activity.

For 2018 Sofia Techpark has 24 high-tech compa-nies and 21 startups. For 2019, Co-working Spaces for up to 60 teams and starters, an author's incubation program, and a multitude of added-value services are foreseen. Emphasis is placed on turning science into products. Promotes and supports entrepreneurship in the field of research and development in Bulgaria and the Balkan region. It works directly with teams and consultants from the Silicon Valley. It has the longest incubation and acceleration program, with a period of up to 3 years. The criteria for inclusion in the structure of the business incubator can be defined as follows: a clear and realistic business idea with market potential, at least 30% of its personnel being engaged in research and development, active interaction with the labora-tory complex on the territory of Sofia Techpark.

Other successful forms of development of the innovation activities of the organizations are the technology parks and technopolis.

Technological parks (Technoparks) are a major tool for stimulating technological innovation activity in existing enterprises, in start-ups or in research institutes. At the same time, the term "technology park" includes the terms "science park" or "research park" and "innovation center".

By definition, the technology park is a place where newly established technology companies can find an appropriate intellectual environment, as well as support for the start-up and development of their business, access to markets, technologies, and so on. The Technological Park is a scientific-production territorial complex with a complex hierarchical structure. As an example we can point to Sofia Techpark, schematically presented in Fig. 1.

The laboratory complex is one of the main elements of the technology park. At Sofia Techpark there are 11 certified laboratories (biopharmaceuticals, bioinformatics, high-performance computations, artifi-cial intelligence and CAD systems, cyber security, 3D creativity and fast prototyping of new products, virtual and expanded reality, intelligent communication structures, nano-technology, etc.) and works with 3 universities.

Technopolis is a complete science-production structure created on the basis of a separate city, in the economy of which technological parks and incubators have a significant place. The university or other higher education institution is the core of technopolis. The biggest technopolis in the world is the Silicon Valley, and Bulgaria is not yet there. There are built-up areas in the country, such as the Trakia Economic Zone (TEZ), represented in Figure 2. At present, the con-struction of a zone of this type between Gabrovo and Sevlievo is being considered, where the two centers of production of products of ABB, Podem - AD, Ideal Standard, Mechatronica, STS - holding group and others are considered.

Barriers to the innovation development of SMEs in Bulgaria

We can define the Bulgarian market as a relatively small one, characterized by low purchasing power and low consumer demand. Our country is among those countries where consumers are mistrustful of innova-tion and, as a whole, lack an innovation culture among the population [5]. The following main factors, which prevent the Bulgarian SMEs from successfully deve-loping their innovative activities, are identified and they relate to:

- the nature of the innovation process (high costs and high economic risk);
- lack of sources to finance innovation activities (mostly from own funds or from attracted investment capital);
- state of the business environment;
- lack of adequate infrastructure to develop innovation;

- a disconnected link between science and business;
- shortage of qualified staff;
- lack of sufficient information on markets and new niche markets;
- shortcomings in the operation of key support mechanisms and instruments (e.g. National Innovation Fund).

The establishment of Centers for Innovation in the Innovation Ecosystem in Bulgaria has begun in order for the industrial transformation to improve the competitiveness of the Bulgarian industry. Creating them will lead to stimulation of the transfer of talent between university and business; to change the market for innovation; to degeneration; to the imple-menttation of European policies on innovation and digitization. Here, it is worth noting that the total budget foreseen under the procedure "Construction and Development of Centers of Competence" in the Republic of Bulgaria is worth BGN 150 million and is divided into the following components [7, 8, 9]:

- Mechatronics and clean technologies – BGN 48 million;
- Informatics and Information and Commu-nication Technologies - BGN 27 million;
- Industry for healthy life and biotechnology - BGN 48 million;
- New technologies in the creative and recreational industries - BGN 27 million.

Funding is under Priority Axis 1 "Research and Technological Development" of the Operational Program "Science and Education for Smart Growth", co-financed by the European Regional Development Fund. Approved after an open competition procedure are seven Competence Centers amounting to BGN 134 million under the Operational Program. The Managing Authority of the Science and Education for Smart Growth OP approved the evaluation committee's report on the evaluation and the ranking of the project proposals under the procedure BG05M2OP001-1.002 "Building and Development of Competence Centers" [8].

One of these national centers is the Competence Center "Intelligent Mechatronics, Eco and Energy Saving Systems and Technologies" at the Technical University of Gabrovo and PROJECT BG05M2OP001-1.002-0019 for "Clean Technologies for Sustainable Environment - Water, Waste, Energy for Circular Economy "(Clean & Circle).

PROJECT BG05M2OP001-1.002-0023 Compe-tence Center "Intelligent mechatronics, eco- and energy-saving systems and technologies"[9]

An opening press conference was given the start of a major project by which the Technical University - Gabrovo is a leading organization, namely the Center for Competence Center "Intelligent Mechatro-nics, Eco and Energy Saving Technologies and Technologies", financed under the Operational Program "Science and Education for Smart Growth" 2014 - 2020, co-funded by the European Union, through the European Regional Development Fund. The grant is BGN 23 569 719,17, of which BGN 20 034 261,29 European funding and BGN 3 535 457,88 nationally [6, 7, 8, 9].

The main objective is to build a sustainably functioning National Competence Center, in which the three sides of the knowledge triangle - education, research and business are in an effective and dynamic interaction based on shared strategies, strong and concrete engagements and joint scientific projects and partnership.

The project partners are seven: Technical University of Gabrovo, Technical University of Sofia, Technical University of Varna, Sofia University "St. Kliment Ohridski", Institute of Robotics - BAS, Institute of Electronics - BAS, Central Laboratory of Applied Physics - Bulgarian Academy of Sciences.

Associated partners are - authoritative industrial enterprises and business associations, as well as technical universities in Berlin and Liberec. The implementation period is until the end of November 2023.

According to University Rector and Project Leader Prof. Raycho Ilarionov, "The idea is to create a technology center, a competence center or a technology park variant at the Technical University of Gabrovo. The university is working on four more projects and has three more competence centers and a center of excellence. The idea is to unite all these projects in one place and to create a Technology Park at the Technical University of Gabrovo to create highly intelligent and technological devices, to train young engineers and PhD students and to create science for the benefit of business (Fig. 4)." The efforts of seven leading scientific organizations and universities in Bulgaria to increase the level of their scientific research and the successful commerciali-zation of the results obtained in a priority for the economy "Mechatronica and pure technologies" as defined in the Innovation Strategy for smart specialization 2014 - 2020 (ISSS).

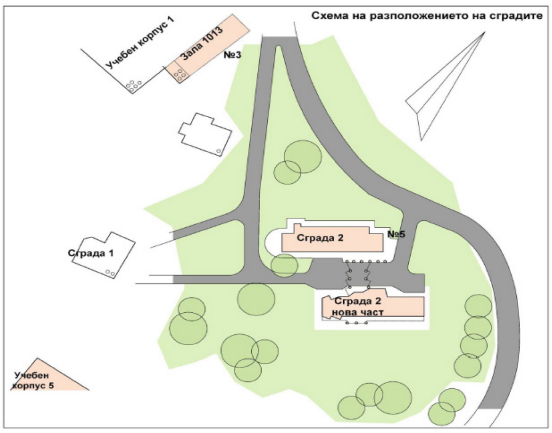

Fig. 4. Technological Park at the Technical University of Gabrovo [9]

The Center of Competence has two major pillars - scientific laboratories and scientific projects to be worked on. One part is intelligent mechatronic systems, and the second part is energy-saving systems and clean technologies. There are two other pillars for disseminating results and for training and qualification - introducing

new training and education methods, marketing and dissemination of results. The aim is to bring research results, to get faster to real business, to translate into practice. Thus, people in education and science and business people will be even more useful to each other, and the transfer of innovation and science to the economy will be real.

The activities are numerous. The first major task is to modernize existing research infrastructures. These are two very big renovations at the Technical University - Sofia branch in Plovdiv and at the Technical University in Gabrovo, as well as at the partners of the Institute of Robotics and Sofia University "St. Kliment Ohridski". A total of BGN 4 859 206.00 is foreseen for repair activities. The second important activity is the purchase of equipment necessary for the realization of the research programs for over BGN 13.5 million. The third core activity concerns the real work of scientists - conducting market-oriented research and development, moderni-zing new technologies at a high international level. For this purpose, about BGN 4 millions are planned under the project. Funds are also provided for the accredita-tion of laboratories so that businesses can not go to make measurements abroad but use the services of the Competence Center. It is clear from the envisaged activities that the project is in fact infrastructure - infrastructure for conducting research and its disse-mination and its implementation as innovation in business.

One of the expected results of its implementation is to provide capacity for research and innovation teams in the field of mechatronics and clean techno-logy by attracting leading research organizations. The other expected result is the retention and attraction in the Republic of Bulgaria of young researchers, scientists and doctoral students by creating modern conditions for research and development. The third result is the practical application of the research results achieved. Fourthly, the results with practical applica-tion or representing the experimental development of technology and technology will be made available to the Technology Transfer Committee to coordinate intellectual property rights protection activities and their subsequent commercialization.

The project itself is an opportunity for inclusion in other international programs and projects. With its implementation, Gabrovo Center for Competence with 33 laboratories in 8 laboratory complexes, 14 joint projects between the Center and the business, research and innovation, etc. will be established. Laboratory 1013 is equipped with the latest generation and works as a development engineer at the Faculty of Mecha-nical and Instrumentation at the University.

The Center's research program reflects the horizontal strands of the Innovation Strategy for Smart Specialization, namely the development of the inno-vative potential in the field of Mechatronics and Clean Technologies for the creation and adaptation of new technologies leading to improved resource efficiency, competitive advantages and increased added value of the products in the production of specialized equip-ment, machine building and instrumentation, compo-nents for production of automobiles, servo systems, electric electrical and electromechanical products, robotics, chemical products.

The acquisition of new knowledge and skills for teaching and the transformation of this knowledge into innovations of interest to the Bulgarian and European economies are a leading factor in all strategies, plans, programs and their corresponding implementing measures.

The joint R & D of the Center and the business should lead to increased private investment in public R & D and complementing public spending with public-private partnerships and projects implemented in cooperation with the business sector. This will allow the Competence Center to develop and become a place where science, business, government, and education get their hands on. The established scientific infra-structure, in line with the best world standards and practices, will promote the development of applied science and innovation in the field of mechatronics and clean technologies to create economic growth, quality jobs and help address national, European and global challenges for society.

Here we have to emphasize that the comercializa-tion of research results is a guarantee of a fully realized potential of the Center for Competence Research Plan. Knowledge transfer is bi-directional - the "active supply" model refers to the commercial application of the knowledge acquired by the research system through intellectual property, technology transfer, and "spin-off" companies, and the "active search" model is where companies receive support from researchers because they have signed cooperative / partnership contracts.

The joint R & D of the Center and the business should lead to increased private investment in public R & D and complementing public spending with public-private partnerships and projects implemented in cooperation with the business sector.

This will allow the Competence Center to be the place where science, business, government, and education go hand in hand. The developed scientific infrastructure, in accordance with the best world standards and practices, will promote the development of applied science and innovation in the field of mechatronics and clean technologies in Bulgaria and will provide the opportunity for a more competitive Bulgarian economy.

We are currently working on a Concept for the use of the funds from the "Intelligent Growth Science and Education" Operational Program for the Operational Program "Innovation and Competitiveness" to support the Regional Innovation Centers (RICs). The main objective here is to build and develop a modern research and innovation infrastructure and expertise for conducting applied open-ended research and development activities, facilitating the accelerated economic and social development of the Bulgarian regions. The research infrastructure is part of the scientific and innovation system in Bulgaria in the priority areas of the Innovation Strategy for Intelligent Specialization (ISIS). The

procedure for development and implementation under Operational program on innovation and competitiveness (OPIC) Priority Axis 1 "Technological Development and Innovation". The main focus is to explore and further develop the research and development potential of research organizations as part of the RIC in cooperation with regional business to create new products, services and processes. They will find investment in open and shared science and innovation infrastructures. Work will be done on enhancing cooperation, networking and knowledge transfer, as well as achieving higher levels of technological readiness. All these efforts are focused on the horizon 2021-2027.

III. Conclusion

In conclusion, the following conclusions can be drawn:

- the essence of innovative enterprises is re-vealed with their respective modern organi-zational structures;
- schemes of business incubators, technology parks and technopolis (Sofia Techpark, Trakia Economic Zone, Technological Park at the Technical University of Gabrovo);
- forms of innovation cooperation defined;
- the barriers to the innovation development of SMEs in Bulgaria have been formulated, highlighting the main factors behind the development of their innovation activities;
- an example is the Center for Competence "Intelligent Mechatronics, Eco-Energy and Energy Saving Systems and Technologies" at the Technical University of Gabrovo and PROJECT BG05M2OP001-1.002-0019 for "Clean Technologies for Sustainable Environment - Water, Waste, Energy for a Circular Economy" (Clean & Circle);
- the role of the innovation centers in the innovation ecosystem in Bulgaria is defined;
- the way of stimulating the transfer of talent between university and business is defined;
- the link between innovation, de-literacy, smart industry and the future is formulated.

The realization of projects under the procedure "Building and Development of Competence Centers" in the Republic of Bulgaria will lead to the improvement of the competitiveness of the Bulgarian economy, shortening and eliminating the distance "scienti-fic achievements" – "real technologies" – "business".

All this proves the author's thesis on the road to intelligent, innovative and sustainable industry in Bulgaria. Current issues, prospects for industry-specific research, as well as alternative solutions against rapid innovation technology aging are proven.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 216-221

Problems of Ensuring Ecological and Economic Security by Industrial Enterprises Under the Arctic Zone Conditions

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***Abstract*— Ensuring regional environmental and economic security is one of the priorities of the state. The problems of sustainable development of regions and their industrial complexes are considered by many scientists, however, insufficient attention is paid to the analysis of the sustainability of industrial enterprises in the Arctic zone (AZ) and their impact on the ecological and economic security of the region. Many of the problems of theoretical and methodological support for improving this security remain underestimated. For industrial enterprises of the Far North as a part of AZ, it is necessary to use a special approach to the development of methodological aspects of ensuring environmental and economic security due to the significant role that entrepreneurial activity has in the socio-economic development of the region and in the environmental situation.**

The purpose of the research is the formation of a mechanism to ensure the environmental and economic security of the Russian Arctic zone (RAZ), as a region where industrial enterprises operate. The object of the research was the ecological and economic security of the region of the Arctic zone, which exists in the modern conditions of globalization of the economy and the increasing influence of geopolitical factors. The subject of the study was a set of problems of a theoretical, methodical and applied nature, related to the development and implementation of a model for the development of industrial enterprises in the Arctic zone. The factors limiting the development of industrial enterprises of the Far North are formulated. A system of indicators for the sustainable development of industrial enterprises and the environmental and economic security of the region of the Arctic zone of Russia is proposed. The interrelation of indicators of the development of industrial enterprises of the Arctic zone with the conditions of the external economic environment has been revealed, which made it possible to conclude that the structure of industrial production in the regions of the Russian Arctic is distorted. This, in turn, necessitates the formation of maritime clusters and the development of small and medium-sized businesses in the industrial sector. A comparative description of the key areas of state regulation of industrial enterprises in foreign and domestic practice has been carried out. The recommendations of the possible use (adaptation) of international experience in the Russian Arctic are formulated.

Keywords*—ecological and economic security, sustainable development, Arctic zone, maritime clusters.

INTRODUCTION

The Russian Arctic zone plays an important role in ensuring the dynamic development of the country; more than 25% of the gross domestic product (GDP) is produced there. The industrial sector of the northern regions of Russia forms more than 40% of the gross value added in industry (in Russia this indicator is 31%) [1]. The dominance of industrial production in the northern regions will continue, which is largely determined by a significant resource base. This in turn affects the prospects for industrial development throughout Russia. At the same time, the main task is to shift the priorities of the export orientation of non-renewable resources towards solving the issues of their processing by Russian companies, including those in the Arctic zone. A rather difficult economic situation necessitates the development of tools for making strategic and operational risk management decisions in crisis situations and overcoming their consequences.

In these circumstances, there is a likelihood of negative trends in the socio-economic development of individual territories. Along with the internal causes of the crisis, it is also necessary to take into account the influence of exogenous factors of external forces represented by the indicators of the world and national economies, as well as the regional policy pursued. The task of studying the influence of external factors with the aim of identifying the signs and causes of deviations in the development of industrial enterprises in the Far North is becoming highly relevant today [2]. All of these require a special approach to the development of methodological aspects of environmental and economic security. Tools and methods for ensuring the environmental and economic security of the Arctic region of Russia are considered by the authors from the position of a systematic approach as constituent elements of the sustainable development of the territory. The impact of adverse socio-economic factors on business development increases the importance of developing programs to adapt them to the influence of the external environment. For the latter, the characteristic properties

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4089

are mobility, uncertainty and instability. Support for business activities, especially in the conditions of the Extreme North, is aimed at creating conditions for the economic growth of these territories: the more stable the system being created, the higher the level of security.

At the same time, the current state of intensive development of AZ implies the need to assess the planned parameters of the effectiveness of the development of the Arctic. One cannot but agree that, for AZ, the effectiveness of the activities of economic actors should not be considered traditionally only from the standpoint of estimating volumes and quantities [3].

MATERIALS AND METHODS

In May 2017, the strategy of Russia's economic security for the period up to 2030 was approved [4]. The decree establishes the fundamental indicators of economic security. From the point of view of the authors, the definition of indicators characterizing the change in the state of AZ in a strategic perspective should be carried out from the standpoint of environmental safety of the region for the population living there, for the animal and plant world, for the water, underground and air environment belonging to the Earth. Therefore, it is advisable to consistently disclose the authors' approaches concerning the selection of indicators of assessment and environmental safety for AZ and definitions of modern forms of interaction between economic actors.

In the annual state report "On the state and environmental protection in the Russian Federation", a special section is devoted to issues of the RAZ, which contains information about a set of measures for nature conservation [5]. The state report also provides an assessment of the costs for enterprises in the protection of the environment. The largest amount of investment in the protection and rational use of natural resources in 2017 was noted in the Yamalo-Nenets autonomous district (67%) and the Krasnoyarsk territory (21%). Current expenses for environmental protection of RAZ in 2017 amounted to 32.13 billion rubles, and the largest amount was spent on waste management (44%) and on the collection and treatment of wastewater (31%).

The activities of industrial companies, oil-production and other forms of mining, as well as the operation of marine transport - all these together lead to the fact that there are areas in the Arctic with anthropogenically modified landscapes. Those landscapes need measures not only to conserve, but also to restore their natural ecological potential. The results of the work done in this context in 2017 are also presented in the Report. For example, Rosneft Oil Company, Gazprom, PAO Novotek and Lukoil approved of corporate programs for the conservation of biological diversity, taking into account the list of flora and fauna that determine the sustainable state of marine ecosystems of the Arctic. These companies conduct monitoring studies of animals, birds, listed in the Red Book of the Russian Federation and other natural objects on a regular basis.

In Murmansk region, Republic of Sakha (Yakutia) and in Khanty-Mansiysk autonomous region in 2017 various measures were taken to eliminate the accumulated environmental damage (reclamation of oil-contaminated land and sludge pits). Oil and gas companies have eliminated 184 accumulated sources of pollution.

An inventory of waste disposal sites is being carried out and in Murmansk region commissioning of the waste sorting line of the first eco-technology park in the Arctic zone of Russia as part of the waste sorting complex and solid municipal waste landfill took place.

The analysis of the activities carried out in the AZ for the purposes of maintaining and developing environmental safety according to the Report allows to draw conclusions that for the most part the activities are aimed at eliminating the results of pollution of water or land objects, rather than for anticipating possible negative effects for the ecological balance of the region. In addition, we would like to note that the question "Are these activities carried out by Russia sufficiently effective for the state of the environment?" has no clear answer in the Report.

For the region's environmental safety requirements to be met not after the identified damage, but to become a systemic activity of a proactive nature, it is necessary to approve the standard environmental safety indicators for enterprises which should be regularly monitored and implemented. It is advisable to choose the indicators that are defined as targets for the implementation of the "Environment Protection" state program [6], and supplement them with the new ones (indicated in italics in the text), namely:

- emission of air pollutants from stationary sources per 1 million rubles of gross domestic product at constant prices (in tons);
- the number of cities and *urban settlements* with high and very high levels of air pollution;
- the number of people living in adverse environmental conditions (in cities and *urban-type settlements* with high and very high levels of air pollution (air pollution index is more than 7 thousand people);
- volume of generated waste of all hazard classes per 1 million rubles of the gross domestic product at constant prices (in tons);
- the share of mammals listed in the Red Book of the Russian Federation and living in specially protected natural areas of federal significance in the total number of mammals listed in the Red Book of the Russian Federation (%);
- the share of bird species listed in the Red Book of the Russian Federation and inhabiting specially protected natural areas of federal significance in the total number of bird species listed in the Red Book of the Russian Federation (%);
- the percentage of the territory occupied by specially protected natural territories of regional and local importance (%);

• the population living in the areas with unfavorable environmental situation, subject to the negative impact associated with the past economic and other activities (the number of people).

For the assessment of the environmental safety the acceptable thresholds which for the period up to 2025 can be set on the basis of the planned results of the state program:

• emissions of harmful (polluting) substances from stationary sources per a unit of gross domestic product should be reduced by 1.3 times;

• the number of cities and urban settlements with high and very high levels of air pollution should be reduced to 45;

• improving the environmental conditions for 36.4 million Russians currently living in the cities and *urban-type settlements* with a high and very high levels of air pollution;

• the volume of waste of all hazard classes per a unit of the gross domestic product should be reduced by 1.2 times;

• improving the environmental conditions of life for more than 700 thousand Russians living in the areas with unfavorable environmental situation associated with the past economic and other activities;

• preserving and increasing the population of the animal and plant world which are listed in the Red Book;

• application of an increase in the depreciation coefficient of 3 when calculating the tax on the profit of organizations making capital investments in the creation of objects of environmental protection;

• adjustment of the payment for the negative impact on the environment due to costs on the implementation of environment protection measures;

• providing loan financing for the implementation of environmental projects by the state development institutions.

For the economic security it is not the economic indicators themselves that matter, but their threshold values do. The criterion of economic and environmental safety can be called the requirement of finding the actual values of indicators within certain limits. Going beyond those limits will mean reducing the system security to an unacceptable level [7].

For the areas of the AZ in view of the objective development problems, among which one can single out poor transport accessibility, difficult climatic conditions, population ageing, it is also necessary to adjust generally accepted indicators of the economic security. In the course of the study a grouping of indicators of economic security was conducted for municipalities of the Far North. Indicators of the first group covered: natural population growth; the ratio of average per capita income to the subsistence minimum; investments in the fixed capital the volume of shipped goods of the own production; the share of manufacturing in the industrial production, in %).

Among the indicators of intensive use of the resource potential we highlight the following: the degree of deterioration of the fixed funds, in %; industrial production per capita, in thousand rubles; the share of imported goods in the industrial potential, in %. Specialization of the northern region has to be described by the ratio of the increase in mineral reserves to the volume of their repayment in the subsoil, in %; extraction of fuel and energy minerals per capita, in thousand rubles; the ratio of electricity generation to its consumption.

The indicator characterizing the degree of economic development of the municipality can be a balanced financial result of the volume of the shipped goods of the own production. The state of the economic security of the industrial enterprises of the Northern region depends on the factors of development and on the quality of management of these factors. Therefore, it seems obvious that the existence of an effective system of the state regulation of industrial development of RAZ, is the most important condition for achieving the economic security of the Arctic region as a whole.

RESULTS AND DISCUSSION

According to the survey of the financial and economic activities of Norilsk industrial region for the period from 2015 to 2017, the authors have developed critical indicators that can characterize the economic security of the municipal district of the Arctic zone. Table I presents the recommended indicators and achieved ones. The following industries are represented in Norilsk industrial region: mining, non-ferrous metallurgy, power engineering, gas industry, transport, communications, construction industry, trade, food industry, housing and utilities. Missing data in Table I are indicated as n/d (no data).

The given system of indicators and their comparison with recommended values allow us to identify areas in which there are certain problems that do not allow a certain level of economic security. For Norilsk this is a decline in the population and the ratio of average per capita income to the subsistence minimum.

Creating a system of advanced strategic management and, in particular, a system of operational monitoring of the state of the economic security of industrial enterprises and analyzing the impact of the external environment on it involves selecting basic and calculated indicators of the state of the social and economic environment of the regions, their synthesis and the development of synthesized indicators. Based on the analytical work, this system can determine the most vulnerable points and influence of the external environment on the development of the region.

TABLE I. Recommended Indicators Of The Economic Security For A Municipal District Of The Arctic Zone

Indicators	Critical values	Norilsk
- natural population growth	more than 1	2
- the ratio of per capita income to the subsistence minimum	more than 3,5	3,1
- investments in fixed assets, as a percentage of the volume of the shipped goods of the companies' own production	15-25	17,7
- share of manufacturing in industrial production, in %	25	74,3
– degree of depreciation of fixed assets in industry, in %	less 40	48,3
- industrial output per capita in rubles	more than 250000	292
- share of imported goods in industrial potential, in %	less 20	n/d
- the ratio of the increase in mineral reserves to their repayment volumes in the subsoil, in %	125 (25% growth)	n/d
- mining of fuel and energy minerals per capita, in rubles	more than 30000	30,5
- ratio of power generation to its consumption	more than 1	n/d
- balanced financial result to the volume of the shipped goods of the companies' own production	more than 1	n/d

Analysis of the impact of the global and local factors on the external environment of a region is impossible without establishing interrelations between indicators of the external environment, as well as monitoring their impact (direct or indirect) on indicators of monitoring the economic security and sustainable development. Having a complete picture of the interrelationships of the indicators can help us to obtain a consistent assessment of environmental factors affecting sustainable development as a criterion for economic security.

The authors have built correlation dependencies to determine the system of interrelations between analized indicators. The indicators characterizing the development of industrial enterprises (among them: the turnover of enterprises, the level of investment, innovative activity, industrial production index, profitability of production etc.) were selected for certain regions of the Far North. Correlation analysis was carried out for 8 regions of the Arctic zone and 30 indicators. In assessing the strength of the connection between the main indicators characterizing the industrial development of the regions of the Extreme North about 300 coefficients were calculated, and only 33% of the coefficients characterizing strong and average communications (more than 0.6) were found. The conclusion is made about the deformation of the structure of the industrial production in these regions of the Russian Arctic. This clearly indicates the need for further development of small and medium-sized businesses engaged in industrial production in the region.

We believe that the participation of the state in the development of industry in the northern regions is necessary as a significant resource of the industrial sector in these regions, with the raw materials orientation of the Russian economy, is of particular importance in exporting and forming the revenue side of the budget. A critical analysis of the foreign experience of the state regulation of the northern territories showed that the use of foreign experience is possible not so much in terms of specific details of regulating the industrial development of the northern regions, as in the general idea of the policy under consideration [8]. That is why foreign experience is of great interest, because it makes possible to avoid repeating conceptual errors.

The industrial activity of the northern states is based on the primary development of resource-extracting and resource-processing industries, by analogy with the industrial development of the northern territories of Russia. Considering the foreign experience in regulating the development of the northern territories, it should be noted that the main features are:

- dominant participation of large corporations in the development of the northern economies;

- active participation of the state, reflected in the continuous evaluation and modernization of the "northern" legislation, which gives additional benefits to organizations and enterprises engaged in economic activities in hard-to-reach areas.

State subsidies occupy the main share in the expenditure part of the budgets of underdeveloped territories, their value reaches 75%. Managing the development of such territories is centralized; the state efforts are directed at improving the even distribution of income from the use of the natural resources of the North. This is typical of Canada and Nordic countries [9]. The solution of this problem has special features for each of the countries, but the general measures to stabilize the economic situation of the northern territories are traced, which have been as follows:

1) special regional stabilization funds have been created;

2) measures are being taken to diversify the economy;

3) control of the areas rich in natural resources;

4) the application of special tax regimes.

In our opinion one of the most important reasons for low the efficiency of the regional industrial policy in the North is the insufficient attention of the state bodies to sectoral and spatial and other local aspects. Hence the need for a systematic study of the development and implementation of the regional industrial policy in the Arctic zone, including cluster policy on the formation of maritime clusters [10], [11].

The state support for the creation of clusters in AZ should be an absolutely unique process both in its content and forms of implementation. Currently, an updated state program called "Social and economic development of the Russian Federation AZ for the period up to 2025" has been approved [12]. The state program sets its goal as raising social and economic development of Russian Artic Zone. The state program sets subprograms for the supporting development zones for the accelerated socio-economic

development of RAZ; for the development of the Northern Sea Route and the provision of shipping in the Arctic; for the creation of equipment and technology of oil and gas and engineering necessary for the development of mineral resources in RA. The state program highlights the "frame-cluster approach", which is based on the advanced development of the transport, power engineering and social framework of the territory and the concentration of resources in the prioritized supporting zones of development. All this indicates the need for forming a special cluster policy of the Arctic zone of Russia. In such a cluster policy for RAZ, the objectives of the functioning of the clusters will be linked the objectives of the state program. This will allow legislation to justify the financing of the activities of marine and coastal AZ clusters. The state program identifies "core development zones" that will create conditions for accelerated socio-economic development of the AZ, and achieving strategic interests and ensuring Russia's national security in the Arctic. It is the cluster formation in the modern conditions of the socio-economic development of the country that can become these supporting development zones. All this indicates a real possibility and demand for creating clusters, for which a clearly formulated cluster initiative is also needed. Such an initiative coming from potential or existing cluster members, associated with the search for potential partners, investors, buyers of cluster products, is of particular importance. It is an extremely significant initiative compared to the actions of the state bodies, since it comes from the goal-oriented and more relevant participants (having scrupulous knowledge of the subject). The weakness of the cluster initiatives is the lack of special knowledge of the owners of the needed resources - investors, government agencies and buyers. Russian researchers determine the typology of maritime clusters, distinguish among the diversity of this type of clusters such characteristics as the presence or absence of trans-boundary and trans-aquatorial clusters in them; whether they are connected with marine economic activities or not [13]. For Russia, the creation of marine clusters has not been achieved yet. For EU countries, the functioning of maritime clusters is a part of EU modern economy that generates income and contributes to the effective development of regions, countries and companies in the maritime cluster. The European network of maritime clusters, which unites 18 EU member states, is well known [14]. The European Network of Marine Clusters supports joint projects for the development of clusters, creation of unified legislation, operating standards and other issues. Studying the problems of the functioning of the maritime clusters of the European Union, the countries of the Baltic region, and also the Asia-Pacific region and the proposed ways to solve them will allow the future RAZ maritime clusters to minimize the potential difficulties of their creation and development.

CONCLUSIONS

For the effective functioning of sea clusters in the Arctic zone, new hybrid forms of cluster formations, namely project alliances, can be used. The reasons for their emergence and implementation are the following objective factors: the feasibility of using the project approach is due to the global trend of reducing the life cycle of technologies and the need to use common cross-border operating standards, legislation, international agreements leads to the emergence of an alliance integration form. Since at present Russia is a party of about 100 international agreements in the field of environmental protection for the effective implementation of international requirements for environment protection and internal environment safety, the creation of marine clusters in Arctic Zone will allow a rational solution for these issues.

Regarding the authors' approach to increasing the attractiveness of the region for high-quality residence and tourism, it should be noted that AZ is a territory where people live permanently. Clusters have always contributed to increasing the employment of the region's population and to a significant increase in their satisfaction with salaries, living conditions, and other social criteria that characterize the quality of life of the population of AZ [15].

Creating a real-life cluster policy for the Arctic region of the Russian Federation, the further creation of marine clusters uniting large, medium and small enterprises, their use of approved indicators of environmental and economic security will allow in the foreseeable future a significant change in the attitude of people to the issue whether to live and work in the Arctic.

To develop the industry in AZ without the support of the state is impossible. Implementation of supportive measures should be based on the administrative, legal and economic opportunities of the state. First of all, it is necessary to correct the essential disproportions in the regional economy with the preferential use of centralized administrative levers. At the same time, the goals of the state policy should, in particular, include: promoting the development of priority industries, improving the quality of life of the population, ensuring the necessary volume of import under the state control over the export of strategic goods. In the future, the transition from the state administrative-restrictive measures to economic levers stimulating the development of the market structure and increasing the number of independent market managing entities will be carried out, which will lead to changing the structure of industry with a focus on competitive relationships.

These measures will contribute to the formation of a sustainable mechanism for ensuring the environmental and economic security of the industrial enterprises in the Russian Arctic.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 222-224

Investigations of Apartment House Cellar Microclimate and It's Improvement Possibilities

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***Abstract*—Apartment houses made in the last century in Latvia have rather big heat transfer factor and not good ventilation, especially in cellar. That leads to formation of condensate on building constructions. During cold weather in winter time, this condensate formats ice layer that damages building constructions ant also lead to inconvenience for inhabitants, for example, disturbs opening of cellar door.**

During investigations the cellar microclimate parameters, such as temperature, humidity and dew point, were measured and different ways to improve them and as result preventing of condensate formation were worked out.

The measurements shows that sometimes the air temperature and the temperature on surfaces reaches dew point and therefore the condensate starts to format.

The possibilities to eliminate humidity and to increase dew point are worked out during investigations.

Keywords—energy efficiency of buildings, heat insulated doors

Introduction

Currently rebuilding (insulation) many apartment buildings on the walls strengthens heat insulation. Windows are mostly replaced only old Soviet times, uses 2 glass packages, only rarely are used most energy efficient with 3 glass packs, exterior doors are not heat insulated. The overall energy performance of buildings is not so high improvement as it could be achieved by focusing on the other essentials [1].

Energy efficiency improvement do not provide for renovation of several essential elements of the building, such as repair or replacement of cold water supply and sewerage, power supply, fire protection system. Evaluating these systems for major defects or pre-emergency situations will allow building owners to decide on the appropriate renovation works. [2]

The Bali conference heard repeated calls for reductions in global greenhouse gas emissions of 50 per cent by 2050 to avoid exceeding the 2°C threshold. While such endpoint targets dominate the policy agenda, they do not, in isolation, have a scientific basis and are likely to lead to dangerously misguided policies. To be scientifically credible, policy must be informed by an understanding of cumulative emissions and associated emission pathways. [3]

There needs to be better awareness and understanding of the energy options available, including their real impact on emissions, their real costs and the impact of pricing. In pursuing the sustainable energy future, we need to balance near-term achievables with long-term imperatives. [4]

Embodied energy and carbon dioxide emissions will become more significant as operational energy consumption is reduced. In the near future, embodied energy could account for a significant proportion of a building's carbon footprint over its lifetime, bearing in mind that the construction of energy-efficient buildings is carbon and energy intensive. [5]

In the south of Finland, about 50 kilometers from the capital, Helsinki, is the small town of Porvo. The city is located in an industrial region, but the ambition of the Porvo municipality is not lacking - it is about to become one of the first cities in Finland to completely free itself from the harmful carbon emissions, thus fighting climate change. Porvere's vice mayor says that when building new buildings, care should be taken to make it more energy efficient, while old houses can be upgraded, for example, by heat insulation so that they do not lose heat in winter. Fon Scholz recalls that the extra heat generated by the heat loss of the building also produces additional harmful emissions. [6]

Within the framework of the scientific research of the publication, the possibility to use additional doors with increased thermal resistance is studied. The construction of the insulated door made of 10 mm thick veneer sheets in wooden frame with the inside protects from warm and humid air with 50mm thick moisture-resistant foam polyester and 100 mm thick mechanically resistant facade stone wool on the outer side, which provides fire safety.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4185

Together, it forms an appropriate heat-insulating material composite that fulfills all the physical-mechanical, building norms requirements and significantly raise energy-efficiency of cellar spaces.

Material and methods

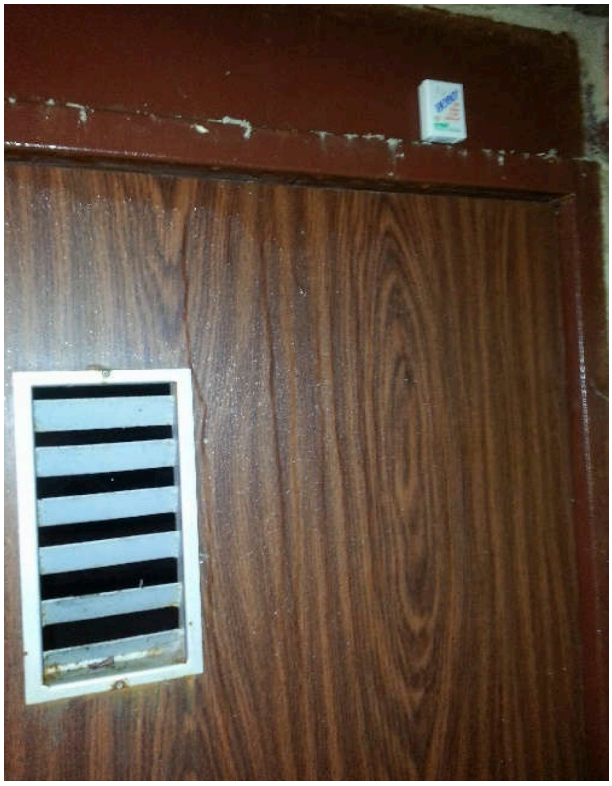
To make necessary calculations for eliminating problems with condensation on the steel door surface, the measurements of temperatures and humidity were carried out during winter period of 2018 from 29th January to 12th February.

The measurements were performed by HOBO loggers H08-007-02. The main paramet4ers are given in Table 1.

Table1. Parameters Of Logger Hobo

No.	Parameter	Range
1.	Operating range (logger): - Temperature - Humidity	-20°C to +70°C, 0 - 95% RH non-condensing
2.	Time accuracy:	approx. ±1 minute per week (±100 ppm at +20°C)
3.	Responsetime:	about 15 minutes

One measuring device was situated on inside surface of the steel door (Fig.1.a) the second on inside surface of inner doors to cellar (Fig.1.b.).



a – outside steel door

b – inside wooden door

Fig.1. Location of measuring devices

During measurements it was carried out, that sometimes the dew point is reached (Fig.2) that explains the formation of the condensate on the steel doors inner surface. This is the place, where warmer air with high humidity from cellar side meets the more cool door's surface. When the temperature falling below zero, the condensate starts to freeze.

Results and discussions

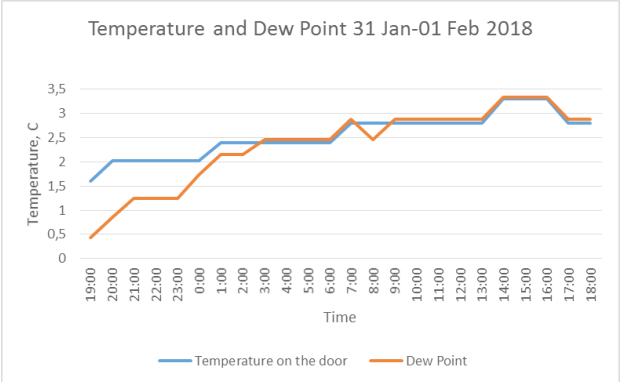


Fig.2. Temperature on the steel door and dew point

There are several methods to eliminate the formation of condensate. One of them is to prevent contact of wet warmer air from cellar with low temperature door surface. The solution is represented in Fig.3.

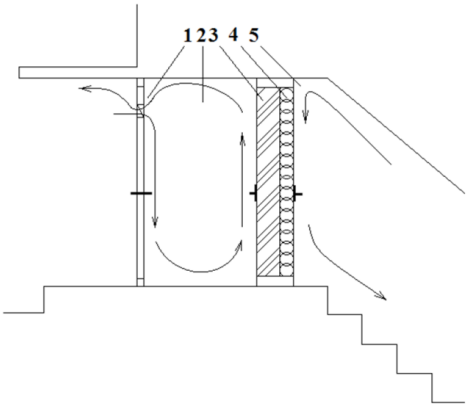


Fig.3. Solution with inner door heat insulation
1 – steel door with ventilation opening, 2 – space between two doors, 3 – rock wool insulation layer in outer side of the wooden door, 4 – polystyrene inside insulation layer, 5 – stair space to cellar.

The placing of door with heat insulation keeps the temperature on inner door above dew point and save the heat, but the ventilation opening in the steel door takes away the humidity from space between two doors. The warm water don't meet the outdoor surface.

Results of measurements established, that the lowest temperature behind the steel door during measuring period in January and February 2018 was -3 ^{0}C.

The highest dew point was established 4 ^{0}C (that don't diverges in time with mentioned temperature, but there are rated the extreme values).

The average temperature of cellar air is approximately 6-7 ^{0} C. The heat flow density if there is dew point temperature 4 ^{0}C on insulated door inner surface, is calculated by following:

$$q=\alpha_{in}*(t_c-t_{di})=8,7*(6-4)=17,4,$$

where:

q – heat flow density from cellar air to door surface, if temperature on surface is equal with dew point, W*m^{-2};

α_{in} – the heat transfer factor for inside surface of inside door, W*m^{-2}*^{0}C;

t_c – average cellar air temperature, ^{0}C;

t_{di} –temperature on door inner surface, ^{0}C.

The heat insulation of the door have to be such, that heat flow density through the door will not exceed calculated value, is:

$$R \geq \frac{t_{di}-t_{d0}}{q} = \frac{4-(-3)}{1\ 74} = 0,4,$$

where:

R – thermal resistance of the door, m^2*^{0}C*W^{-1},

t_{di} – average cellar air temperature, ^{0}C;

t_{do} – temperature of air in the space between door, ^{0}C.

Therefore, if the rockwool will be used as the heat insulation of the door, the thickness of wool layer have to be more than approximately 2 cm.

This type of insulated door significantly reduces heat loss from basement spaces, protects external doors from icing and freezing, improves comfort conditions on the ground floor of the apartment building because the floor is considerably warmer and significantly improves the overall heat consumption balance of the building in the long time. The use of such doors is recommended to be included in the energy efficiency improvement measures of buildings in order to prevent heat loss from the point of view that has not been addressed so far.

Conclusions

1. Additional heat insulated door provide protection of cellar hot and wet air condensate on outside steel door and freezing to save possibility that open in all times.
2. Additional heat insulated door save significant amount of heat in to inside of building that way increase energy efficiency of building and also save heat energy expenses.
3. Ground floor of the apartment building is considerably warmer and significantly improves comfort of living.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 225-228

Composition of Refuse Derived Fuels in Latvia and Estonia in Comparision with Worldwide Average Values

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***Abstract*—Information about composition of RDF worldwide was collected using literature analysis. RDF samples produced in Latvia and Estonia were collected, those fractional and elemental composition analyzed using standard methods. Comparing obtained results with worldwide data we have found that the quality of local RDFs in general is higher than typical values, while elevated content of chlorine must be mentioned as a problem. Results also show that majority of chlorine in studied samples exists in organic form. Recommendations to overcome this problem have been developed.**

***Keywords*— RDF, SRF, quality, Latvia, Estonia.**

I. Introduction

Waste is a resource that still must be considered as strongly underused in Baltic states. Refuse derived fuels (RDF) is the light fraction of solid wastes enriched in organic content and calorific value using multiple technical approaches, such as manual sorting, screening, sorting by air stream etc. Use of RDF not only reduces amounts of waste that requires landfilling, but also might be a source of energy that is free of charge or even have a negative value. It is estimated, that in the case of Latvia, use of RDF could replace imported fossil resources and cover up to 3.5 % of states total energy needs [1]. The main consumers of RDF today are cement plants, sometimes this fuel might be used in traditional energetics as well, while cement plants have strict quality requirements, that are not always easy executable for waste management companies, while simple incineration with lower quality requirements is undesirable, not only from the point of view of environmental pollution, but also considering the need to bring our economies closer to the concept of circular material flows. Development of novel waste management approaches, based on pyro-gasification technologies is needed to implement mentioned concepts. Deep understanding of the composition of feedstock in the case of pyro-gasification is much more important than in the case of simple incineration [2].

In our study we have defined typical composition of RDF, by using data from worldwide scientific literature. RDF produced by different waste management companies in Latvia and Estonia have been analysed, using standardised physically-chemical methods, composition of these fuels established. Valuable information about strengths and deficiencies of analysed fuels as well as about reasons of these qualities have been got by comparison of obtained values with typical composition.

II. Materials and Methods

Samples of RDF were collected in 4 RDF processing facilities in Latvia (the names of facilities are not disclosed; results are presented only after statistical treatment). Collection of samples performed after the shredder (or after biotreatment in cases of Estonian samples). In every factory, 20 samples (around 1 kg each) taken and then mixed together. Moisture of samples detected using drying at 105^0C (Standard method CEN/TS 15414-2:2006). Fractional composition characterized using manual sorting: 1 kg of sample in 5 replicates have been sorted, results averaged. Elemental composition analyzed using standard methods: calorific value EN ISO 18125, sulphur and chlorine content LVS EN ISO 16994, nitrogen, carbon and hydrogen content LVS EN ISO 16948, oxygen content calculated. Proximate analysis made using thermogravimetric method described in [3].

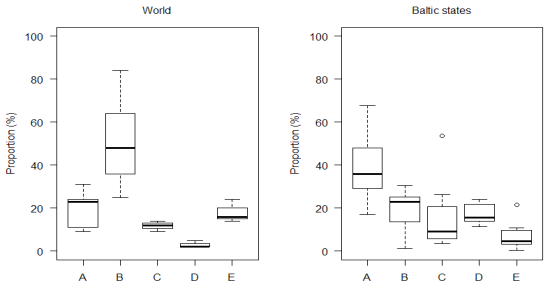
Composition data of RDF outside Baltic states was collected using literature review method. Typical fractional composition estimated using the data provided in [4]-[10]. Typical elemental composition, proximate composition and calorific values were estimated based on data provided in [9]-[29] geographically covering industrial countries of Europe, North America and Asia.

III. Results and discussion

As we see on the Figure 1., fractional composition of RDF in Baltics differs strongly from typical worldwide values. The most important differences are related with the content of plastic and lignocellulose (paper cardboard and wood) fractions. Content of lignocellulosic wastes in RDFs collected in Baltics is approximately two times

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4128

lower than typical values found in literature, while content of plastics is about 2 times higher. Content of food fraction in Baltic RDFs is significantly lower, than average. The main qualitative characteristic of RDF: its heating values (HV) in Latvia



Legend:
A: Plastics
B: Paper, cardboard and wood
C: Textiles
D: Other coarse compounds
E: Food wastes and fine fraction

Figure 1. Fractional composition of RDF in studied samples compared with the typical values.

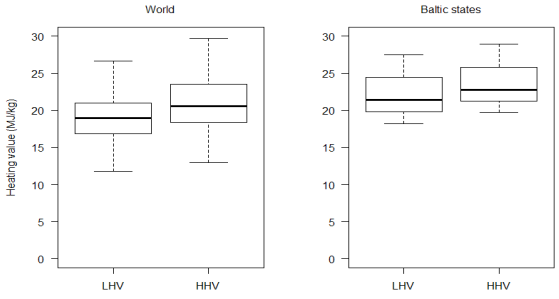


Figure 2. Comparision of calorific values of studied samples with the typical values.

and Estonia are significantly (≈3 MJ/kg) higher (Figure 2.) than it is typical worldwide. Taking into account, that plastic fraction is the one with the highest HV, while lignocellulosic fraction shows lower HV [9], this fact may be explained with the first finding of this study.

Analysis of the content of main organic elements (Figure 3.) show that the content of carbon in studied fuels must be considered very high: this element constitutes up to 65% of studied fuels: much more than average typical value (≈50%). Content of oxygen show opposite tendencies: its value is under 20%, while typical values are around 30%. Hydrogen content in studied samples is slightly higher than typical values. Also these differences arise from dissimilarities in fractional composition. Fossil based materials, such as plastics are the main sources of carbon and hydrogen, while oxygen dominantly is supplied by cellulose based materials such as paper and cardboard [29]. Analysis of the content of undesirable non-metallic elements (Figure 4) shows that values of nitrogen and sulphur content are absolutely typical, while content of chlorine is 3 times higher than typical values. Chlorine, is a key element causing high temperature corrosion in Waste to Energy plants based on incineration [30], as well as on gasification [31]. Chlorine also must be considered as the most serious issue regarding the use of RDF in

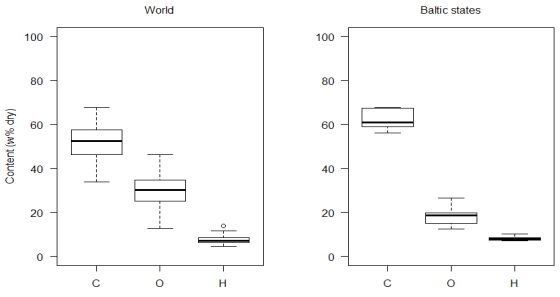


Figure 3 Comparison of the content of main elements in studied samples with the worlwide literature data.

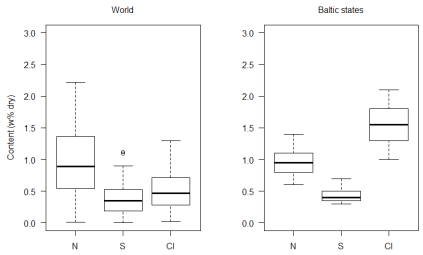


Figure 4. Comparison of the content of undesirable non-metalic elements in studied samples with typical values.

cement kilns, since it weakens the cement and causes the corrosion of steel bars in reinforced concrete [32]. The main source of organic chlorine in RDF is the non-packaging plastics fraction, while the dominating sources of the inorganic chlorine are fractions of food and garden wastes [30]. Typically, around one half of the chlorine content comes from poly(vinyl chloride) (PVC), while the second half are chlorides of alkali metals coming from organic waste [33]. Taking into account that ratio of food waste and plastic fractions in studied materials are not typical, it may be concluded, that absolute majority of chlorine in RDFs produced in Latvia and Estonia is organic and is arising

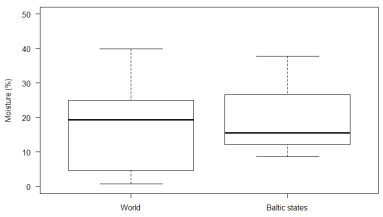


Figure 5. Comparison of moisture content (as received) of studied RDFs with typical values worldwide.

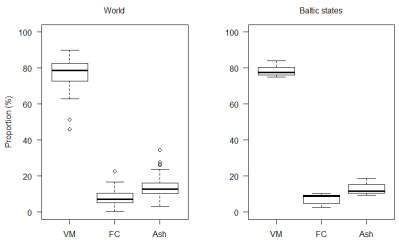


Figure 6. Comparison of proximate composition (dry) of studied samples with typical values.

from high PVC content in plastic fraction. They are multiple ways to dissolve this problem. As it was pointed by [34], one way is to supplement the pre-treatment system with sorting by means of near-infrared spectroscopy (NIR) to reduce the share of PVC directly. The second way is indirect reduction of PVC content by increasing recovery of fractions low in chlorine (such as paper and cardboard), or by addition of biomass with low chlorine content. Decrease of calorific value and increase of moisture must be mentioned as the main disadvantages of this way. The third possible approach is a low temperature thermal treatment of RDFs known as torrefaction, mild pyrolysis or destructive drying. Torrefaction as an approach useful for upgrading low quality waste derived fuels received a wide attention from the scientific community in last years [35]-[37], and was showed to be highly effective for increasing attractiveness of RDF as energy source. The effects of torrefaction include increase of grindability due to disappearance of fibrous structures, [36], increase of heating value and improvement of combustion characteristics [35]-[37], significant decrease in chlorine content [35]-[36], reduction in the oxygen content, increase in the carbon content [35], as well as significant decrease of heterogeneity [36]. Fuel obtained as a result of RDF torrefaction shows better fuel characteristics than coal. Dechlorination in the process of torrefaction is explained with conversion of organic chlorine to HCl and evaporation of acid [38], thence it may be direct solution for the observed problem. Torrefaction may be used as separate pre-treatment stage, bus as well may be incorporated into two staged pyrolysis-gasification process.

As it is shown on Figures 5-6, contrary to elemental composition, proximate composition of studied RDFs may be considered as absolutely typical.

IV. Conclusions

Fractional composition of RDFs produced in Latvia and Estonia differ from typical values. It is characterised by significantly higher content of plastics as well as lower content of cellulose. This fact results not only in high-quality features of studied fuels, such as high calorific value, hydrogen and carbon content, but also in significant problem: high chlorine, that make this fuel/feedstock almost unusable. Differences in ratios of plastic fraction and food waste fraction in comparison with typical RDF composition, clearly show that absolute majority of the chlorine in studied materials is organic.

V. Acknowledgements

This work has been supported by the European Regional Development Fund within the project No. 1.1.1.1/16/A/050 “Variable fuel gasification for municipal solid waste recovery”.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 229-235

Composition and Quality of Freshwater Lake Sediments (Balvu and Pērkonu Lakes)

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***Abstract*—Water quality, watershed basin and urbanization are key factors from the perspective of freshwater management; however, actual depth of waterbodies is often an overlooked element. Actual depth represents the overall depth of lake bed and depth of sediments. Some cases have been reported, where with increase of average depth of lake, it is possible to expect improvements of water quality when sediments are removed. If lakes are eutrophic, shallow, overgrown with macrophytes and contain high concentrations of biogenic elements water and lake ecosystem quality can be endangered. Removal of sediments can be an expensive procedure and also depends on the composition, structure, local conditions and total amount of sediments, also the disposal or possible use of sediments must be considered. Therefore, it is crucial to understand not only the genesis of sediments, but also possible pollutants, especially in urban territories. Two lakes in Latvia, where the coastal areas of lakes are urbanized at different levels, were studied. Lake Pērkonu was less affected from urbanization than Lake Balvu, cumulative effects of sedimentation and eutrophication were shown as these two lakes are interconnected. Characterization of lake sediments was done, including measurements of pH, ash content, analysis of C/N ratio, biological composition, metals, polyaromatic hydrocarbons (PAH), content of organic matter and concentration of humic acids. Results show that structure and composition of sediments in studied lakes differ with increasing depth, giving opportunity to track environmental changes in the past and differentiate possible applications of sediments. In deeper layers sediments were mostly formed from algae, but in more recent stages of lake development macrophytes were more dominant. Sediments formed after Ice-Age and located close to the bottom of the lake differ from conditions on paste (relief of lake bed, streams etc.), because areas with accumulated clay material and areas with sandy material were present.**

***Keywords*—eutrophication, dredging, lake sediments, pollution.**

I. Introduction

Lake ecosystems provide valuable economic and recreational resources for humans and play important role in regional, environmental and ecological issues, such as hydrological cycles, element biogeochemical cycles and growth of wetland vegetation [1]. In addition, water level and its fluctuations could influence the biodiversity patterns and functions in lake ecosystems [1] - [3]. In shallow lakes, where overgrowing with macrophytes are pronounced, and can affect the lake ecosystem, these factors have to be controlled. Increase of macrophyte biomass, particularly reed biomass, can be correlated with eutrophication [4].

Although, macrophytes influence the functioning of water ecosystems, they also play a crucial role in the mobilization, transportation and accumulation of nutrients, limiting the resuspension of sediments [5]. They are responsible for reduction of penetrating pollutants from the catchment area to the pelagial zone, as they absorb and inactivate a variety of compounds (nutrients, metals), removing them from the water column [6]. Thus, pollutants and nutrients are accumulated in sediments, the photosynthetically active radiation is limited to the littoral sediments, and the resulting effects can lead to increased eutrophication and degradation of shallow lakes [7]. These findings have significant importance for freshwater management of urban lakes, where, under intense human activity, water quality can decrease. It can happen due to the appearance of cyanobacterial blooms, pathogenic bacteria, pollutants and nutrients that may result from an influx of sewage, surface runoff and storm waters [8].

Without the described factors, important element cycles being discussed as part of water chemistry are nitrogen (N) and phosphorus (P) cycles. Even after decreasing external loads of nutrients, especially P can affect shallow lake ecosystems for decades with their cycling between sediments and the overlying water column [9]. Several methods for reducing the amount of P exist, but most of them are solid phase P-sorption products including industrial by-products and naturally occurring or modified mineral complexes designed to remove soluble phosphorus through sorption into solid state material [9] - [11]. Rapid regeneration of lakes has been reported in cases where, both, catchment derived and internal P loading have been controlled simultaneously or sediment removal was applied [12].

Sediments are accumulating in the lakes during long periods of time, they are formed from remains of organisms living in the lake and its surroundings, and mineral material supplied to the lake from catchment area and atmosphere [1], [3]. In the freshwater bodies,

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4129

sediments (sapropel, gyttja) are formed from aquatic plants, plankton and benthic organisms which are transformed by bacteria, and mixed with mineral components from atmosphere deposition [3]. Sediment types are often classified by their physical features or chemical composition, however, anthropogenic events can have considerable impact on these factors [1]. Excavated sediments have potential for different applications giving opportunity to restore lake environment by applying sediment removal methods [13].

Although accelerated eutrophication and requirements of the Water Framework Directive impose searching for effective restoration methods [11], sediment removal is not used frequently [14], [15] due to the different quality of sediments [16] and environmental risks which include influencing and destroying water ecosystem in the particular area [5]. Nevertheless, the applied recultivation actions have been studied and show different success rates and activity costs, most of the studies show necessity to continue activities for several years [11]. Excavation of sediments is believed to change or significantly affects the ecosystem, however, it is believed, that in the studied lakes it can lead to rapid regeneration of natural ecosystem with increased water quality, without the use of chemicals or solid phase sorption products [9] - [10].

Before removal of sediments, it is crucial to understand not only the genesis of sediments, but also contamination with possible pollutants, especially in urban territories. The aim of the following work is to characterize lake sediments of two lakes in Latvia with accumulated sediments, which are affected by anthropogenic influence.

II. Materials and methods

Balvu Lake "Fig. 1" is located in NE Latvia with area – 1.68 km^2 and average depth – 2.2m (max - 3.9 m) and catchment area – 248 km^2. Pērkonu Lake is located in NE Latvia with area – 2.28 km^2 and average depth – 1.3m (max - 3.0 m) and water from Pērkonu is flowing to Lake Balvu. They have Pleistocene glacial origin, they are connected and outflowing, indicating strong sedimentation rates in the particular watershed basin. This phenomenon is pronounced in Pērkonu Lake, which is the first waterbody with decreased water flow, and therefore with accelerated sedimentation. The lowest water depth was detected in Pērkonu Lake close to Lake Balvu due to human actions (dredging) in river (Bolupe River) hydrological cycle in the 60-ies of last century, water level of studied exoreic lakes was decreased by 1.5 m, accelerating growth of macrophytes and decreasing overall water quality. Visual characterization and analysis shows that in central part – small extension of Lake Pērkonu is the main area, where sediment removal can be applied with expected sapropel amount - 0.88 million m^3. This area is approximately - 0.32 km^2 with average water depth below 1 m and max depth 1.4 m.

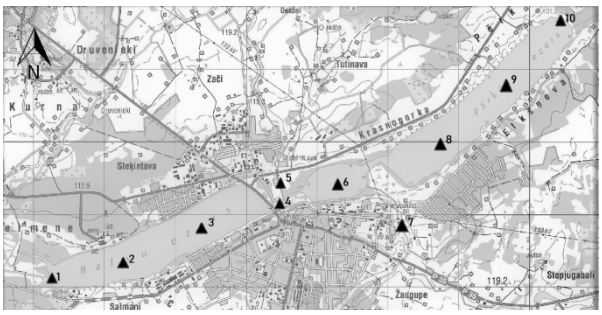

Fig. 1. Location of sediment sampling sites (1-5) in Balvu and Pērkonu Lakes.

Sampling of sediment cores was performed in the central part of the lakes and in coastal area. Full characterisation of samples from the central part of the lake was done, sample cores from the coastal area were used to obtain overall depth of lake sediment as well as and their genesis. Analysis of texture, elemental (C, N, P) and moisture content, presence of pollutants (metals, polyaromatic hydrocarbons, polychlorinated biphenyls), loss of ignition (LOI) and pH were determined. Sediments also called sapropel, gyttja was covering mineral soil layer which was mostly sand, gravel and rarely glacial till. Coring of sediments was done using a sediment sampler equipped with a 1.0 m long (d=5 cm) tube. Every sample was put into a non-transparent airtight plastic bucket with a lid and stored at constant temperature (+4 C°) to achieve *in situ* conditions during the storage.

Loss of ignition (LOI) method was applied for sediment analysis in order to estimate the moisture level and content of organic matter, carbonates and mineral matter in the sediments [17]. Moisture of sediments was determined after drying samples at 105°C in drying oven (Gallenkamp "Plus 2"). Content of organic and carbonate matter was analysed by incinerating the samples sequentially at 550°C for 4 h and at 900°C for 2 h.

Total carbon and nitrogen concentration was determined using a CN elemental analyzer Eurovector EA3000 Series. Sediment pH was determined in 1 M KCl solution with HANNA Instruments HI2210 pH Meter.

Phosphorus determination in lake sediments. Sediments were dried at 105℃ before digestion. Approximately 500 mg of sample was weighed in a Teflon capsule and 9 mL of concentrated HNO_3 and 1 mL of 30% H_2O_2 was added to the sample. The capsule was sealed and placed in a microwave oven (Milestone Ethos Easy) and was digested at 200℃ and 49 bar pressure for 15 minutes. After digestion the sample was filtered through a filter paper, diluted up to 50 mL with distilled water and phosphorus concentration was determined with ICP-OES (Thermo Scientific iCAP 7000 series).

Analysis of metal content in sediments. Approximately 1.0 g of dried sediment sample was weighed in a pressure durable teflon capsule and 25 mL of concentrated HNO_3 (Enola) and 5 mL of 30% H_2O_2 (Sigma-Aldrich)

was added to the capsule. Samples were digested in a microwave extraction unit (Milestone ETHOS EASY) at 200°C, 49 bar pressure for 20 minutes. A blank was made in each series of digestion. After digestion samples were cooled, filtered through a filter paper and diluted to 50 mL with distilled H_2O. Samples were then analysed with inductively coupled plasma spectrometer (ICP-OES) with optical detection (Thermo Scientific iCAP 7000 series).

Analysis of organic pollutants (PAH, PCB, hydrocarbons). For the measurement of total hydrocarbons, fractions of hydrocarbons as well as PAH, samples were extracted in double distilled hexane and analysed using gas-chromatography/mass spectrometry (Shimadzu GC-2010 Plus). The method used for extracting the PCBs from sediments was modified from the US EPA Method [18]. Sediment (30 g) (analysis done in triplicate) was extracted for 8 h using the Soxhlet extraction unit with 200 ml (1:1) of *n*-hexane-CH_2Cl_2. Prepared extracts were analysed with gas-chromatograph (Shimadzu GC-2010 Plus). The sediment extracts were evaporated under a flow of nitrogen so that the dry residue corresponds to 20 mg. The dry residue of extract was dissolved in in pyridine (1500 µL, Sigma-Aldrich). GC-MS analysis was performed using GC-2010 plus (Shimadzu, Japan). The column used was Restek Rxi®-5MS (30 m × 0.25 mm × 0.25 µm; Crossbond ® 5% diphenyl + 95% dimethyl polysiloxane, Restek USA) with working temperature range 40 to 350 °C. He (Helium) was used as carrier gas with a total flow rate of 10.8 mL min^{-1} and column flow rate of 0.71 mL min-1flow rate. The split ratio was 1:10 and injection temperature 290° C. The temperature programme used was: oven temperature 200 °C (2 min) increased to 250 °C at the rate of 30 °C min^{-1} and held for 7 min then increased to 310 °C at the rate of 10 °C min^{-1} and kept for 14 min. Injection of 1.0 µL sample was performed using an autosampler. Identification and quantification of the compounds was done using the retention time (RT) of authentic standards, data acquisition and processing was done using Shimadzu LabSolutions 4.30 software.

Analysis of content of humic substances. The humic substances were extracted from lake sediments (10g) with 50 ml 2% NaOH solution and shaking for 24h. Then samples were purified using the procedures recommended by the International Humic Substances Society (IHSS) [19].

III. Results and discussion

Studied lakes are connected and they are part of Bolupe River watershed basin (total area - 936 km^2). Water, nutrients, organic matter and suspended material are carried from eastern part of Latvia and lakes can be as archives for sediments and their fluxes. In this area ~ 40 % of land is used in agriculture and ~ 10 % are occupied by bogs and wetlands [20]. In Balvi municipality 65.6 % of agricultural lands are with installed drainage system. Land use and changes with drainage system due dredging of Bolupe River lead to decrease of water level in lakes by 1.5 m, thus eutrophication increased [20]. One eutrophication parameters is macrophytes [4] and they cover only 15% of Lake Balvu, while Lake Pērkonu coverage reaches 50 %. In coastal area of Lake Pērkonu are indications of formation of wetlands (bogs and marshes). These changes are more visible in the central part of lakes, especially in small extension of Lake Pērkonu, where coverage of macrophytes exceeds 50% and average lake depth was less than 1 m, which depends on season. In this particular area in Lake Pērkonu depth of lake sediments ranges from 0.5 m to 8 m, therefore after removal of sediments the average depth could be significantly increased in this part of the lake and the occupation with macrophytes decreased. In result, water flowing into the Lake Balvu probably would have lower temperature and would be carrying less suspended material.

Dredging is one of methods that has been used for lake restoration, and removing the contaminated sediment from the lake bed. Dredging reduces the internal loading of nutrients by removing the upper sediment layer. This process has been successfully applied on peat lake sediments in the Netherlands [14]. It has also been successfully used in Sweden, with lakes showing reduced cyanobacteria biomass in the years following sediment removal [15]. There can be side effects for sediment removal such as: changes in sediment stability and impacting neighbour sediment structures, significant impacts on water quality (by releasing organic matter and nutrients), disturbed ecosystems by removing and killing organisms which can play an important role at the base of aquatic food chains [21]. If the sediments are polluted, toxic chemicals such as heavy metals and other pollutants can release back into the water. In addition to changes of water flow, also impact to the fish fauna can be observed, in deeper lakes the area is more accessible to larger predators, not only small fish [22].

In Lake Balvu high biomass of cyanobacteria (algae blooms) can be observed, while Lake Pērkonu suffers from stress caused by decreased oxygen concentrations in winter period. The extension of Lake Pērkonu has no significant role in fishery, because of lack of healthy benthic fauna. On one hand, excavation could change the ecosystem of these lakes (or part where applied), but on the other hand, as open lakes they can be more resilient to changes of ecosystem after sediment removal [23]. Moreover the actual excavation and changes of ecosystem can reach only 14 % from total area of Lake Pērkonu if applied only on particular extension of lake.

TABLE I. Elemental composition and their relations of sediment cover in Balvu and Perkonu Lakes

Sam-pl-ing point No.	N, %	C, %	P, g/ kg	C/N	C:N:P
1	1.08	18.54	0.99	17.17	187:11:1
2	1.20	18.70	1.21	15.58	155:10:1
3	1.43	23.74	0.96	16.60	247:15:1
4	0.59	8.45	0.90	14.32	94:7:1
5	0.91	12.40	1.29	13.63	96:7:1

Described benefits of sediment removal on Lake Pērkonu and possible improvements of lake ecosystem shows importance of sediment characterization before activities connected with accumulated sediments. Texture of sediment profiles was homogenous and similar with relatively minor differences compared to the max depth of sample cores. With increasing depth the content of organic matter in sediments increased from 19.09 % to 73.60 %. These changes indicate presence of humification processes in sediments [24], water flow through lakes, and anthropogenic impact which affected sedimentation rates. Deepest parts of the lake bed in past were with more stagnant water regime, therefore with higher sedimentation rates (especially small, suspended particles) could be observed. Upper layers indicate impact of human actions in watershed basin and in coastal area with significantly increased ash content and proportion of allochthonous material (Table 2). For example, if C/N ratio (Table 1) 6 - 9 corresponds to plankton, then C/N ratios 15 – 20 corresponds to terrestrial vascular plants and their derivates in sediments and about 39.4 for macrophyte materials [25]. In surface waters N:P ratio is well characterized [26], [27] and indicating increased loads of phosphorus in studied lakes and their sediments, therefore accelerating eutrophication of lakes and P ability to resolve from sediments in anoxic conditions [26].

TABLE II. CONTENT OF ORGANIC MATTER, ASH AND MOISTURE IN SEDIMENTS OF BALVU AND PĒRKONU LAKES

Sampling point No.	Depth, cm	Moisture, %	Ash, %	Organic matter, %
1	0-10	84.37	70.66	29.33
	90-100	89.64	53.16	46.84
	190-200	90.32	44.01	55.99
2	10-20	86.95	66.41	33.59
	110-130	89.86	48.19	51.80
	280-290	91.43	48.57	51.43
	350-360	90.46	34.16	65.84
3	10-30	84.32	57.49	42.51
	220-230	91.03	41.64	58.36
	360-360	91.65	39.07	60.93
	440-450	91.68	41.07	58.93
	590-600	91.15	39.15	60.85
	700-710	91.90	26.40	73.60
4	10-20	75.68	80.91	19.09
	120-130	86.35	60.64	39.36
	250-260	81.05	68.73	31.27
	400-410	72.46	83.39	16.61
	420-430	28.44	91.22	0.78
5	10-30	85.50	73.93	26.07
	140-150	89.22	57.00	43.00
	270-280	88.42	55.50	44.50
	350-360	88.33	49.15	50.85

High C:N:P ratio (102-202:6-16:1) is typically associated with agricultural runoff [28], [29], which also can be observed in studied lakes, which can be affected by their location in hydrological cycle and catchment area (Table 1). The upper part of sediments from Lake Balvu significantly differs from Lake Pērkonu based on their C:N:P ratios demonstrating influence of allochthonous material sources in last decades in Lake Pērkonu. These differences support described hypothesis of sediment removal in the extension of Lake Pērkonu, because increased eutrophication can lead to changes of Lake Balvu.

TABLE III. CONTENT OF HUMIC ACIDS, CARBONATES AND PH IN SEDIMENTS OF BALVU AND PERKONU LAKES

Sampling point No.	Depth, cm	pH	Carbonates, %	Content of humic acids, mg/g
1	0-10	6.72	2.55	256.64
	90-100	7.07	2.34	427.02
	190-200	6.97	3.12	358.15
2	10-20	6.89	2.60	n.a.
	110-130	7.25	3.09	n.a.
	280-290	6.82	3.12	n.a.
	350-360	6.88	4.34	n.a.
3	10-30	6.30	2.96	278.35
	220-230	7.0	2.78	451.97
	360-360	6.59	2.45	385.43
	440-450	6.80	2.85	413.90
	590-600	6.81	3.84	425.78
	700-710	6.71	4.40	495.87
4	10-20	6.58	2.04	n.a.
	120-130	6.82	2.05	n.a.
	250-260	6.98	2.50	n.a.
	400-410	7.96	3.71	n.a.
	420-430	7.07	0.33	n.a.
5	10-30	6.7	3.14	291.11
	140-150	6.89	3.28	673.02
	270-280	7.09	3.90	347.72
	350-360	6.98	3.86	254.90

n.a. – concentration not analysed.

Analysis of biological composition of sediments demonstrate, previously described factors about sedimentation, eutrophication, overgrowing with

macrophytes and formation of wetlands in coastal area. Early lake ecosystem can be described by the presence of organic matter in the bottom layers which is mainly formed from blue-green algae, green algae, plants and water animals. Upper part of sediments shows large proportion of vascular plants and macrophytes (63-78%), diatoms (11-23%) and up to 21 % green algae. Small proportion of macrophytes by biological composition and C/N ratio are due to relatively high average depth (>2 m) in studied lakes, especially before decreasing of water level in lakes by 1.5 m. In the middle part of sediment profiles in all studied lakes were found biological composition that corresponds to fen peat. There are several factors influencing this pattern, and one of them could be presence of organic material form coastal area and catchment area. Other aspect could the climatic events 4000 years BP, when the water level was extremely decreased, because of the cold and dry climate [30]. Content of humic substances (Table 3) did not show clear pattern in sediments of studied lakes due to different climatic conditions and biological composition of sediments as well as their different accumulation rates and humification. It can be influenced by different rates of humification [31], [32], available material amount, sources included in those reactions and possible washing out of humic substances due to run-off hydrological regime [30]. Presence of water flow and streams in lakes in past can be determined in bottom part of sediments schistous texture of sediments is present (sand, gravel, clay), which is not detected in all sampling, indicating areas with more intense water flowrates in the past.

TABLE IV. TOTAL HYDROCARBONS, POLYCYCLIC AROMATIC HYDROCARBON (PAH) AND POLYCHLORINATED BIPHENYLS (PCB) IN SEDIMENTS OF BALVU AND PERKONU LAKES. UNITS REPRESENT MG OR MG OF SUBSTANCES FOUND IN KG OF SEDIMENT

Sampling No.	Depth, cm	Total hydrocarbons, mg/kg	Polycyclic aromatic hydrocarbons, µg/kg	Polychlorinated biphenyls, µg/kg
1	0-10	63	136	3.2
	100-110	123	41.5	n.a.
2	10-20	94	226	10.3
	110-130	97	100	n.a.
3	10-30	65	631	15.1
	200-220	43	112	n.a.
4	10-30	14	1278	1.6
	120-140	28	131	n.a.
5	10-30	56	633	<0.5
	130-150	31	65	n.a.

n.a. – concentration not analysed.

The studied lakes are surrounded by urban territories and with surface runoff typical pollutants from there can be detected. Therefore presence of heavy metals, total amount of oil including polycyclic aromatic hydrocarbons (PAHs) and polychlorinated biphenyls (PCBs) were analyzed. Analysis of sediments show that total amount of oil products does not exceed concentrations found in natural conditions [33]. PCB's are directly correlated to human activities, the main sources of PCBs emissions into the environment can be divided into 5 groups: 1) production of PCBs and products (equipment) containing PCBs; 2) use of products containing PCBs; 3) utilization of PCBs and materials containing PCBs; 4) emission from reservoirs polluted by PCBs; 5) thermal processes [34]. PCBs were analysed in 5 samples of the upper sediment (Table 4). Although individual compounds of PCB's such as PCB-52 (points 1-3) and PCB-28 (points 2-3) have exceed minimal reqs (1 µg/kg), these sediments could not be classified as polluted. As described above, possible sources of PCBs in lakes can be emissions from fuels combustion, transportation and urban runoff, in this case especially from road and streets pavement [35] – [37] and landfills [38] in the catchment area of studied lakes. PAH's in studied sites show different pattern than PCBs. Elevated concentrations of PAHs were found in Lake Balvi in comparison to Lake Pēkonu, where the coastal area is less urbanized. Concentration of PAH's are elevated only in upper sediment layer due to their nature [39] and low solubility in water [33]. Increased PAH concentrations in Lake Balvi were not reaching hazardous levels, also the government set maximum concentrations were not exceeded (Table 4).

TABLE V. CONTENT OF HEAVY METALS (MG/KG) IN SEDIMENTS OF BALVU AND PĒRKONU LAKES

Sampling No.	Depth, cm	Zn	Cu	Cr	Ni
1	0-10	165	18.1	18.0	19.5
	100-110	263	27.9	19.4	22.7
2	10-20	221	17.4	18.9	26.0
	110-130	335	41.7	17.8	40.4
3	10-30	166	17.8	17.3	17.4
	200-220	271	36.5	18.6	25.3
	700-710	123	20.3	9.7	23.8
4	10-30	130	15.9	15.9	14.4
	120-140	201	19.4	17.0	17.6
5	10-30	202	25.6	23.1	22.3
	130-150	238	24.3	17.4	23.6
	350-360	169	41.8	30.3	34.6

TABLE VI. CONTENT OF HEAVY METALS (MG/KG) IN SEDIMENTS OF BALVU AND PĒRKONU LAKES

Sampling No.	Depth, cm	Pb	As	Cd
1	0-10	9.8	10.60	1.44
	100-110	2.7	9.67	1.80
2	10-20	8.0	14.50	2.27
	110-130	6.3	6.04	1.52
3	10-30	13.1	11.50	1.40
	200-220	6.7	9.60	1.92
	700-710	2.2	8.00	0.25
4	10-30	23.6	5.37	0.89
	120-140	2.4	8.73	0.97
5	10-30	35.4	14.90	1.46
	130-150	4.6	10.50	1.60
	350-360	4.1	8.60	0.21

Higher concentrations of heavy elements in sediments were detected in upper layer corresponding to possible anthropogenic impact and in deeper located sediments corresponding to metals carried with groundwater (Tables 5, 6). Sources of metals in sediments can include airborne sources, solid waste, sludges, soils and direct groundwater contamination [40]. Concentrations of metals in the studied lakes were comparable with other studies done in Latvia [41] – [43]. In comparison to other lakes with no or insignificant human impact, there are slightly elevated concentrations of Zn, Cd, and some cases – Ni. Zinc is one of the most mobile heavy metals in surface waters and groundwater and can be absorbed by sediments or suspended solids, including hydrous iron and manganese oxides, clay minerals, and organic matter. Most common cadmium sources can be the mining of sulphide ores of lead, zinc and copper and the disposal of cadmium-containing wastes. Sorption of Cd is influenced by the cation exchange capacity of clays, carbonate minerals, and organic matter present in sediments [40]. Concentrations of studied metals (Zn, Cu, Pb, Cr, Ni) in lake sediments are attributed to natural factors such as geochemical properties of bedrock and soil [26], but such metals as Pb, As, Cd shows presence of industrial activities (Table 6). As, Cd have no similar patterns or correlation with ash and organic matter content of sediments as other metals. For these metals sources are connected with anthropogenic impact, but for Pb sources can be mixed. Possible sources of these metals also can be atmospheric deposition [44], surface runoff from urban territories and landfills. The bottom layers showed lower ash content, which can be attributed to lack of anthropogenic influence (Table 2).

IV. CONCLUSIONS

Water quality, watershed basin and urbanization of coastal area are key factors from the perspective of freshwater management; however, studied lakes show presence of human impact. Studied lakes show indications of eutrophication which is an ongoing process. Therefore, without using the offered ecosystem services it is also important to apply available knowledge and technologies to reduce human impact on lakes and catchment area, or even reconstruct the environment. Reducing the loads of nutrients in lakes is important, another aspect, due to possible climate changes and influenced hydrological regime, is keeping stable water level in the studied lakes. There are no options to raise water levels to the levels seen before dredging of River Bolupe, in addition the biomass production in these eutrophic lakes lead to decrease of water depth due to sedimentation. As most effective solution for the studied lakes, the sediment excavation can be considered. By performing excavation, the average and maximum depth of water in Lake Pērkonu will increase, meanwhile reducing the available amount of phosphorus. Sediment removal in the extension of Lake Pērkonu will reduce coverage of macrophytes, and possibly improve the water quality of Lake Balvu. Despite the discovered human impact on quality of sediment, excavated sediment can be successfully used for different purposes, for example, as fertilizer. Sediment analysis show possible pollution sources which can be managed by the municipality.

V. ACKNOWLEDGEMENTS

This work was supported by University of Latvia grant "Sustainable use of nature resources in the context of climate changes. "No.AAP2016/B041".

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 236-240

Kuprava Clay Deposit Research Comparison

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***Abstract*—Clay minerals and their structures are extensively studied in the world, both from the point of view of geological research and material science. The aim of the research is to identify and summarize the resources of the Kuprava clay deposit, their placement in the field and selective extraction possibilities. Total clay resources in the Kuprava area are significantly more than 16 million m³. The clays are located in several uneven layers with relatively different characteristics. Until now, clay has been studied in separate layers for the production of bricks and high quality lightweight expanded clay aggregate (LECA).**

The work is based on using and comparing the geological survey data of 1951 to 1992, the latest laboratory test data, as well as the technical documentation of the former Kuprava factory. The study also includes a review of two recent studies of the composition of Kuprava Member clay. New eco-innovative composite materials require clay with a fully defined composition and properties. Clay extraction must be selective - on separate layers, so that the use can be accurately determined by the research. Cartographic material has also been added to accurately locate each of the four fields studied.

***Keywords*—adsorption, clay, clay deposits, Kuprava.**

I. Introduction

The aim of the study is to identify and compare the clay resources of the Upper Devonian Famennian stage Katlesi formation Kuprava member, their placement at the deposit and the possibilities of extraction.

Both clay and lime kilns have operated in the vicinity of Kuprava, but they are long closed.

Kuprava clay deposit is one of the most important clay deposits in Latvia (see Fig. 1). The stocks of clay studied at Kuprava deposit reach 16 million m³, yet together with resources forecasted around the deposit it amounts to several billions m³ [1].

Fig. 1. Location of Kuprava clay deposit.

First details on the production of clay bricks are related to the needs of Vilaka church. Vilaka church was built in Gothic style from red bricks made at the Bronti site [2].

According to data from Sorokin [3], Katlesi formation Kuprava member consists of brick-red, cherry-red or mottled clays with interlayers of siltstone and domerite. From the thick clay layer its upper and lower parts are formed by clay, but in the middle traceable layer of sand can be found, the thickness of which changes slightly due to sedimentogenic creep processes at the time of its formation [3]. During the period of 1951-1992, a detailed geological survey has been carried out in 4 clay sites (see Fig. 2).

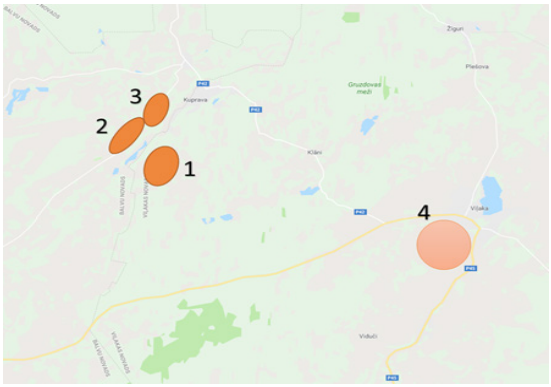

Fig. 2. Schematic map of geological exploration sites: 1 - Kuprava clay quarry and its adjacent area; 2 - Mednieki clay deposit; 3 - Veckuprava (Kuprava clay field); 4 – Vilaka deposit.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4164

Clay extraction at industrial scale took place only at the current Kuprava clay quarry (see Fig. 2, 1 site). No newer studies have been carried out and no information on them can be found in databases.

II. Materials and methods

The survey of geological studies and drilling sites took place after the conversion of survey specific coordinates to the current maps.

Rock samples were collected, and their composition analysis was carried out.

The rock samples were dried to an air-dry state, crushed in a mortar till powder consistency. Element analysis was performed by using XRF method with X-ray fluorescence spectrometer Bruker AXS S4 PIONEER. Phase detection was performed by using XRD method with X-ray diffractometer Bruker AXS D8 ADVANCE.

Samples of dolomite, white clay and red clay from various clay deposits in Kuprava member were analyzed separately.

To determine the adsorption capacity of clay Methylene Blue method was used [4], [5].

Relationship of the optical density in Methylene Blue solution depending on the concentration of Methylene Blue in the ranges of 20-100 mg/l and 100-700 mg/l was experimentally measured with spectrophotometer at wavelength of 400nm. For measurements of Clay adsorption capacity Methylene Blue standard solution with a concentration of 1 g/l was prepared. Clay samples were dried and crushed. For measurements 1g of corresponding Clay was poured into flask, 50 ml of Methylene Blue standard solution were filled in, and that was subject to mixing for 30 minutes. Afterwards suspension was centrifuged, and samples were taken to determine the optical density of suspension in cuvettes in 1 cm deep solution layer.

Methylene Blue concentration in those solutions that were exposed to adsorption was than determined using calibration curves for the corresponding ranges. Clay adsorption capacity – was than calculated using the following formula.

$$Ad = \frac{(C_0 - C_1)V}{m} \quad (1)$$

Results in (1) are in mg/g, where C_0 - initial MB concentration (1000 mg/l), C_1 - Methylene Blue concentration after adsorption in mg/l, V - volume of solution (50 ml), m - mass of Clay sample (1 g).Results and discussion

Kuprava member clay has similar rock stratification in all four areas studied by geologists.

The most thorough clay studies were at Kuprava clay quarry, where Katlesi formation clay part makes up almost all the cut with a thickness of 40-65 m. Studies were carried out at Gailava and Irikava villages [6], [7], [8], [9]. Here, several layers of clay are distinguished, which have been tested for use in the production building materials such as brick and expanded clay (LECA).

In the Mednieki clay deposit [10], studies were conducted on average to a depth of 6 m, and stocks were calculated according to them, but in the Zenchenko study [6], wells were made and clay layers found up to 20.70 m deep. In Veckuprava according to Zenchenko's studies, useful clay layers were found up to 12 m depth; During the search for white burning clay, Jurevics [11] drilled holes up to 20 m.

According to Zenchenko's research [6], there may be several small mining sites in the Vilaka deposit, but no large prospective areas have been identified. Soil layers, aleirolite or dolomite layers usually form so-called empty rocks at the sides of the deposit.

In the Kuprava clay deposit, the top layer of soil formed during the Quaternary period is relatively thin - an average of 30 cm. In some places a thicker layer of moraine, consisting of loam, has been preserved.

Clay mining is hampered by the hard rock layer beneath the Quaternary rocks. The Kuprava clay deposit is partly covered by 0.5 - 1.5 m thick dolomite, dolomite sandstone layers that impede access to quality clay. To remove this layer, blasting must be done [9].

So far, dolomite residues have collapsed in large pits at the edge of the quarry. During the slope processes, they slip into the clay quarry, mix with clay, creating a burden for clay mining. Dolomites that have not been removed or moved at a sufficient distance during quarrying make slippery slopes (see Fig. 3).

Fig. 3. Dolomite landslips in the Kuprava quarry wall.

The Dolomite layer in the Kuprava neighborhood below the Quaternary rocks is not evenly distributed. In places where agricultural land has been installed, the dolomite layer has been partially removed and used for production lime [12]. For example, dolomites in the neighborhood of Oknupe were taken to the Miezaji lime burner. However, in some places it is still exposed to the ground and is well visible after field cultivation (Veckuprava).

The Kuprava quarry in the western section according to Jonins research [9] consists of territories that are covered with dolomite and are therefore not recommended for clay quarrying.

The chemical composition of the dolomites was

determined in the southern part of the Kuprava quarry, compared to the dolomite of the Murava deposit used for lime burning [12]. The composition shows that there is more silicon and potassium in comparison to classic dolomite (see Fig. 4).

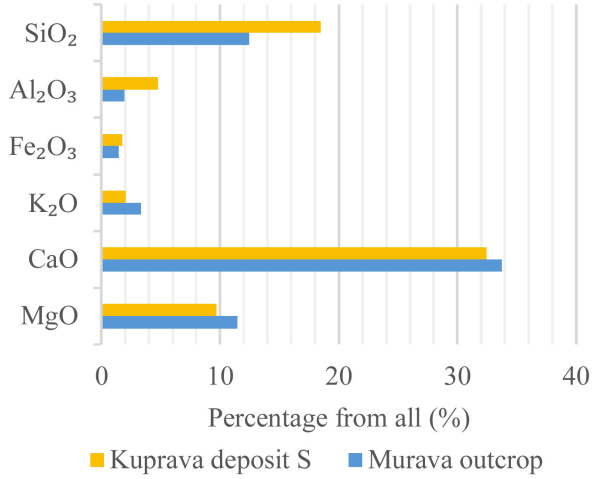

Fig. 4. Comparison of dolomite composition.

The X-ray diagram shows that dolomite, including calcite, quartz, muscovite and orthoclase, dominate in these rocks. By composition and structure, it can be called sandy dolomite, although geological wells are marked as fossilized sandstone (see Fig. 5)

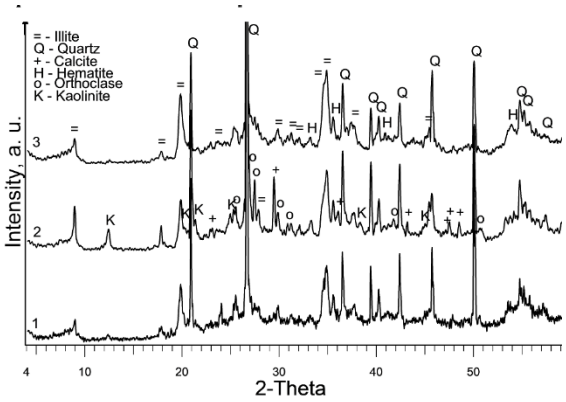

Fig. 5. X-ray diagram of clay composition Kuprava Clay Region: 1. Kupravas district. 2 Mednieki deposit, 3 – Quarry South section

Under the dolocrates, there is a layer of light aleirolite that is not usable for leaning the clay and gives a mottled color to the ceramic products.

The Kuprava clay deposit is laid in several uneven layers. The layers of the Katleši formation consist mainly of bluish, red, and colored clay.

The composition of the blue clay is compared to the two deposits on the left and right bank of Bolupe River. A comparison of the most common elements is given in the Fig. 6.

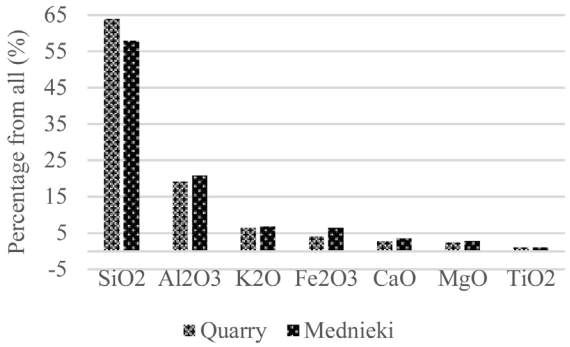

Fig. 6. Comparison of blue clay composition.

The composition of the phases also has similar results - the clay part is made up of illite, quartz, orthoclase, as well as kaolinite and calcium carbonate in the Kuprava district.

In turn, dolomite curves are more pronounced in the Mednieki deposit. The composition of the red clay is compared to all four fields, two sampling sites have been selected for the Kuprava quarry - in the south and west section (see Fig. 7).

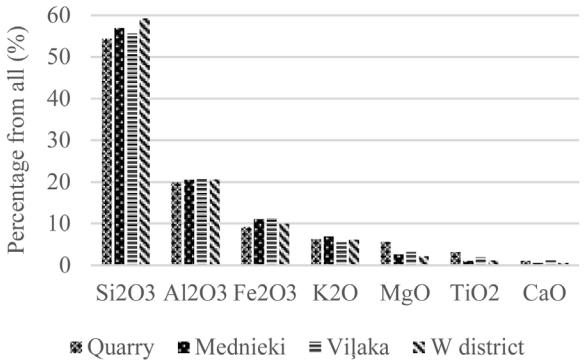

Fig. 7. Comparison of red clay composition.

The most distinctive is the composition of the Kuprava quarry, South part, where inclusions of small-grain (up to 0.3 mm) dolomite grains have been detected. Traditionally, not all rock layers are used in the clay extraction process. Suggestions for using individual layers are given.

There are relatively thick layers of sand between the useful layers of the clay, which, according to total calculations, account for up to 6% of the corresponding thickness of the clay layers. Devonian sand of the Kuprava clay deposit is a very fine, even size that determines that it is not necessary to sort or sift it before (see Fig. 8).

After the project, the Devonian sand was not intended to be used in the production of ceramic products, but was later used for the leaning of brick clay [13], [14], thus reducing the cost of sand from the project's quarries.

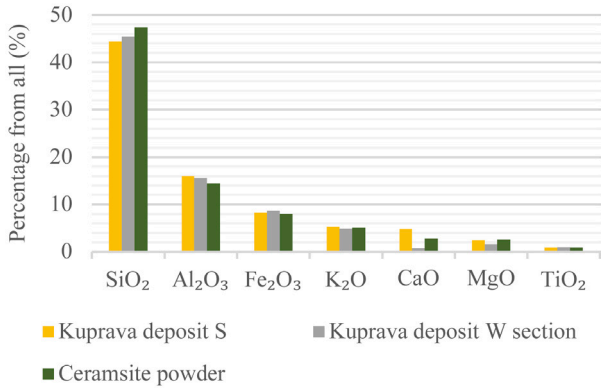

Fig. 8. Comparison of unfired clay and prepared ceramsite composition.

Comparing the composition unfired clays of the Kuprava quarry with composition of ceramsite produced at the Kuprava factory, it can be seen that the SiO is on average higher than in clay samples. Heavy metal clusters and associated radiation zones in Kuprava is unevenly distributed in the clay layers, in the form of individual islands, leaking inclusions. (Figure 9)

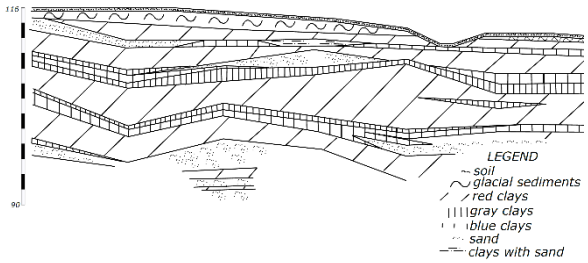

Fig. 9. Profile of Kuprava deposit (example).

The topsoil can be used to improve soils in agricultural lands, gliding after reclamation. Due to its high potassium content, illite clays can be used in agriculture for long-term enrichment with potassium, especially when root crops are grown.

Nowadays, the extraction of dolomite from a thin layer of lime is not economically beneficial due to the small market demand. The use of these dolomites could be the basis for the production of various composite materials, providing sufficient silicon and carbonate in their raw material.

Dolomites have varying degrees of hardness in different areas of the deposit, but most of their hardness and chemical properties correspond to the construction needs of the road base [9]. Because of the need to build driveways in the clay extraction process, the use of the material for these purposes will reduce the amount of unused rock and reduce the cost of constructing access roads to the quarry. This material can also be used to improve local ground roads.

Aleirolite, a bluish clay layer with high K and Mg content and coarse-grained calcite inclusions can be used to improve the surrounding sandy soil.

Another possibility of using aleirolite and loam is the production of pellets for road construction, as this process does not require such fatty clays as in Kuprava. As a leaning additive, sand may be used for very plastic clay (up to 0.3% in diameter if less than 0.3 mm in diameter) [15].

Practical studies of the extraction of such materials with the sandstone and aleirolites of the Kuprava deposit have not been carried out so far, which could be one of the directions of further research.

As for adsorption properties, each measurement was repeated three times - and in all cases the difference between measurements did not exceed 0,5-0,7 %. Given the heterogeneous nature of Clays, the accuracy of these data is fully satisfactory.

Average values of measurements were used for further calculations.

Parallel experiments with mixing time of 5 hours were carried out to determine the effect of the suspension mixing time on adsorption capacity, that showed, that adsorption capacity does increase yet very insignificantly - only by 5 % (for example, from 44,5 mg/g to 46,8 mg/g). That means that mixing time of 30 minutes per sample is sufficient to determine Clay adsorption capacity.

Adsorption isotherms (Fig. 10) were also determined using Methylene Blue. The following initial adsorbate - Methylene Blue concentrations were selected: 0,05, 0,1, 0,5, 0,7 g/l.

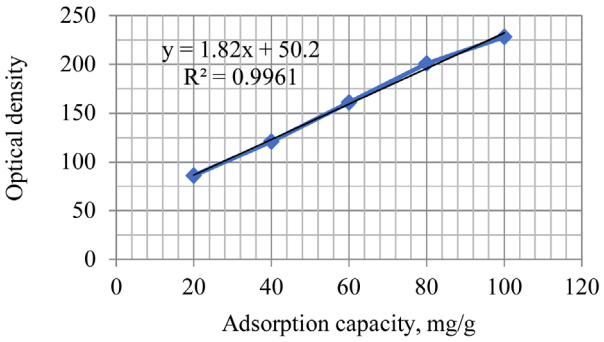

Fig. 10. Graduation curve.

For comparison, adsorption isotherms for two Clay samples from Kuprava clay deposit were determined by analogous methodology. As for Kuprava clay deposit than these were type II adsorption isotherms and they are characterized by high capacity of adsorption - given adsorption concentration 1 g/l it does exceed 48 mg/g. Adsorption capacity of Methylene Blue for Kuprava clay deposit sample K1 was 48,8 mg/g and for sample K2 it was 48,4 mg/g (see Fig. 11). Both samples contained I-Illite, Q-Quartz, O-Orthoclase, C-Calcite and K-Kaolinite.

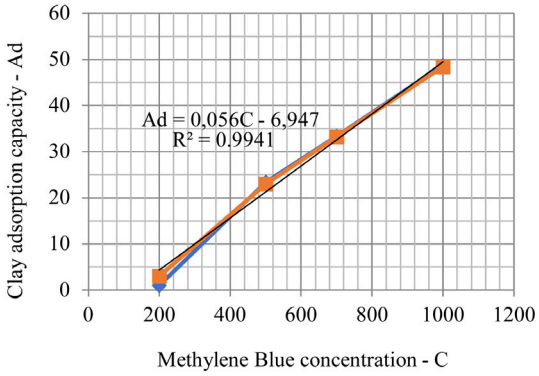

Fig. 11. Kuprava clay sample adsorption capacity base on Methylene Blue concentration.

Further studies on use of Kuprava clay material adsorption properties should be carried out.

III. Conclusions

A study on the composition of clay in the area around Kuprava was carried out. Researching the results of the research carried out so far, it is concluded that it is possible to realize the extraction of non-waste minerals in the Kuprava clay deposits - using all the layers of rock to produce different products.

Four potential clay quarry sites have been identified – Mednieki, Vilaka, Kuprava clay ground in Veckuprava and Kuprava clay quarry in Gailava.

IV. Acknowledgements

The author expresses her gratitude to the Institute of Inorganic Chemistry of RTU for the possibility to use the equipment of X-ray diffraction and X-ray spectroscopy and Aija Krūmiņa for the provided consultations.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 241-244

Management of Semi-Wild Large Herbivores' Grazing Sites in Latvia

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***Abstract*—Large herbivores were a common part of European nature in the pre-agrarian times. With the development of farming and over-hunting, the number of wild large herbivores rapidly decreased. Wild horses and cattle became extinct. In the 1920-30's, scientists created two new herbivore breeds that resembled the extinct aurochs and tarpans - Heck cattle and Konik horses. Nowadays the introduction of Heck cattle, Konik horses and other similar large herbivore breeds is widely used in specially protected nature territories (SPNT) as a strategic answer to the question – what should we do with the agricultural lands that have lost their economical meaning. Since 1999, semi-wild large herbivores are introduced in various SPNT of Latvia as well, mainly in nature parks and nature reserves. Based on field visits, interviews and policy analysis, this paper discusses two main approaches to semi-wild grazing animal population management in Latvia: (1) introduced herbivores as a part of rewilding process and (2) introduced herbivores as instruments for habitat protection. The former represents the implementation of western wilderness values, while the latter is related to more specific protection of species and habitats according to particular place-based nature protection goals. This study contributes to the growing discussion on rewilding practises in Europe and the introduction ideas of semi-wild animals, as well as landscape management practices in the era of post-productivism.**

***Keywords*—introduction, large herbivores, natural grazing, rewilding.**

Introduction

In Latvia, as in many other European countries, in the latter part of 20th century large areas of land in less productive regions have fallen out of agricultural use [1], [2]. However, an open landscape, grassland habitats and many flora and fauna species cannot exist without such ecological stresses as mowing or grazing [1], [3] – [5]. An alternative to the mechanical management is the introduction of large herbivore breeds that are capable of surviving in the wild with minimal human assistance or without it [1], [4], [6], [7]. One of the pioneer projects of large herbivore introduction is the Oostvaardersplassen polder in the Netherlands where large herbivores were introduced in the beginning of 1980's to 'rewild' the landscape. Since then the introduction projects have gradually spread all over the Europe [4]. The keystone species for the introduction are (semi)wild cattle and horses – Heck cattle, Konik horses and other similar breeds that have the capability to survive in the wild with minimal human assistance [5], [8].

The first large herbivores in Latvia, Konik horses and Heck cattle, were introduced in 1999 in the Nature Park "Pape" as a part of WWF Latvia's initiative that aimed to restore the natural habitats in the Pape polder – a marginalized agricultural area [10]. Since 1999, grazing areas of semi-wild large herbivores have been established in numerous specially protected nature territories (SPNT) in Latvia, mainly in nature parks and nature reserves [11].

Although all of the semi-wild large herbivore grazing sites in Latvia have many common features, the complexity of management approaches varies from site to site. However, we can distinguish two main approaches for management of semi-wild herbivore populations in terms of wider political contexts. One sees the introduced animals as effective asset for habitat management, while the other sees the introduced animals as an integral part of a rewilded landscape in the future [12], [13]. The question of the larger idea that lies beneath one or another management approach is crucial because it affects the grazing site management practices, for example, the surplus feeding or veterinary care level [12], as well as the overall character of a grazing landscape, effecting also the national landscape values.

In this paper, we outline and discuss the differences between two main approaches for semi-wild herbivores grazing sites' management in Latvia – introduced animals as part of rewilding and introduced animals as instruments for habitat protection, focusing on various aspects of the management approaches. The aim of this paper is therefore to identify the main differences and similarities in both approaches in four case studies by discussing the particular indicators that characterize management aspects, wider nature protection contexts and place-based specifics.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4082

MATERIALS AND METHODS

We used field observations, interviews, analyses of literature and documents to understand the specifics of (semi)wild large herbivores grazing sites both generally and specifically in the case of Latvia. Our fieldwork, based on information-oriented selection of four maximum variation cases, was conducted in 2018 and 2019, when we visited altogether four grazing areas: grazing site in Nature Reserve "Floodplain Meadows of River" (Pilssala), grazing site in Nature Park "Pape" and two grazing sites in National Park "Ķemeri".

Concerning the above-mentioned case studies, we conducted six semi-structured interviews with nature protection experts and managers. The main topics discussed with the experts and managers were related to: the objectives of introduction projects, main functions of grazing sites, de-domestication process and human contact, surplus feeding issues, grazing specifics and spatiality, animal registration, the income of grazing sites, potentiality for tourism, as well as other practical management specifics.

RESULTS AND DISCUSSION

Semi-wild herbivore grazing sites in SPNT of Latvia

The grazing areas of semi-wild large herbivores are established in numerous SPNT of Latvia, mainly in nature parks and nature reserves (see Fig. 1, Fig. 2 and Table I). Currently the area of semi-wild grazing sites ranges from approx. 100 ha to 400 ha. The largest grazing areas are located in the Nature Park "Pape" and the Nature Park "Dviete Floodplain".

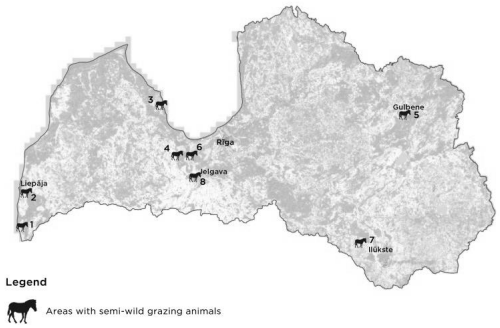

Fig. 1. Semi-wild herbivore grazing sites in SPNT of Latvia (base map from kartes.geo.lu.lv, topographical map M1:10 000 LĢIA; number of a grazing site corresponds to the one in Table I).

TABLE I.
SEMI-WILD HERBIVORE GRAZING SITES IN THE SPNT

	Location of the grazing site, the year of introd.	Current number of grazing animals*	Type of introduced herbivores
1	Nature Park "Pape", 1999	205	Semi-wild horses and cattle, European bison
2	Nature Reserve "Lake Liepāja", 2002	60	Semi-wild horses and cattle
3	Nature Park "Lake Engure", 2002	56	Semi-wild horses and cattle
4	National Park "Ķemeri" (The Dunduri Meadows), 2004	168	Semi-wild horses and cattle
5	Nature Reserve "Sita and Pededze Floodplains", 2005	information n/a	Semi-wild horses and cattle
6	National Park "Ķemeri" (Floodplain of River Lielupe), 2006	141	Semi-wild horses and cattle
7	Nature Park "Dviete Floodplain", 2006	180	Semi-wild horses and cattle
8	Nature Reserve "Floodplain Meadows of River Lielupe" (Pilssala), 2007	71	Semi-wild horses

* Approximate number, according to managers of grazing sites (2018)

Fig. 2. Grazing site in Nature Park "Lake Engure" (2016)

The most common introduced herbivore breeds are semi-wild horses (mainly *Konik polski* horses) and various breeds of semi-wild cattle (e.g. Heck cattle, Highlanders). In the grazing site of the Nature Park "Pape" European bison have been introduced as well. However, they left their grazing enclosure in 2009 and since then live in the wild surrounding of Pape [14]. All of the grazing sites share some common features. Firstly, the location - all of them are located in former agricultural lands that are characterized by low soil fertility and unsuitable conditions for profitable agricultural activity. Secondly, all of the grazing sites are situated next to a natural waterbody that can provide animals with drinking water. Thirdly, all of the cases bear a similar objective – protection and restoration of mosaic landscape and grasslands [11].

Management of semi-wild large herbivores' grazing sites in Latvia

The first introduction projects of large herbivores were commenced already 40 years ago, still there are many discussions and fierce conflicts regarding the introduction idea. Studies show (e.g., [1], [8], [13]) that on the one hand, the replacement of the extinct large grazing animals is being promoted as a possibility to renew the lost 'European wilderness' and to recover the natural mosaic landscape as it was in the pre-agrarian

times. On the other hand, some specialists believe that the method is too unpredictable and the introduction of large herbivore breeds can be acknowledged only under careful examination and the introduced animals should be considered only as a tool for habitat management. The two main conflicting beliefs have led to two very different principles of managing the grazing sites of introduced large herbivores: (1) introduced herbivores as part of rewilding and (2) introduced herbivores as instruments for habitat protection. Using literature analysis [1], [4], [5], [8], [12], [13], [15] – [17], field observations and interviews with managers of grazing sites, we elucidated the main differences between both management approaches that are pertinent to the Latvia's case (see Table II).

TABLE II.
approaches of semi-wild herbivores' grazing site management: the main differences

Introduced herbivores as part of rewilding	**Introduced herbivores as instruments for habitat protection**
Idea of rewilding vs. habitat protection	
Emphasis on the idea of 'rewilding' the landscape as it was in the pre-agrarian times (see Vera's [4] hypothesis on the role of large herbivores in European landscape creation in the pre-agrarian times).	Emphasis on the protection of specific habitats and/or species
De-domestication process and human contact	
The de-domestication and the development of animals' natural behaviour is a crucial factor; the contact with humans should be limited to a minimum	The development of the natural behaviour of animals is a secondary issue; the main reason for limiting the contact is the safety of visitors of the grazing sites
Surplus feeding	
Surplus feeding acceptable only in the extreme circumstances	Additional feeding is acceptable, especially during winter.
Spatial specifics of grazing	
Animals can move freely in the grazing site all year long	Animals are periodically transferred to specific parts of a grazing site to achieve the habitat conservation goals
Population vs. individuals	
The welfare of an individual animal is secondary, the priority is the wellbeing of population	The welfare of each individual animal is considered important
Veterinary assistance	
Veterinary assistance only if the animal is in need of care because of human negligence (e.g., entangling in barbed wire)	Animals may receive any veterinary care
Income of the grazing sites	
Animals are not used for meat or any other production, the income of a grazing site depend mainly on subsidies	The main income usually are subsidies for habitat protection; but the culled animals may be processed for meat production*
Animal registration	
Preferably the renunciation of animal registration in the future**	The need of animal registration is seen only as a practical inconvenience
Management of the dead bodies of animals	
Death is seen as part of a life cycle - unless an animal has died close to a visitors' access point, the remains of dead animals are left for natural decomposition	The bodies of dead animals are not left for natural decomposition
Predation	
Presence of such predators as wolves is highly tolerated; predation and fear factor are important aspects of a functioning ecosystem	Contact with natural predators, such as wolves, is limited to a minimum

* If allowed by the responsible authorities (food safety issues)
** The tagging of semi-wild cattle is mandatory in all grazing sites in Europe, except for the Oostvaardersplassen polder [8].

Of course, one must bear in mind that the division between both management principles is relative – in reality most of the grazing sites possess some characteristics from both approaches. For example, all managers of the analysed grazing sites in Latvia use the surplus feeding during winter months, even in grazing sites that would classify as examples for approach "introduced herbivores as part of rewilding" (e.g., both grazing sites in the National Park "Ķemeri", grazing site in the Nature Park "Pape").

Besides the fact that both approaches might overlap in some aspects depending on the beliefs of optimal management of the managers of grazing sites, there are some more characteristics that are usually similar to both approaches:

- Populations of introduced herbivores live in fenced areas (except European bison in the Nature Park "Pape", who left their grazing enclosure in 2009 and now live in the wild [14].);
- The introduced herbivores are allowed to feed, breed and socialize more freely than their livestock kin;
- Introduced animals live outside all year long;
- The birth of animals is not assisted by human.

In general, the main difference between both approaches lies in the broader ideology of introduction that in both cases relates to the landscape management problematics. The approach "introduced animals as part of the rewilding" supports Vera's hypothesis [4] that suggests that large grazing animals were an important ecological force in landscape formation in Europe in the pre-agrarian era and experimentally try to re-create the pre-agrarian ecosystems and landscapes. The approach "introduced animals as instruments for habitat protection", on the contrary, concentrates more on the practical advantages of introduction: the introduced semi-wild large herbivores are seen as effective alternative for managing grassland habitats, disregarding the speculations about their historical role in the European landscape.

Another important aspect of differences between both approaches is the "domestication status" of the introduced herbivores – should they be seen as wild or as domesticated animals. As this aspect is directly connected to the animal welfare ethics [12], [18] it has caused fierce discussions both between specialists and general public also in Latvia (e.g., news stories about grazing site in Pilssala [19] and in National Park "Ķemeri" [20]). The approach "introduced animals as part of rewilding" considers introduced herbivores as wild animals (or at least wild animals to-be) therefore they receive less help from humans (such as surplus feeding or veterinary care) as their livestock kin. Thus the introduction approach "introduced animals as part of rewilding" is often criticised by animal protectionists.

However, both management approaches have very different ideologies and objectives therefore they have very different advantages and disadvantages as well. The approach "introduced animals as part of rewilding" is mainly based on the controversially received hypothesis of large herbivores as creators of mosaic landscape in Europe in the pre-agrarian times [4], [9]. This approach is more experimental and fit for SPNT without very strict nature conservation rules (as the result of introduction is not always predictable), while the approach "introduced animals as instruments for habitat protection", which offers more control over introduced animals, is seen as more fit for achieving concrete nature conservation goals such as improved quality of specific grassland habitats.

CONCLUSIONS

The first grazing site of semi-wild herbivores in Latvia was established in 1999 in Nature Park "Pape" as a part of WWF-Latvia initiative that aimed to restore the natural habitats in the Pape polder. Since then, the semi-wild large herbivore grazing sites have been established in numerous SPNT in Latvia. Even though all of the grazing sites share many common characteristics (e.g., all of them are located in the former agricultural lands and all of the grazing sites are populated by semi-wild horses and/or cattle), the management approaches of grazing sites are very different. However, they can be divided into two general groups that bear distinct objectives and underlying ideologies - (1) approach that sees the introduced animals as part of rewilding process and (2) approach that sees the introduced animals as instruments for habitat protection. In general, the main difference between both approaches lies in the higher goal of introduction (landscape rewilding or habitat protection). The approach "introduced animals as part of rewilding" supports Vera's hypothesis [4] that suggests that large herbivores were a crucial ecological force in mosaic landscape formation in Europe in the pre-agrarian times and experimentally try to re-create the pre-agrarian ecosystems. The approach "introduced animals as instruments for habitat protection" more conservative and mainly concentrates on the practical advantages of introduction: the introduced semi-wild large herbivores are seen as effective alternative for managing grassland habitats, disregarding the speculations about their historical role in European landscape.

However, they differ also in other practical management aspects such as surplus feeding, human contact, level of veterinary assistance, spatial specifics of animal movement, income of the grazing sites and the management of the dead bodies of animals.

Although some aspects of approaches in the analysed grazing sites may overlap, the list of main characteristics of both management approaches developed in this study can be used as a basis for identification of grazing site specifics in the further analysis of ecological and socio-economic aspects of grazing landscapes, as well as in analysis of societal attitude towards these new post-productivist landscapes.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 145-248

Factors Affecting Chinese Hamster Ovary Cell Proliferation and Viability

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***Abstract*—Advantageous cultivation procedures for the Chinese hamster ovary (CHO) cells are necessary for the productive commercial production of biopharmaceuticals. A main challenge that needs to be addressed during the process development is the differences in each cell line requirements concerning the nutrients and feed strategies in order to achieve the desired growth characteristics. Therefore, within the current research, a naïve high cell density serum free suspension adapted CHO cell line was tested with glucose and glutamine rich feeds in fed-batch Erlenmeyer shake flask cultures. Glucose consumption rate was adjusted to develop the optimal feed strategies. Obtained results indicated that high glucose and L-glutamine feeding did not improve maximum viable cell density compared to the control samples. During the exponential phase, cell proliferation and viability of all feeds showed no statistically significant difference. Instead, the fed-batch processes tested led to statistically significant differences in viable cell density and cell viability during the decline phase, compared to control (batch) culture. The difference between glucose and glutamine feeding was indistinguishable, most probably due to the concentration imbalance with the rest of the nutrients in feed. The overall study presented a method to slow down the decrease in CHO cell proliferation and viability during the decline phase, instead of increasing the maximum cell density at the plateau phase.**

***Keywords*—biotechnology, cell proliferation, Chinese hamster ovary cells, feeding strategy.**

I. Introduction

Chinese hamster ovary (CHO) cells are widely used for biopharmaceutical production. Production of recombinant cytokines, fusion proteins, monoclonal antibodies and others requires specific nutrient components to support cell growth in vitro [1]. Therefore, nutrient composition in culture media and the manner of media supply during the cultivation process have been extensively studied.

The main energy sources in chemically defined CHO cell culture media are carbohydrates (glucose, primarily) and glutamine [2]. Supplementation of glutamine in cell media can help to maintain higher cell viability profile and reduce lactate generation [3]. In the absence of glutamine, cells have a delayed start of exponential phase [4]. On the other hand, as a result of cell metabolism and the so-called glucoglutaminolysis, potential inhibitory by-products are generated [5]. High glucose concentration can lead also to lactate accumulation which can further affect the cell growth [6], therefore, glucose concentration limits have been extensively studied [7]. High glutamine supplementation, however, can lead to ammonium accumulation which significantly inhibits the cell growth [8]. In this regard, maximum permittable ammonium concentrations should be seriously considered during the experimental procedures. Also, an interaction between consumption rates of glucose and glutamine has been investigated. For example, glucose consumption can be influenced by the glutamine excess [9]. Substitutions for both glucose and glutamine as the energy sources in the media have been proven to be effective [2].

Cell cultivation can be organized in either a batch or a fed-batch process. Fed-batch process means that after supply of basal medium at the beginning of fermentation, cells are later on supplemented with a feed medium which, in its simplest form, supplies only glucose in the range of 1.0-10.0 mmol/L [10]. Feed media usually contain 10-15 times higher nutrient concentrations than in the basal medium [10]. In order to optimize the process, both appropriate feed medium design and the experimental approaches have to be selected. While the stoichiometric model serves for the measuring of nutrient demand rates, the metabolic flux analysis provides an opportunity to understand metabolic pathways in-depth [11][12].

During present research, CHO cell cultivation process development using controlled glucose consumption rate in a fed-batch regime was carried out in order to test the effect of glucose rich and L-glutamine rich feed media on CHO cell proliferation and viability.

II. Materials and methods

A. Materials used

A naïve Chinese hamster ovary cell line FreeStyle™

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4106

CHO-S adapted to high maximum cell density, serum-free suspension culture from Thermo Fisher Scientific (Carlsbad, USA). Cell culture basal medium FreeStyle™ CHO Expression Medium (Life Technologies, New York, USA). Media supplements: L-glutamine (200 mM) (Gibco®, Life Technologies, Paisley, UK), PenStrep antibiotics (Gibco®, Life Technologies, New York, USA), glucose powder (Cargill, Krefeld, Germany). Other reagents: phosphate buffer (hereinafter, PBS) without Ca^{2+} and Mg^{2+} (Dulbecco's PBS, Gibco®, Life Technologies, Paisley, UK), trypan blue stain (Life Technologies, New York, United States). Materials: 125 mL Erlenmeyer cell culture shake flasks (Corning®, Merck, New York, USA) with 40 mL initial basal media working volume, 0.2 μm membrane filters (LLG®, Meckenheim, Germany). Equipment and devices: CO_2 incubator (New Brunswick™ S41i, Eppendorf, Hamburg, Germany), hemocytometer (Neubauer Improved Assistent®, Hecht-Assistent, Sondheim/ Rhn, Germany), glucose meter Accu-Check® Active (Roche Diagnostics, Mannheim, Germany).

B. Methods for the preparation of cell media

Cell culture basal medium was prepared by supplementing FreeStyle™ CHO Expression Medium with 8 mM L-glutamine and 1% (v/v) antibiotics. Apart from glucose, there are inorganic salts containing magnesium, calcium, potassium, sodium, phosphate, chloride, sulfate, bicarbonate ions, trace elements, approximately 20 different amino acids, approximately 10 different vitamins, and several growth factors contained in the basal medium [2].

In combination with basal medium, three feed systems and the control were compared being: 1) basal medium with increased glucose concentration (hereinafter, Glucose Feed); 2) basal medium with increased glucose concentration (hereinafter, Glutamine Control); 3) basal medium with increased glucose and L-glutamine concentration (hereinafter, Glutamine Feed); and 4) basal medium with phosphate buffer solution (hereinafter, Control Feed).

Glucose Feed consisted of 4 mL/day basal medium supplemented with glucose powder. The target levels of glucose concentration are listed on Table I. Firstly, the amount of glucose m_n (g) in one flask is calculated according to equation 1:

$$m_n = C_n \times V_n \times 180.156 \times 10^{-6} \quad (1)$$

where Cn (mmol/L) is glucose concentration as measured, Vn (mL) is the cell culture volume before feeding and 180.156 is the molar mass of glucose.

The amount of glucose mbasal (g) in the basal medium is calculated according to equation 2:

$$m_{basal} = C_{basal} \times V_{feed} \times 180.156 \times 10^{-6} \quad (2)$$

where C_{basal} (mmol/L) is glucose concentration in basal medium used for the preparation of feed media (Table II) and V_{feed} (4 mL) is the total volume of the feed. Finally, the total amount of glucose m (g) to be added in the Glucose Feed medium is calculated according to equation 3:

$$m = m_{n+1} - m_n - m_{basal} \quad (3)$$

Glutamine Control (4 mL/day) consisted of basal medium, PBS solution and glucose powder. The total amount of PBS to be added is calculated according to equation 4 (see below), and the volumes used are listed on Table III. The target levels of glucose concentration for this feed are listed on Table I. The total amount of glucose to be added is calculated according to equations 1-3 and 5.

Glutamine Feed (4 mL/day) consisted of basal medium, L-glutamine solution and glucose powder. The target level of glutamine concentration was set to 4 mmol/L during the whole feed schedule. It was set on 4 mmol/L or one half of what is recommended for the initial basal medium, respectively. The amount of L-glutamine (mL) to be added is calculated according to equation 4:

$$V_{GLN} = \frac{4 \times (V_n + 4)}{C_{GLN}} \quad (4)$$

where C_{GLN} (200 mmol/L) is the concentration of glutamine based on supplier's information. Volumes of L-glutamine used are listed in Table III.

Glutamine Feed was supplemented with glucose as glutamine cannot support the cell growth in case of its absence [13]. The target levels of glucose concentration for this feed are listed on Table I. The total amount of glucose to be added is calculated according to equations 1-3, except that in case of L-glutamine addition to the feed, Eq. 2 has to be modified in respect to V_{GLN} according to equation 5:

$$V_{feed(GLN)} = V_{feed} - V_{GLN} \quad (5)$$

Control Feed (4 mL/day) consisted of PBS only.

TABLE I.

Type of feed	Target level of glucose concentration (mmol/L)			
	Feed day 1	Feed day 2	Feed day 3	Feed day 4
Glucose Feed	18	18	26	26
Glutamine Control/ Glutamine Feed	16	16	16	16

TABLE II.

Type of feed	Glucose concentration of basal medium** (mmol/L)			
	Feed day 1	Feed day 2	Feed day 3	Feed day 4
Glucose Feed	26	26	26	26
Glutamine Control/ Glutamine Feed	31	31	32	32

** Although prepared according to the same supplier's protocols, different glucose concentrations were measured among batches of basal medium.

TABLE III

Type of feed	Volume of L-glutamine or PBS (mL)			
	Feed day 1	Feed day 2	Feed day 3	Feed day 4
Glutamine Control/ Glutamine Feed	0.88	0.96	1.04	1.12

C. Fed-batch cultures

Prior inoculation of the fed-batch cultures purchased Chinese hamster ovary cells were thawed, sub cultured in basal medium every 2-3 days (duration of one passage) in the lag phase at 0.2×10^6 viable cells/mL and cryopreserved in a cell bank. Then cell passages 22 and 29 were taken from the cell bank, thawed and inoculated in disposable 125 mL Erlenmeyer cell culture shake flasks with 40 mL initial basal media working volume in triplicate at 0.2×10^6 viable cells/mL. Cells were cultivated in CO_2 incubator with shaking speed 125 rpm (25 mm orbital shaking diameter) at 8% CO_2, 37°C and 95% humidity.

Feed addition was started when cells reached plateau phase for all tested conditions with a daily bolus addition (4 mL) of four different feed media as described in section "Methods for the preparation of cell media". Plateau phase was defined when the average cell density did not increase within the standard deviation range for one consecutive day. The measurement of average glucose concentration at the day before plateau then was taken as the target glucose level (see Table I). Feed supply was restricted to 40% of initial working volume. Accordingly, there were four feed additions in the volume of 4 mL each. Before adding to the cell cultures, feed was filtered through 0.2 μm membrane filter. Cell cultures were terminated when the average viability of triplicates dropped below 60%.

D. Cell density and viability measurements

Daily sampling started from day 1 of cultivation for every cultivation experiment. In sterile conditions, 10 μL sample was taken directly from each cell culture flask and mixed with 10 μL trypan blue stain for a manual determination of total and viable cell density by the trypan blue exclusion method using a hemocytometer. Briefly, cells in hemocytometer chamber were counted under the microscope and sorted into viable (white colour) and dead (blue colour) cells. Glucose concentrations were daily measured using glucose meter. Glucose consumption (g/L) is calculated according to equation 6:

$$GC_n=(C_{n-1}-C_n)\times180.156\times10_{-3} \quad (6)$$

E. Statistical evaluation

All results were expressed as the mean value ± standard deviation (SD) of three independent samples. The significance of the results was evaluated using unpaired Student's tests with the significance set at $p>0.05$. One way analysis of variance (ANOVA) was performed to evaluate the difference between the results.

III. Results and discussion

In this study, the method of media supply during the cell cultivation process was based on glucose consumption rate. In terms of viable cell density (VCD) and viability, cell response to the maintenance of high glucose (Table I) and L-glutamine (4 mmol/L) concentrations during cultivation process was different among the phases of cell growth (Fig. 1). During the exponential phase, VCD in all experiments that were conducted showed no statistical difference and increased on average from 0.2 to 5.3 ± 0.3 ($\times10^6$ cell L^{-1}) at day 5 of cultivation. Feed additions that for all experiments were started on day 5 of cultivation and ended on day 8 (Fig. 2) took into account the measured amount of glucose 26 – 32 mmol/L that is by default present in the basal medium (Table II). On cultivation days 7-8 only in case of the Glucose Feed target glucose concentrations were increased higher than the plateau concentrations in order to provide excess glucose for cells if they recover in proliferation (Table I). However, on day 6 the proliferation in all feed conditions tested decreased on average to 4.6 ±0.3 ($\times10^6$ cell L^{-1}) marking the end of a very short plateau phase (Fig. 1). Thus, increased glucose and glutamine concentration in none of the feeding strategies used improved the proliferation of CHO cell culture.

During the decline phase (days 6–12 Fig. 1), the differences caused by increased glucose and glutamine concentrations were observed. In case of Glucose Feed, a statistically significant difference of 0.7 ($\times10^6$ cell L^{-1}) higher VCD compared to the control culture was observed (days 7-9 Fig.1). Also, irrespective of the fact that the concentration of glucose was kept at plateau level in all feeding strategies, Glucose Feed showed the highest cell viability of 91% on day 9. On day 10, cell viability in case of Glucose Feed was 28% higher than in case of Glutamine Control. Difference between these two feeds was only in the amount of basal medium added to the feed. On day 6, Glutamine Control experienced a statistically significant decline in VCD of 1.4 ($\times10^6$ cell L^{-1}). On the third feeding day (day 7 of cultivation), half of the samples recovered from decline in proliferation. These observations suggest that other factors besides glucose and glutamine concentration affected cell growth and proliferation. Probably, other nutrients contained in the basal medium had an effect on cell proliferation and viability during the decline phase of cell growth. In other words, glucose and glutamine on average led to higher proliferation and viability during cell decline phase, but at the same time they were not the only factors that affected the process.

In Fig.2 glucose concentration profiles show zigzag patterns due to the daily feed additions for all conditions tested, except the control samples. In Fig. 3 glucose consumption curves in comparison to VCD are shown. Overall, cell glucose consumption rates at various phases of growth were rather inconsistent. During the exponential phase, only in the case of Glucose Feed smooth increase in glucose consumption was observed (days 1-5 Fig. 3). Usually, increase in glucose consumption is expected at

stationary phase [14], but due to a very short stationary phase it was not the case in the present study. During the decline phase, cells in case of the Glucose Feed experienced a decrease by 0.7 (g L^{-1}) in glucose consumption when the feed was disrupted (day 8) which was recovered on day 9 (Fig. 3).

Overall, the decrease in cell proliferation and viability was not caused by the glucose scarcity (Fig. 2 and Fig. 3) leading to a conclusion that glucose and glutamine could not increase the proliferation when, most likely, other nutrients were depleted. Obtained results suggest that glucose and glutamine serve as the energy sources for cells, therefore, it allowed the cells to live longer, but not to proliferate. In order to improve cell proliferation, the addition of growth factors, typically peptides, small proteins and hormones, to the feed media is necessary [2].

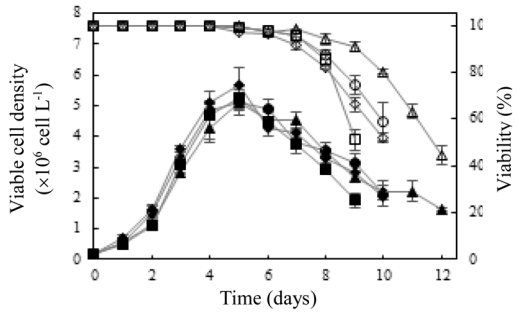

Fig. 1. Viable cell density (closed symbols) and viability (open symbols) with Glucose Control (squares), with Glucose Feed (triangles), with Glutamine Control (rhombuses), and Glutamine Feed (circles). Error bars represent one standard deviation from three biological replicates.

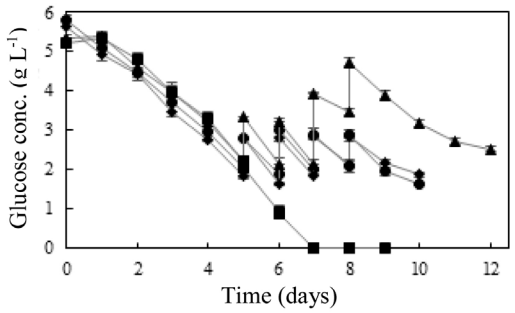

Fig. 2. Glucose concentration with Glucose Control (squares), with Glucose Feed (triangles), with Glutamine Control (rhombuses), with Glutamine Feed (circles). Error bars represent one standard deviation from three biological replicates.

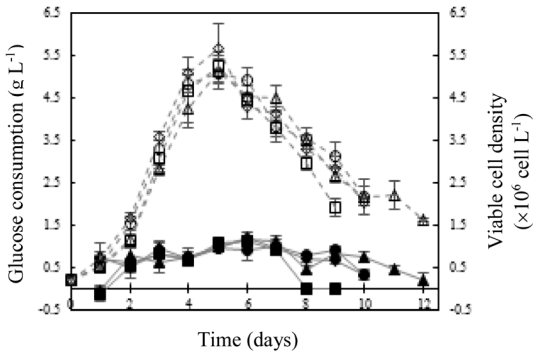

Fig. 3. Glucose consumption (closed symbols) and viable cell density (open symbols) with Glucose Control (squares), with Glucose Feed (triangles), Glutamine Control (rhombuses), with Glutamine Feed (circles). Error bars represent one standard deviation from three biological replicates.

IV. Conclusions

In this study, cultivation process of FreeStyle™ CHO high density, serum-free suspension culture cell line was characterised at increased glucose and glutamine levels maintained during the cultivation process. Obtained results suggest that increased concentration of glucose and glutamine had no statistically significant influence on CHO cell proliferation at exponential and plateau phases. However, cell proliferation and viability were affected during the decline phase. Results revealed statistically significant differences in viable cell density and cell viability in case of different feed media compositions when the same glucose and glutamine levels were maintained. It could be related to the preparation method of the feed media which was based on the supplementation of only two nutrients in the imbalance with other feed components in chemically defined cell culture medium.

Acknowledgements

This work has been supported by European Regional Development Fund within the project "Influence of the magnetic field initiated stirring on biotechnological processes" No. 1.1.1.1/16/A/144.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 249-251

To the Solution of Some Problems of Developing Assembly Technology by Modeling Assemblies in CAD Systems

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***Abstract*—Considers the features of the automated design of technological processes of assembly of products in mechanical engineering, in terms of their impact on production processes.**

***Keywords*—assembly, computer-aided design, computer simulation, assembly tree.**

I. Introduction

Experienced assembly technologists have always tried to adapt the available automation capabilities of design and graphic works to their needs. So, from the lists of drawings obtained in graphic editors with scissors, parts were cut out, laid out and glued in such a way as to obtain the required assembly unit (knot). In the process of unfolding, the composition of assembly units and the sequence of installation of parts and parts of the product in them were determined, which made it possible to analyse the variants of the assembly process and select the optimal one [6].

Currently, even for relatively simple parts, three-dimensional modelling is used. In this case, the assembler technologist has to deal with three-dimensional models of parts and assemblies [1,3]. This led to the fact that some technologists are trying to "manipulate" three-dimensional models of assemblies (group models of product parts, taking into account the technological possibilities of manufacturing) in the CAD model space. The possibility of such a "manipulation" directly depends on the applied approach of design modeling of an assembly in a CAD environment, and these possibilities are not focused on assemblers.

In 1996, Intergraph launched the SolidEdge system, a tool designed to perform a set of work on solid-state modeling in the Windows environment on PC-class computers [2].

II. Assembling from bottom to top

SolidEdge has become one of the first successful implementations of approaches that allow working with assembly in the traditional, customary manner for a modern designer [4].

The SolidEdge system was originally designed for parametric solid-state modelling of subassemblies. Namely, for positioning parts of a product or creating new ones with reference to elements of a structure that already exist in the model assembly space. New parts can be created using neighbouring elements.

Subsequently, this idea of parametric solid-state modelling spread to almost all modern CAD designed for modelling assemblies. Let us analyse two main approaches of design solid-state modelling "bottom-up" and "top-down" for solving the problems of developing assembly technology [7].

Briefly, the bottom-up design modelling approach implemented in CAD comes down to the following steps:

- at the first stage details are modelled;
- on subsequent models of nodes are created from previously created models of parts;
- at the last stage, when all nodes are modelled, they are added to the product assembly.

Using the same CAD capabilities, an assembly technologist can "assemble" assembly units from ready-made construction models of parts, thereby determining the sequence of their assembly and composition. The sequence of assembly will be determined by the order of inclusion of models of parts (nodes), and the composition of the models of parts (nodes) in the composition of the assembly model.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4095

In the technological model of the assembly, as in the design model, the creation history is graphically represented by an object — an acyclic, directed graph containing the history of model building (often called the construction tree, or, more briefly, the tree) of the assembly model. The tree is a single-level, ordered structure that reflects the order in which the models of parts (nodes) are included in the assembly model.

With respect to assembly modelling tasks, you can relate a timeline and an assembly tree. The starting point of time on the timeline will be related to the first part of the product that falls into the assembly, that is, the one that is highest in the assembly tree. Then all the parts that are lower in the tree fall into the assembly later in time than the first. One part of the product, located above the other part in the assembly tree, will join earlier than the other.

Thus, we can talk not only about the history of the assembly model, but also about the assembly process that develops over time, and about the modelling of the assembly process itself and at the same time using the same tools for creating assembly models as in the design.

The tree of the design model of the assembly is traditionally used as a means of navigation and editing. The tree of the technological model expands the indicated applications and allows, editing, to influence the technological sequence of assembly. It can be considered that in terms of content such a tree approaches a technological assembly scheme.

For this purpose, SolidEdge includes a navigator that displays the tree-like assembly structure and helps you navigate complex nodes, select and use the necessary parts for work, and also manage the assembly visualization process on the screen.

III. Assembling from top to bottom

Unlike the designer, the technologist, determining the order of entry into the assembly of models of parts of the product, sets not only the bindings (parametric and dimensional links), but also takes into account the technological capabilities of the assembly (access to the installation site, preserving integrity when moving, stability in the assembly process, etc.) [8,9].

Thus, using CAD it is possible to "manually", that is, without involving additional algorithms for making decisions about rearrangements and grouping the structure of the product model, to solve the following problems of designing an TP assembly:

• determine the composition of the assembly units (perform technological division);

• determine the sequence of installation of parts and assembly units in the assembly process.

• generate data for the list of product assembly (assembly units of different levels).

The nuance to which attention should be paid is that the assembly technologist re-executes the constructor's actions and must be proficient in the methods of working with CAD.

The longer the designer works at the same workplace, and the more he accumulates product models, the less often he will resort to bottom-up design. This is due to the fact that for real production rarely completely unique designs are created, changes are often local in nature. Therefore, it is more expedient to use the top-down approach for cases where there are one or more analogues.

The essence of the top-down design modelling approach implemented in CAD comes down to the following steps:

• at the first stage, borrowing models of assembly units and editing geometric and dimensional relationships;

• at subsequent stages, models of assembly units and parts are created with reference to already existing parts of the structure (in the context of assembly);

• at the last stage, when all nodes are modelled, they are added to the overall assembly of the product (if not the whole product was borrowed).

It would seem that an assembly technologist could use the "top down" approach, take design models of nodes as analogy models and break them down into technological ones at their own discretion. However, in modern CAD there is no tool that allows you to quickly break a large number of previously imposed assembly constraints without subsequently occurring errors and inconsistencies. The solution to this problem becomes the more complicated the more parts in the original assembly unit and, accordingly, the greater variety of geometric and dimensional constraints connecting the parts of the assembly at the point of rupture.

In this case, it may be a surrogate decision to extinguish (make non-visible) a part of the product that will not get into the assembly unit, which the technologist works with. A surrogate solution is also the use of a tab with performances, where each version will contain the state of the assembled product, starting from an assembly unit consisting only of parts, ending with a product. In this way, the technological composition can be fixed at the assembly stage, but the tree will not reflect the assembly sequence.

I would like to hope that the realization of the inconsistencies and difficulties in using three-dimensional models to perform tasks related to the development of assembly processes will force software developers to take a new look at the problem and as a result, a new tool or module will appear in the CAD that is addressed to to the collector.

IV. Conclusion

In the precomputer era, engineers had to submit sequences of assembly / disassembly, maintenance, or repair using posters with so-called "spaced assemblies". Thanks to these posters it was possible to display intermediate results of the assembly in the sequence of its implementation.

The function of creating views with "separated" assembly components (the English term "exploded view" - Exploded View), is currently implemented in many CAD (Sol-id Works, Solid Edge, etc.) both in standard form and in the form of plug-in software. modules (SolidWorks Composer or CATIA Composer).

According to the authors, the use of these tools is the most accessible and easy-to-use means of technological modelling of the assembly process today.

At present, methodological recommendations have been developed on the use of distributed species for technological modelling of the assembly process.

The essence of this approach is reduced to the following stages:

- at the first stage, borrowing models of assembly units of the design model of a product is performed;
- on the following - the models of assembly units and parts of all, except for those joined by the first (one or several assembly transitions), are hidden;
- using the Exploded View tool creates an "exploded assembly" of visible elements of the assembly. The results of the assembly are recorded in a graphic file that displays the states before and after the attachment or as a video;
- then the following elements attached to the already "assembled" parts become visible;
- their separation is also carried out by editing the exploded "exploded view", and the results are recorded;
- at the last stage, when all assembly units and parts are visible, the technologist has a sequence of technological states describing the assembly technology.

Thus, the technologist can break the design model into technological assembly models and fix the assembly sequence at his own discretion.

According to the authors, for the widespread use of this technique in production, only the capabilities of Exploded View are not enough. The assembly process is not only the joining of parts of the product, as reflected in the design specification, but also the assembly and disassembly of elements of assembly devices and temporary, but necessary for performing operations, elements (protective covers, covers, etc.).

In this regard, the authors propose the development of a special library of three-dimensional models of assembly devices for assembly-welding on a universal assembly table, which are included in the technological model along with the design elements. Thus, it is possible to obtain graphic files, containing a full replacement of assembly operational sketches.

Analysis shows that the proposed method does not replace, but complements the traditional assembly scheme. At the same time, this technique requires a well-organized organization of the storage of graphic files of the technological model, which can be implemented with modern document management systems (PDM), as implemented by standard CAD tools. It is also advisable to store these files as nested (reference) documents of assembly operations designed with the help of CAD software, thus complementing traditional operational sketches.

The described techniques reflect, on the one hand, the practical experience of the authors developed in advising a number of enterprises in the city of Pskov (OJSC TESO, OJSC Pleskava, OJSC ADS) in the process of integrated implementation of CAD systems, as well as more than 20 years of teaching experience at the University of Pskov. Some results are reflected in articles [] and textbooks [9].

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 252-257

Modelling of the Bagular Aneurysms of the Wall of The Blood Vessel Taking Into Account the Rheological Properties of the Blood

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***Abstract*—The article presents some results of the modeling of the bag-like aneurysm by the finite element method. The model takes into account the specificity of the blood flow from the point of view of various rheological models, as well as a significant change in the shape of the saccular aneurysm depending on pressure.**

***Keywords*—Aneurysm, CAE, modelling, rheological**

I. Introduction

According to the existing views, aneurysm of the vessel is a chronic degenerative dystrophic disease, consisting in a significant expansion of the artery or, more rarely, veins in the form of a limited protrusion of the blood vessel wall or its even stretching in a certain area.

True arterial aneurysm develops mainly under the influence of pathological changes that have arisen in the vessel wall, and only occasionally due to erosion and injury. The modified (thinned) wall of the artery cannot withstand the pressure of the blood and gradually stretches and bulges. Aneurysms arise and develop gradually over several years. Pathological process is not accompanied by special symptoms, especially at the beginning. In the later stages of aneurysm development, its symptoms can be severe: rupture of the vessel, its dissection, thrombosis, embolism (blockage), compression or destruction of adjacent tissues, organs, etc.

Depending on the shape, there are bagular (Fig. 1) and diffuse (Fig. 2) aneurysms. Sack-like aneurysmal formations are the most common, and diffuse enlargement of the artery is much less common for a considerable distance. Bag-shaped aneurysms are single and multiple, single or multi-chamber, ranging in size from a few millimeters to an adult's head.

The size of the aneurysm depends on the caliber of the affected vessel, the degree and nature of changes in its wall, the duration of the aneurysmal pathological process.

Fig. 1. Bagular aneurysm.

Fig. 2. Diffuse aneurysm.

With local expansion of the vessel in the affected area increases the cross-sectional area with, as a rule, a decrease in the strength of the vessel wall due to its thinning. Increased cross-sectional area leads to a local increase in pressure, thus forming positive feedback. Increased pressure leads to expansion of the vessel, and expansion - to an increase in pressure and in the future - to rupture of the wall.

Blood supply through the vessels is carried out by

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4096

jerks, as a result of which a situation may arise in which the frequency of the pulsation of the blood flow will be close to the natural frequency of the bag-shaped cavity, which can be regarded as a membrane, which is fraught with resonant oscillations and destruction of the vessel.

Diagnosis of aneurysm is performed by ultrasound imaging, x-ray computer contrast or magnetic resonance imaging. However, to obtain a complete picture of the possible consequences of detecting an aneurysm in a patient, assessing the degree of criticality of aneurysmal formation, it is advisable to simulate the affected vascular area and identify the degree of "neglect" of the aneurysm, to make a forecast for the development of this pathological process. This analysis is based on complex model studies of the stress-strain state of an artery with an aneurysm while simulating blood flow in the vessel.

II. Formulation of the problem

It is known from [1] that the problems of biomechanics for bodies of complex shape and heterogeneous structure, such as blood vessels with blood pulsing in it, burdened with an aneurysm, are most often solved using numerical mesh methods, in particular, using the finite element method. The artery-bloodstream system is characterized by the interaction of blood flow on the one hand, and the elastic walls of an arterial vessel with a complex geometry on the other. The need to take into account in the aneurysm model the mechanisms and conditions for the interaction and interaction of elastic solids — blood vessel walls and flowing fluid — blood flow reduces this task to a class of multidisciplinary multiphysics tasks requiring simultaneous model reconstruction of various physical phenomena taking into account their interaction with each other.

Consequently, this task belongs to the class of FSI (Fluid Structure Interaction) [2] class of tasks — the interaction of elastic solids and fluid flows, which is one of the complex multidisciplinary tasks that require simultaneous coupled modelling of various physical phenomena, taking into account their mutual influence on each other . Most often, such problems, as is known from [2, 3, 4], are most effectively solved by finite element modelling tools, such as COMSOL Multiphysics [3] or ANSYS [2, 4].

The complexity of the solution and the realism of the solutions obtained depend on the overall goal of the research, the dimension of the problem, the accepted assumptions and the chosen methods of solution. Thus, the problem under study can be considered in a quasistationary (with a steady state) and non-stationary formulation. It is possible to organize the simultaneous calculation of the mutual influence of hydrodynamics and strength (coupled, two-way coupled) and independent, based on the assumption that fluid flow (blood flow) does not significantly change the shape of an elastic solid (segregated or one-way coupled) - a blood vessel. The quality and speed of calculations depends on the calculation systems used, the means of numerical finite element modelling, the degree of preparation and detail of mathematical model descriptions of interacting objects and continua.

III. Methodology

Before proceeding to the description of the process of building a model and experimenting with it, we introduce the following basic assumptions [1,5]:

1). The blood vessel and aneurysm are three-dimensional bodies.

eight). The dome of the aneurysm is axisymmetric and has a spherical shape.

2). The base of the aneurysm is rigidly fixed in the blood vessel.

3). The geometrical dimensions of the aneurysm and the internal pressure of the blood in it are considered in the physiological range.

4). Blood is an incompressible fluid that has certain viscosity properties.

5). The walls of arterial vessels are a complex multi-layer structure with characteristic parameters of strength and anisotropy of properties.

The general scheme for modeling aneurysm of an artery includes the following steps:

Step 1. The construction of the geometry of the object of research - in this case it is a section of a blood vessel with a bag-shaped aneurysmal formation.

Step.2. The task of the rheological properties of blood. It is necessary, first of all, to decide what kind of formal description sets the viscosity of the blood.

Step 3. Determination of the properties of the blood vessel walls, mainly the elastic properties and structural isotropy / anisotropy.

Step 4. The choice of the initial situation for the simulation, i.e. the establishment of the basic model characteristics of the object under study is the size of the simulated portion of the vessel with the aneurysm, the pressure of the blood in the vessel, the method of its fixation, etc.

Step 5. Building a finite element model of an aneurysm vessel.

Step 6. Formation of a scheme for solving a multiphysical problem of modelling a bag-shaped aneurysm.

Let us consider in more detail the implementation of these steps with an example.

As the initial real object of modelling we choose a straight section of a blood vessel with a caliber D = 5 ... 20 mm, a limited length L = (3 ... 5) ... (15 ... 80) mm, a wall thickness h = 0.5 ... 2.0 mm with a bag-shaped sphere-like aneurysm with diameter A = (1 ... 2) ... (5 ... 40) mm, offset from the vessel axis by S = (1 ... 2) ... (7.5 ... 30) mm.

Step 1. A geometric model of such a vessel with an axisymmetric spheroidal aneurysm in projection on the XZ plane has the form of a horizontal cylinder (the center

of symmetry coincides with the origin of the coordinate system) and shifted along the vertical axis of the sphere - see fig. 3. Three-dimensional mapping of this model is presented in fig. 4.

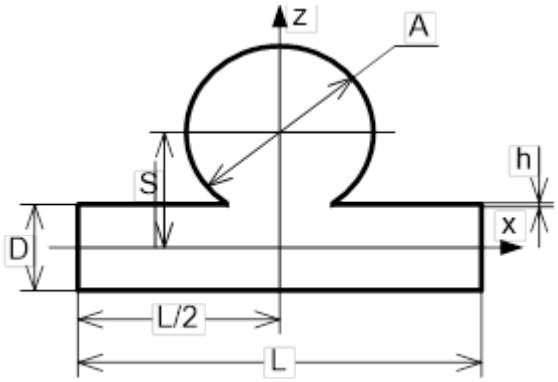

Fig.3. Geometric model of an aneurysm vessel in the xz plane.

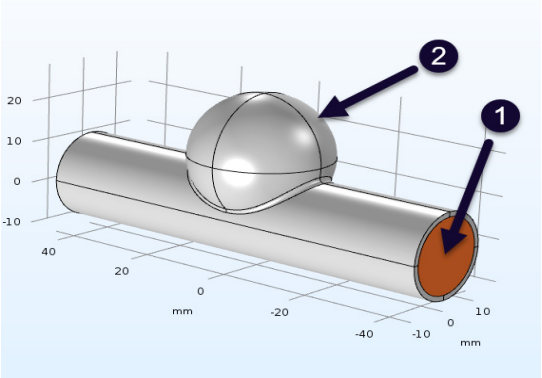

Fig. 4. Three-dimensional model (1 - blood, 2 - a vessel with an aneurysm)

Step 2. There are a number of models that describe the properties of blood. The most popular is the Newtonian model [6], according to which blood is an incompressible fluid, the viscosity coefficient of which depends only on its nature and temperature and does not depend on the conditions of the flow of the fluid, i.e.

$$\eta = \text{const}, \qquad (1)$$

however, the normal blood density is ρa = 1052…1062 Kg·м3, and its viscosity η = 0,005 Pa·c.

This formal description is suitable for relatively fast blood flow, but does not take into account the specificity of the behaviour of blood at low speeds of its flow, and this is especially important, in particular, when studying the possibility of carrying out stenting of the coronary vessels of the heart.

Non-Newtonian (or, more precisely, generalized Newtonian) models take into account the dynamics of changes in blood viscosity depending on the changing shear force, which is especially important at low blood flow rates. Among these models, one of the most famous is the Carro-Yashid model (Carreau-Yasuda model) [6,7], which reflects the non-linear dependence of dynamic viscosity on shear rate [8,9] and looks like:

$$\eta(\dot{\gamma}) = \eta_\infty + (\eta_0 - \eta_\infty)[1 + (\lambda\dot{\gamma})^\alpha]^{\frac{(n-1)}{\alpha}} \qquad (2)$$

where λ, α, n – constants determined experimentally, in this paper we use constants taken from the work [7]: λ = 46,53 c; α = 0,5; n = 0,342; η0 = 0,15 Pa·c и η∞ = 0,0035 Pa·c.

Note that the Carro-Yashid model describes blood as a non-Newtonian fluid between two limit Newtonian states — at infinitely small and infinitely large shear rates — with asymptotic viscosities η0 and η∞, accordingly [10]. It should also be noted that this model representation is in good agreement with the experimental data presented in [8,9].

A comparative analysis of the calculation results for the Newtonian and non-Newtonian models, carried out in [10], shows that the Carro-Yashid model gives about 10% higher tensile stresses in the walls of blood vessels, which makes it possible to recommend this model as preferred, significant fluctuations in blood flow velocity are expected.

Step 3. From numerous clinical studies [11] it is known that blood vessels (arteries and arterioles) can be represented in the form of a multilayer cylindrical shell. Most often, three layers (three shells) are distinguished in the walls of the artery - the inner layer (consists of a layer of endothelial elastin cells located on the connective layer), medium (elastic tissue and smooth muscle fibers - this is the thickest layer and it "controls" the changes in diameter arteries) and external (consists of collagen connective tissue). An arteriole differs from an artery in that its wall has only one layer of muscle cells, due to which it performs a regulatory function.

The mechanical behavior of the blood vessel wall depends on its structural components. With low internal blood pressure, the main role is played by elastin fibers of the inner layer, with high-collagen fibers of the outer layer, with physiological - both components.

For the case under consideration, we assume that the material of the blood vessel wall is isotropic with Young's modulus E = 500 MPa, Poisson's ratio μ = 0,4 and density ρc = 1378 Kg·m3.

Step 4. To conduct model experiments, it is necessary to determine the initial situation, i.e. set the dimensions of the model area of a blood vessel with a bag-shaped sphere-like aneurysm, choose a scheme for fixing the vessel in the body, establish the initial value of the initial blood pressure in the vessel. Let the area of the artery with an aneurysm spheroid formation is characterized by the following dimensions: length L = 80 мм, diameter D = 20 мм, wall thickness h = 1,5 мм, aneurysm diameter A = 40 мм, offset relative to the axis of the vessel aneurysm S = 24 мм. Let us assume that the blood pressure in the artery is changed from 80 Hg mm (10665 Pa) to 120 Hg mm (15998 Pa), the edges of the blood vessel have a fixed anchorage, the rest of the vessel has no support and the gravity is 0 (i.e. we assume that the simulated blood vessel with blood circulating in it has no weight).

Step 5. After the geometrical model of the object under study is constructed, we will create its finite element

(discrete) model, i.e. on the area of space occupied by the object, we will apply a grid of nodes and elements. Usually the area is divided into more finite elements of relatively simple form, interconnected in nodes. The elements have common nodal points and together approximate the shape of the area.

We will construct a finite-element model of an artery with an aneurysmal formation by splitting the dome of the aneurysm and the cylinder of the vessel into shell elements of a triangular shape (Fig. 5).

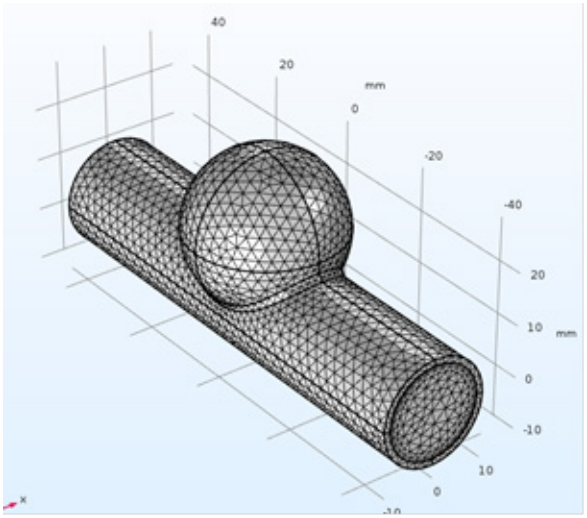

Fig. 5. The finite element grid.

Step 6. In order to solve the multiphysical problem of modeling bag-shaped aneurysm, in principle, you can use the following software environments for finite element modeling: COMSOL Multiphysics [3] and ANSYS [2,4].

The COMSOL software system allows you to model physical processes, which can be described as a system of partial differential equations. With it, you can build finite element models, describe physical processes, form partitioning grids, simulate, and also process calculation results.

The ANSYS software package is designed for structural analysis of engineering and biomechanical structures based on the principles of finite element modeling. With the help of ANSYS it is possible to carry out static, frequency, harmonic, transient dynamic, vibrational structural analysis, as well as finite element analysis - from simple linear static to complex nonlinear dynamic (non-stationary).

Theoretically, COMSOL offers a more correct finite-element design scheme and an intuitive logic of model mapping of mulphysical tasks, however, as applied to the tasks of modeling blood vessels with pathological aneurysmal formations, the ANSYS software system turned out to be more effective in organizing the interface circuit jointly and simultaneously using various design modules and implementing the algorithm solutions of the considered problem. Fig. 6 present this pairing scheme.

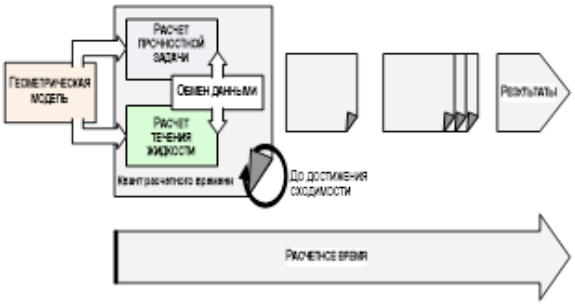

Fig. 6. The scheme of joint solution of multiphysical tasks in ANSYS.

The computational problem in a non-stationary (transient) formulation is based on a single geometric model of the object of research - a vessel (artery) with an aneurysm, including a model of a subregion (domain) in which the blood flow is calculated and the domain of the vessel wall. The computational model process is realized during a given computational (model) time, divided into computational steps (quanta), as a rule, of a fixed size.

Within each quantum, an independent calculation of the strength and hydrodynamic problems takes place. Results are transferred from one domain to another and vice versa. In this case, the force factors of the strength problem affect the shape of the blood flow channel. Theoretically, convergence of the design scheme should be guaranteed by a small time step and automatic restructuring of the computational grid (both of the blood flow channel and the walls). Next, an increment of the estimated time to the specified step occurs, using the results of the previous step as initial ones with the repetition of the process of joint calculation of heterogeneous physical problems.

The described algorithm for solving a model problem with its relatively high labor intensity has certain advantages. In particular, it is very variable and allows the use of various solvers for both the strength problem and the hydrodynamic problem, it is characterized by rather high performance and moderately demanding of computational resources.

The noted qualities made it possible to reproduce the behavior of the blood vessel wall and blood flow under model conditions using the Fluent and Transient Structural modules of the ANSYS package under model conditions, and the Fluent module was used in the double-precision calculation mode. Note also that the need to simulate a nonstationary load in Fluent required the authors to write a small custom UDF procedure.

IV. Results and discussion

We now consider some results of numerical finite element modelling. We will conduct computational experiments with an earlier characterized object - a section of a blood vessel (artery) with an aneurysmal formation, the geometric model of which is shown in Fig. 3, and the characteristic dimensions are indicated in section III of this article. Calculations will be carried out at two values of blood pressure: low - 80 mm Hg. and normal - 120 mm Hg. In fig. Figures 7 and 8 present the results of the

calculations — diagrams of blood pressure distribution in the vessel and stresses in the vessel wall and aneurysm, respectively, with low (80 mm Hg) and normal (120 mm Hg) blood pressure.

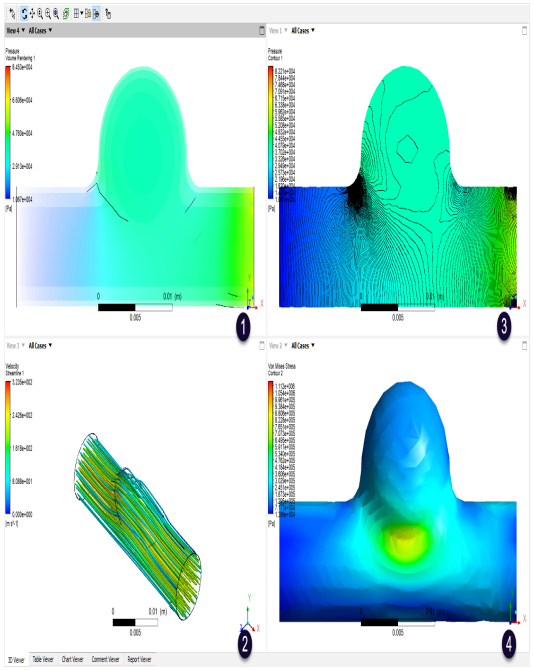

Fig 7. The results of the calculation of blood flow at low pressure (80 mm. Hg). Here: 3 - pressure in the flow in the axial (meridional) section, 4 - stresses in the vessel walls.

In the presented results of model experiments, one can see the blood pressure wave propagating through the vessel (in Fig. 7.1 and Fig. 8.1), and the danger zone exposed to the greatest stresses (in Fig. 7.4 and Fig. 8.4). Also, the analysis of stresses in the vessel walls made it possible to determine the maximum equivalent stresses according to von Mises - see the graph in fig. 9.

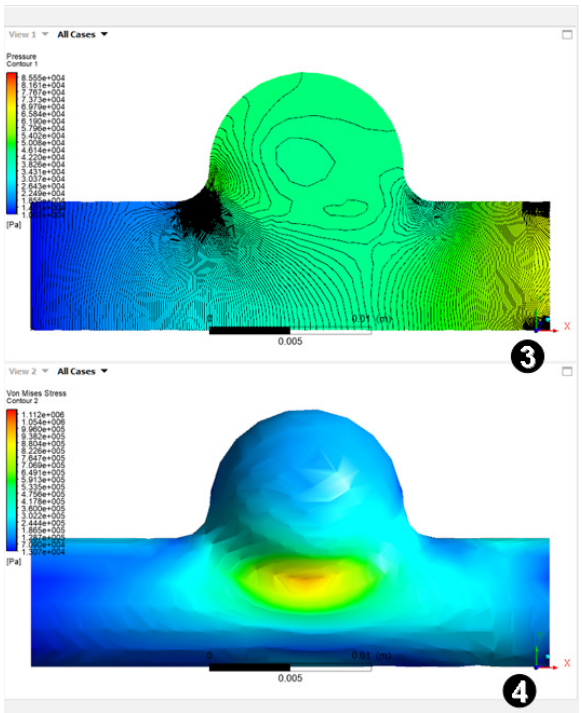

Figure 8. The results of the calculation of blood flow at low pressure (120 mm. Hg). Here: 3 - pressure in the flow in the axial (meridional) section, 4 - stresses in the vessel walls.

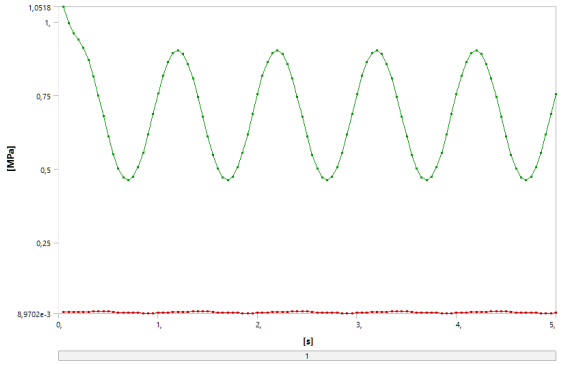

Fig. 9. Graphs of the distribution of blood pressure in the vessel and the maximum equivalent stress according to von Mises in its wall.

From the graph it is seen that the stresses repeat the pressure with some scale factor. This result is not completely physically justified, since it does not demonstrate the expected damped oscillations of the vessel walls and is associated, firstly, with a certain simplification of the artery model with an aneurysm in terms of specifying the vessel fixing mechanisms (fixed support at the ends and missing support on the outer surface) and secondly, using as a source simulating the process of changing blood pressure in a vessel, not a square wave generator, but a sinusoidal load driver.

However, despite the simplifications noted, the finite-element model of an artery with an aneurysm is suitable for computational experiments, since it reflects known patterns and phenomena in vessels affected by aneurysmal formations. At the same time, even the approximate nature of numerical calculations on the model showed that the stresses in the walls at low (Fig. 7.4) and normal (Fig. 8.4) blood pressure differ almost 2 times. From these plots it also follows that the section of the wall of the vessel with the aneurysm, in which the highest stresses are observed, is the zone of transition from the aneurysm to the wall of the bearing blood vessel.

To assess the risk of aneurysm rupture, we plotted surface tangential stress plots at low (Fig. 10) and normal (Fig. 11) pressure of blood in the vessel. In fig. 10 and 11 shows the diagrams of the distribution of tangential stresses in the vessel wall. From the presented plots it is seen that due to the compliance of the wall blood vessel, the danger zone is not on the aneurysm, as such, but on the wall section of the main vessel.

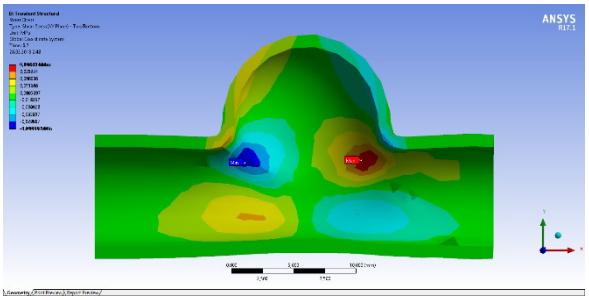

Fig. 10. Distribution of tangential stresses in the vessel wall at low pressure (80 mm Hg).

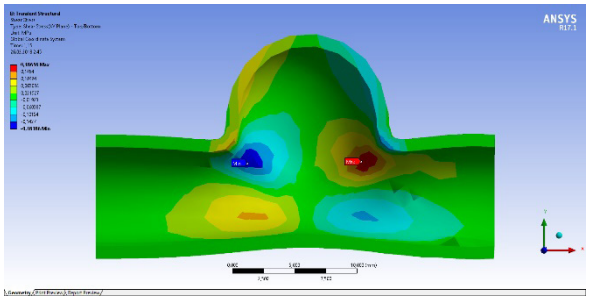

Fig. 11. Distribution of tangential stresses in the vessel wall at normal pressure (120 mm Hg).

V. Conclusions

The application of the finite element method when conducting numerical modeling of biological objects is a relatively new direction in the theory of elasticity. The problems arising in this problem area are characterized by considerable computational and algorithmic complexity, and verification of the results of computational model experiments does not always give unambiguous results and is not always possible. On the other hand, even the construction of a partially simplified finite-element mathematical model of a biological object often makes it possible to conduct a series of virtual numerical experiments and obtain results on the basis of which certain practical conclusions can be drawn and outlines ways to improve and develop methods of finite element modeling of biological objects. This thesis is well confirmed by the finite element model of the saccular aneurysm of the blood vessel described in this article, as well as by the results of computational model experiments in this model. At the same time, the developed model of the vessel with an aneurysm has demonstrated its suitability and it can be argued that it has practical prospects for use and its further improvement.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 258-261

Dynamic Nature of Hydrological Similarity

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***Abstract*—Nowadays, there is a growing interest in understanding how water bodies and their catchments react to environment, landscape and climate change. Runoff change is an integral indicator of climate and landscape changes. Similar landscapes form a similar hydrological catchment response to precipitation.**

The algorithm for identification of homogeneous groups of catchments (in terms of hydrometeorology) has been developed and tested. The 26 catchments studied are situated in the south-eastern part of the Baltic Sea Basin. Observational data from 1986 to 2016 were used for cluster analysis. Catchments clustering over three consecutive ten-year periods has shown some variability in the clusters content due to changes in the hydrological response of the study catchments. The results obtained were analyzed based on both hydrogrometeorological and landscape characteristics.

***Keywords*—clustering, landscape-hydrological similarity, runoff characteristics.**

I. Introduction

Hydrological similarity is not constant, neither are the factors that determine it (stream flow, genesis, landscapes, forest, bog, lake coverage). Under the climate stationarity, the hydrological response can show the landscape changes occurring within catchments, which cannot be identified using the open accessible landscape information in Russia, since it was mainly obtained about 50 years ago and is out of date.

Reliable assessing landscape-hydrological changes over relatively short periods using averaged data is not possible. Therefore, to study intra-annual and inter-annual flow dynamics, daily runoff data for 1986-2015 were used for 26 river catchments in the geologically homogeneous south-eastern part of the Baltic Sea basin.

Creation of such a large database is extremely time and effort consuming. Thanks to modern technologies for processing large data series, it has become possible to carry out broad landscape-hydrological research effectively.

Initially, such studies were carried out in the United States in 2014 [1] and covered the entire country. Based on this experience, the authors have attempted to develop a methodology that would take into account the availability of hydrometeorological data in Russia. The basis of the method is the k-means cluster analysis. Using daily runoff data, four signatures for clustering were calculated. Clustering was carried out in STATISTICA. The ten-year time period was assumed to be long enough to capture climatic variability, but short enough to not be affected by climatic trends.

Clustering results have shown that the content of the three formed clusters does not remain constant, which may be an indicator of the dynamic nature of hydrological similarity.

II. Data and methods

A. Data

Daily runoff data from 1986 to 2007 were digitized from paper-based sources [2]. Since 2008, the data have been available on the website of the Automated Information System of Water Bodies State Monitoring [3]. Gaps in the data series are not more than 5%.

Annual precipitation amounts and average annual temperatures were obtained from the digital archive of the All-Russian Scientific Research Institute of Hydrometeorological Information [4]. Six weather stations were analyzed: Belogorka, Tikhvin, Staraya Russa, Velikiye Luki, Pushkinskiye Gory, Pskov. The analysis has shown the absence of significant trends in annual precipitation over the study period (Fig. 1). However, due to the increase in temperature, the wetness of the territory, estimated by the De-Marton index of aridity index (the ratio of the annual precipitation to the average annual temperature), decreases (Fig. 2).

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4083

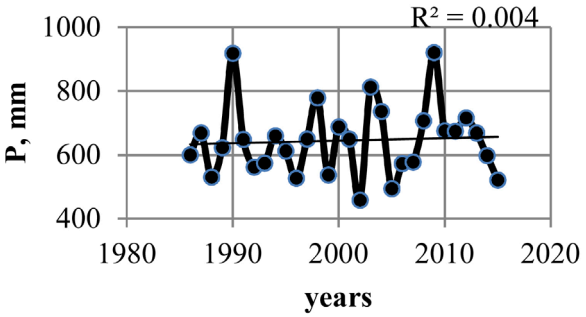

Fig. 1. The long-term course of annual precipitation, Staraya Russa

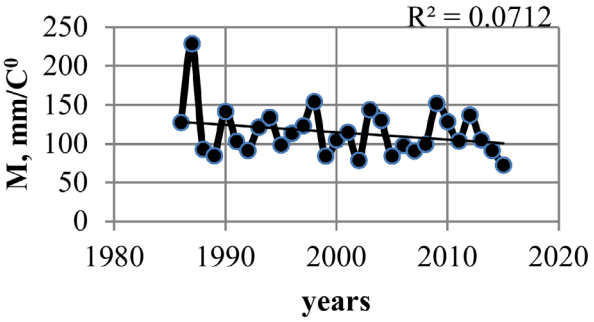

Fig. 2. The long-term course of the DeMarton index, Staraya Russa

Landscape characteristics were used for clustering results analysis: lake coverage (f_{lake}), bog coverage (f_{bog}), forest coverage (f_{forest}), average catchment height (h_{catch}), average catchment slope (I_{catch}). The values of these signatures were obtained from reference books [5].

Clustering signatures

Based on the daily runoff and precipitation observation data, for the three decade periods (1986–1995, 1996–2005, 2006–2015), four signatures were calculated for calendar years.

The complete list of signatures used in this study is the following:

1. Runoff ratio (R, [-]) – the ratio of the average runoff layer (mm) to the amount of precipitations (mm) over the catchment. It was calculated for each catchment for each ten-year period. To better considering the precipitation irregularity over the territory, hydrological posts were referred to the nearest meteorological station.

2. Slope of the Flow Duration Curve (S, [-]) – the slope between the 66% and the 33% flow exceedance percentiles, which is an indicator of streamflow variability [6]. A low value of this coefficient may indicate the prevalence of rain and / or underground feeding of rivers. The signature is defined as,

$$S = \frac{ln(Q33\%) \quad ln(Q66\%)}{(0.66 \quad 0.33)}, \qquad (1)$$

where S − the slope of the flow duration curve, $Q_{33\%}$ − the 33rd streamflow percentile, $Q_{66\%}$ − the 66th streamflow percentile.

3. 10th percentile –10 % streamflow ($H_{10\%}$, [mm]), indicator of high flows.

4. 90th percentile – 90 % streamflow ($H_{90\%}$, [mm]), indicator of very low flows.

Thus, for each catchment, sets of the above signatures were designed for 30 years. To be used for clustering, each signature must provide independent information (Table 1).

TABLE I. Linear correlation values for four signatures used in this study, 1986-1995

	$H_{10\%}$	$H_{90\%}$	S	R
$H_{10\%}$	1	0.66	-0.09	-0.22
$H_{90\%}$	0.66	1	-0.52	0.03
S	-0.09	-0.52	1	-0.47
R	-0.22	0.03	-0.47	1

B. Clustering

K-means method is a cluster analysis method that allows *partition* n observations into k clusters, in which each observation belongs to the cluster with the nearest mean. The Euclidean distance is the proximity measure. The method has gained great popularity due to its simplicity, clarity of implementation, and rather high quality results [7].

After a preliminary generalized analysis of signatures, it was decided to allocate the catchments into three clusters. For each catchment, coefficients of their natural over-regulation were calculated. (Ω), but they were not used during clustering, due to their high correlation with other characteristics. The analysis and results interpretation were carried out taking into account the landscape characteristics of the catchments, based on the landscape-hydrological approach.

III. Results interpretation

As a result, the catchments in Cluster 1 are considered lowlands: their average height is 84 m (Table 2). They have low forest coverage (46%) and high bog coverage (10%). These catchments do not have sufficient natural over-regulation and it first decreases but then increases in the third period. Compared with the catchments in Cluster 3 (Table 4), the catchments in Cluster 1 have insignificant slopes and, as a result, lower runoff coefficients.

TABLE II. AVERAGE VALUES OF SIGNATURES AND LANDSCAPE CHARACTERISTICS, CLUSTER 1

Year	$H_{10\%}$, mm	$H_{90\%}$, mm	S	R	f_{lake}, %	f_{bog}, %	f_{forest}, %	h_{catch}, m	I_{catch}, ‰	Ω
1986-1995	6680	373	0.034	0.35	1.53	9.96	46.3	87	6.68	0.54
1996-2005	5970	343	0.039	0.34	0.79	10	46.2	80	5.8	0.48
2006-2015	4970	262	0.038	0.3	1.33	9.63	45	85	8.38	0.51
Mean	5873	326	0.037	0.33	1.22	9.86	45.8	84	6.95	0.51

TABLE III. AVERAGE VALUES OF SIGNATURES AND LANDSCAPE CHARACTERISTICS, CLUSTER 2

Year	$H_{10\%}$, mm	$H_{90\%}$, mm	S	R	f_{lake}, %	f_{bog}, %	f_{forest}, %	h_{catch}, m	I_{catch}, ‰	Ω
1986-1995	9139	235	0.043	0.47	1	3	41.3	104	4.5	0.49
1996-2005	5095	503	0.027	0.32	3.13	4.83	45.6	123	14.2	0.6
2006-2015	7395	1770	0.015	0.56	2.12	7.37	67.2	158	23.1	0.73
Mean	7210	836	0.028	0.45	2.08	5.07	51.4	128	13.9	0.61

TABLE IV. AVERAGE VALUES OF SIGNATURES AND LANDSCAPE CHARACTERISTICS, CLUSTER 3

Year	$H_{10\%}$, mm	$H_{90\%}$, mm	S	R	f_{lake}, %	f_{bog}, %	f_{forest}, %	h_{catch}, m	I_{catch}, ‰	Ω
1986-1995	7996	1437	0.017	0.5	2.11	8.55	65.5	149	19.2	0.68
1996-2005	7039	1502	0.017	0.48	1.62	9.56	66.7	147	19.2	0.65
2006-2015	6767	800	0.024	0.41	1.85	7.35	59.8	138	9.6	0.61
Mean	7267	1246	0.019	0.46	1.86	8.49	64.0	145	16.00	0.65

Cluster 2 has turned out to be quite unstable, its characteristics vary from period to period by more than 10% (Table 3). As a result, its content is constantly changing. In the third period, this cluster is formed by small catchments with high natural over-regulation (Ω = 0.73), and therefore, the values of the coefficient S, which characterizes the variability of the flow, are minimal (0.015).

Cluster 3 includes quite elevated catchments, the average height is 145 m (Table 4). They have high forest coverage (64%) and relatively high bog (8%) and lakes (2%) coverage. Consequently, the coefficient of natural over- regulation is higher than in other clusters. However, it decreases with time.

TABLE V. CATCHMENTS CHANGING CLUSTERS

Number in the database	**River**	**1986-1995**	**1995-2005**	**2006-2015**
17	Velikaya	3	2	3
25	Uza	1	2	1
26	Plyussa	1	2	1
11	Bol'shoy Tuder	2	1	3
19	Sorot'	1	1	3
13	Perekhoda	2	1	1
23	Cherekha	2	1	1
10	Lovat'	1	2	1
15	Luga	1	2	1
21	Kudeb	1	2	1
18	Alolya	3	3	2
22	Zchelcha	3	3	2

According to the results of clustering over three periods, 14 catchments stayed in the same cluster, but 12 catchments shifted between clusters (Table 5). Several rivers formed stable groups in which they moved from cluster to cluster.

Catchments Uza and Plyussa could shift from cluster 1 into cluster 2 in the second period due to the fact that the high flow and coefficient S significantly reduced. Therefore, the rivers were included in the cluster with smaller average values of these characteristics (second period: cluster 1 $H_{10\%}$ – 5970 mm, S – 0.039, cluster 2 $H_{10\%}$ – 5095 mm, S – 0.027).

Catchment Bol'shoy Tuder is the most unstable. The shift from cluster to cluster is mainly due to changes in the high flow. In the first period, the river is in cluster 2, which is characterized by the maximum average value of the high flow (9139 mm). In the second period, the river goes into cluster 1, since its high flow (6972 mm) is approximately equal to the average value for the cluster (6680 mm).

High and low flows of the Perekhoda and Cherekha rivers are quite changeable. Their shift from cluster 2 to cluster 1 in the second period is probably due to a decrease in the high flow. Besides, cluster 1 in the second and third periods has minimum low flows among the three clusters.

Catchment Lovat' goes from cluster 1 to cluster 2 and then back, possibly due to the variability of average characteristics in cluster 2. In the second period, the characteristics of the cluster ($H_{10\%}$ – 5095 mm and $H_{90\%}$ – 503 mm) and the catchment ($H_{10\%}$ – 4581 mm and $H_{90\%}$ – 585 mm) turned out to be closest.

Catchment Velikaya goes from cluster 1 to cluster 2 in the second period, possibly due to a decrease in high flow. In the third period, the catchment returns to cluster 3, since its low flow becomes close to the corresponding value in this cluster (800 mm).

Catchments Alolya and Zchelcha could go into cluster 2 in the third period, because the average value of the low flow in cluster 3 has changed significantly (800 mm) compared with the second cluster (1770 mm).

The above-described changes in cluster affiliation are shown in Figures 3-5.

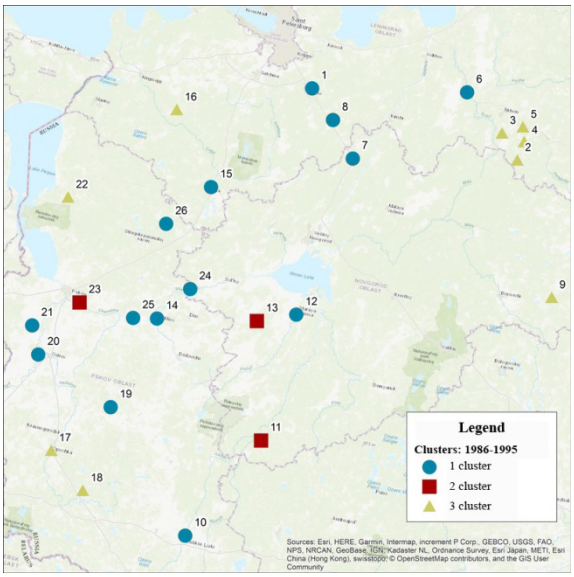

Fig. 3. Geographical location of clusters, 1986-1995.

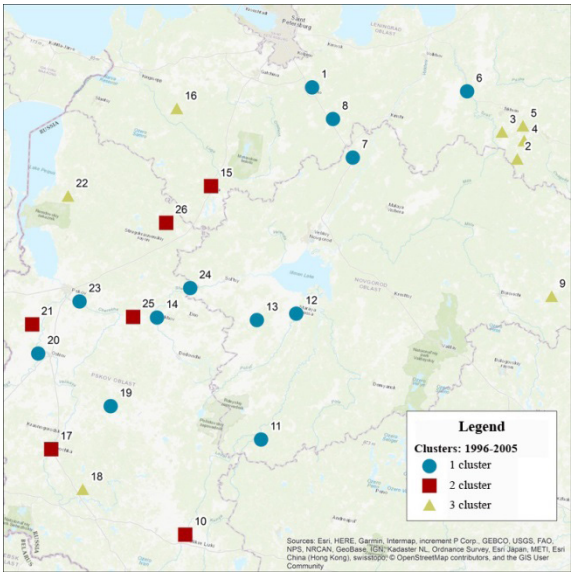

Fig. 4. Geographical location of clusters, 1996-2005.

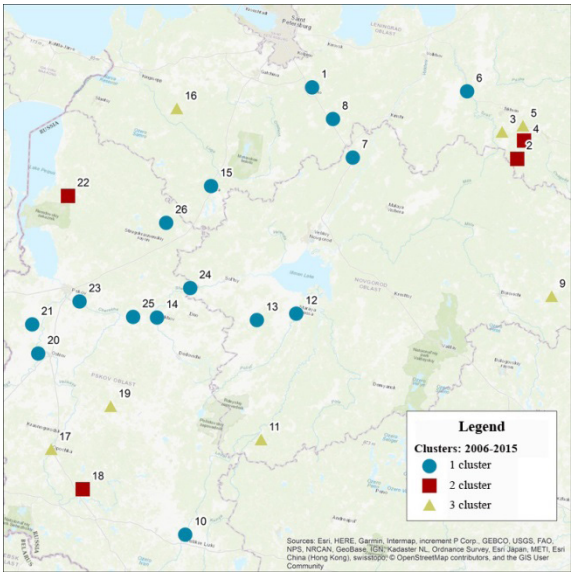

Fig. 5. Geographical location of clusters, 2006-2015.

Conclusions

The authors consider their first attempt to assess the dynamics of hydrological similarity using the clustering method to be quite successful. Catchments clustering can be a valuable tool for understanding hydrological changes, as it allows to compare them with the physical and climatic characteristics.

The observed temporal variability of the catchments behavior was interpreted on the basis of landscape-hydrological analysis. In conditions of a decrease in the wetness of the study area, a decrease in the flow during the study period is observed, what is proved by the previously completed study [8]. Natural over-regulation of most catchments decreases towards the second period and increases in the third one. This may be due to changes in the genesis of runoff and landscape conditions, related to a decrease in the area's wetness.

Nowadays, it is not possible to assess large-scale genetic changes in runoff and landscapes reliably; therefore, the relevance of the proposed approach is obvious.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 262-266

Importance of Catering Enterprises' Classification in Service Guality Assessment From the Customer's Point of View. Case of Rezekne City.

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***Abstract*—There are a lot of catering companies offering their services on the market, hence, there is a fierce competition between them. It is essential to provide customers with the appropriate level of service they expect from the respective caterer (restaurant, café, bar, etc.). The aim of the paper is to explore the importance of classification of the catering companies in service quality assessment from the customer's point of view in Rezekne city. The paper is developed within the framework of the RTA scientific grant "Quality Assessment of Rezekne City Catering Companies". Within the grant project, an expert questionnaire was developed to carry out quality assessment of Rezekne city catering enterprises. As a result of the research, it was concluded that the customer service in Rezekne city differs depending on the type of the catering establishment. The monographic, logical constructive, and graphic method, as well as the method of observation (expert questionnaires) were used for the research.**

Keywords*—classification, foodservice, foodservice industry, Rezekne city catering enterprises.

I. Introduction

Food industry is one of the fastest growing industries, and demand in this field increases rapidly. According statistics, revenue in the Food and Beverage industry amounts to US$ 107,792 M in 2019 [1] and is expected to grow by 2 percent by 2022 [2].

The history of the catering business dates back to the ancient world, when the emperors of the Ancient Rome spent large sums to satisfy their needs transforming a simple kitchen into a horn of abundance. The catering business was born in the ancient world, experienced its decline in the Middle Ages and its rebirth during the Renaissance, developing to the perfection at the present. Therefore, nowadays there are an infinite number of the catering companies with unique history, traditions, culture, organisation of operations and services, and their offer evolves and develops every year [3].

Dining outside is becoming increasingly widespread, people prefer having meal outside for various reasons, for example, entertainment, festivities, and business [4]. Consequently, during the last five decades the number of catering establishments has grown significantly [5], [6]. Dining at the catering establishments is not a part of daily routine, it can be considered as an important entertainment activity [7].

Defining the problem, the authors believe that every entrepreneur, when providing the services, expects there is a demand. Hence, the customer's satisfaction with a particular service is crucial. Thus, the main goal and task of the entrepreneur is to satisfy the needs and wishes of the clients. In order to meet the customers' desires, the entrepreneur has to find out what is important to the client, still, there is always a great contradiction here, as most people want to get the services at the highest possible quality level at the lowest possible price. In this process, one of the most important factors is the quality that characterises the service.

The aim of the article is to investigate the importance of the classification of catering companies in the service quality assessment from the customer's point of view in Rezekne.

The following tasks were set to achieve the aim:

- To explore classification of the catering businesses;
- To classify Rezekne city catering companies;
- To evaluate catering services offered by Rezekne city caterers.

II. Materials and Methods

The article summarises the findings of the authors' research on the quality assessment of Rezekne city catering enterprises. In the paper, the previous researches carried out by the authors, as well as other scientific and practical information was used.

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Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4110

graphic method, as well as the method of observation (expert questionnaires) were used for the paper.

Object of the research: classification of catering enterprises

Subject of the research: quality assessment of catering services

Hypotheses: evaluation of the catering services' quality depends on the type of catering establishment.

III. Results and discussion

Catering is a complicated system providing a staff and the equipment in the process of preparing and serving the food [8]. A commonly accepted definition of the term "catering" or "food service" is "the provision of food and beverages away from home" [9]. The tourism and hospitality glossary defines the catering establishment as a place where public or semi-public catering services are provided offering food and beverages for the consumption [10].

Classifying the foodservice industry can be undertaken in a number of ways; one is to split the industry in two sectors [8]. Lillicrap D. and Cousins J. [11] propose to divide the catering enterprises in two sectors – the first, profit orientated businesses for a restricted market segment (transport catering, clubs, private welfare, industrial (contract)) or for the general market (hotels/restaurants, popular catering, fast food, retail stores, pubs and wine bars, etc.), and, the second, cost provision sector (institutional catering, schools, universities and colleges, hospitals, armed forces, prisons) [12]. In addition to the mainstream restaurants, there are also a number of 'unusual' restaurants which seek to differ themselves by offering unique dining experiences. These include suspended or under-sea restaurants, or establishments that are built entirely of ice [13].

An alternative classification is one where the industry is classified according to its business rationale: where foodservice is either the primary goal of the business; where it is part of the overall experience; an 'additional' offer, used to add-value to the business; or where it is either essential or desirable, but not the primary business goal [14].

There are several principles for classification of catering businesses [15], [3], [16]:

1. By functionality (nature of service):
   - sales of finished goods;
   - sales of finished goods combined with organization of the customer's leisure.
2. By type of production (technical facilities, structure of premises):
   - companies working with raw materials, ingredients – a full production cycle;
   - companies working with semi-finished products – processing (finishing) companies.
3. By structure of customers (distribution market):
   - general access – opened type (general market);
   - closed type (limited market).
4. By assortment (diversity requirements, technological complexity):
   - full service;
   - specialised.
5. By type of service:
   - waiters/ waitresses;
   - self-service;
   - mixed type of service.

After studying different classification systems [15], [16], [17], paying particular attention to the profit-oriented sector, and studying the organisation of the Rezekne catering companies, the authors have come to the conclusion that the catering services can be as well classified as follows:

- Canteen – a public type company, fast service for a wide range of customers to meet their demands, produces and distributes food according to a varied menu.
- Restaurant – an opened type company where catering is combined with organisation of leisure and entertainment. In many Western countries, all catering establishments are called restaurants making a distinction between full-service restaurants (wide choice of food, waiter services); specialised restaurants (fast-food, national cuisine, etc.); self-service restaurants.
- Café, confectionery – a catering company producing and selling a wide range of hot (coffee, tea, cocoa, hot chocolate) and cold beverages and assortment of desserts, for example, ice cream and confectionery.
- Fast-food – catering companies for fast customer service.
- Bar – a small fast service company serving at the counter, offering a wide variety of mixed and pure beverages, as well as some snacks, confectionery. Bars can be classical and specialized. Specialization can be based on the dominant beverage (vodka bar, wine bar, juice bar); musical program (disco bar, jazz bar); customers' interests (sports bar, ladies' bar).
- Buffet – a popular way to cater large groups of people using a minimum number of employees.
- Other catering establishments – mobile catering, catering in public transportation, etc.

Any catering company has a structure of processes including [17]:

- basic processes, the result of which is consumed by the customer (production, customer service, sales, etc.);
- supplementary processes that are essential for provision of the basic processes (purchasing ingredients, personnel management, information systems management, etc.).

Two types of production can be distinguished in the catering business. One is production of tangible products (food and beverages), the other – production of intangible

product (service of providing the finished products to the consumers). Customer satisfaction includes quality of both food and service [18]. Pizam and Ellis [19] review the theory basis underpinning consumer satisfaction.

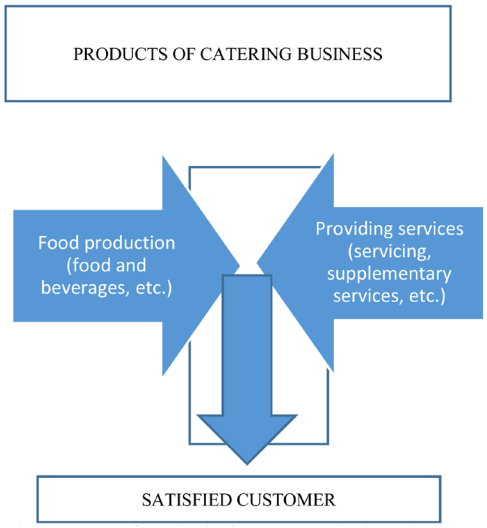


Fig. 1. Nature of catering business product (by the authors)

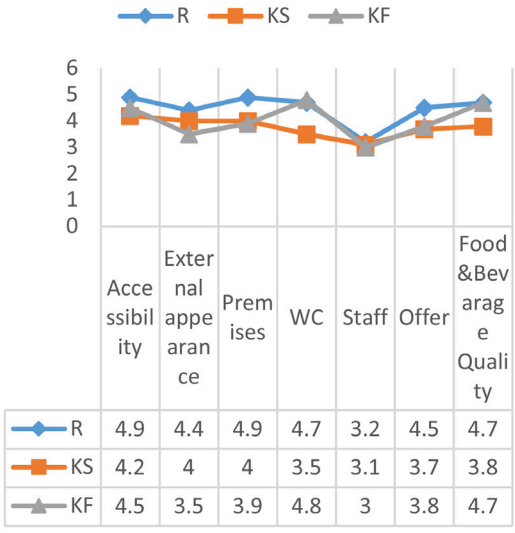
It can be concluded that the product-forming processes, which determine the production of safe, high-quality products and provision of the satisfaction, are crucial in the catering business. The organisation both of information and material flows, or a complex approach, is important for the provision of the services in the company. It is very important to study and analyse the customers' wishes and needs in order to offer a suitable range of food and beverages (tangible product), as well as certain service and supplementary services (intangible product). The share, importance and evaluation of tangible and intangible products vary in the service delivery process. During the flight service, transportation itself will be the most important part of the service, and food as part of the service will be less important, as the customer basically buys transportation rather than meals. In the grocery store, the tangible product itself is important and servicing as well. When choosing a catering company, this proportion will depend on the type of catering company. For the school canteen, food quality, fast service at a low price will be important. At the restaurant, the client wants to receive a high-quality food, high-quality service, taking into account that it will cost more.

Within the framework of the project, from June 2018 to September 2018, classification of Rezekne city catering enterprises and evaluation of the offered services were carried out. The evaluation of the catering companies was based on the observation method (recommended, for example, by I. Millere [17]), which provides that a number of experts make observations, record their observations while actively participating in the process of using the service as a "secret customer", in the result, providing their assessment, conclusions and recommendations on improving the quality of catering services and indicating potential development opportunities for the catering businesses.

In Rezekne city, the catering companies that were evaluated within the study can be classified by combining the above mentioned principles. As a result, in Rezekne city, there are:

- 3 restaurants;
- 4 opened type cafés,
- 11 specialised cafés, including:
  - 1 confectionery concept;
  - 5 fast-food concept;
  - 1 family concept;
  - 4 canteen concept;
- 1 pub.

The authors have carried out the service evaluation of 21 Rezekne city catering company using the observation method and have filled in the expert questionnaire, providing the evaluation and recommendations for the elimination of deficiencies and for business development. The expert questionnaire was composed on the basis of the expert questionnaire [20] developed within the Rezekne Augstskola's ESF project "Development and implementation of professional development programs for employees of catering enterprises of hospitality industry". The expert observation questionnaire consisted of seven sections including the following: accessibility, external appearance of the enterprise, customers' premises, WC, staff, menu, and food and drink quality. In each of the sections, criteria were set which were used to provide assessment on a 5-point scale, where 5 = very good; 4 = good; 3 = average; 2 = unsatisfactory; 1 = weak. The 21 company that was evaluated corresponds to different categories of the catering businesses, therefore, the results were analysed separately for each group of the enterprises. In this article, only restaurants, general type cafés and specialised cafés are analysed, as there are only a few other types of companies, and analysing them would infringe the data confidentiality. Only summarised results are presented providing an average indicator for a particular type of the company (Fig.2).



	Accessibility	External appearance	Premises	WC	Staff	Offer	Food &Beverage Quality
R	4.9	4.4	4.9	4.7	3.2	4.5	4.7
KS	4.2	4	4	3.5	3.1	3.7	3.8
KF	4.5	3.5	3.9	4.8	3	3.8	4.7

Fig.2. Quality assessment of Rezekne city catering companies (by the authors based on the observation data)
*R – restaurant; KS – specialised café; KF – general type café

Criteria to assess accessibility: signs for visitors, parking facilities, accessibility by public transport. The average evaluation is higher (4.9) for the restaurant-type catering establishments, as they are located in the city centre, on the main street, within 300 meters from each other. Specialised cafés are situated throughout the city and have different accessibility, as a result, the average assessment is the lowest (4.2). The company's external appearance was assessed using criteria such as first impression, facade signboard, entrance appearance, and menu at the entrance, references to the special offers and opening hours. The lowest results (3.5) are for general type cafés, as several cafés are located in the residential blocks or business buildings that are not owned by the caterers, so they are not free to place advertisements or make facade repairs and renovations. Customer's premises are characterized by criteria such as first impression, room ambience, overall cleanliness, equipment compliance with the company type, lighting, air quality, noise and other disturbances. The lowest assessment is in general type cafés (3.9), though, it is not particularly high in specialised cafés as well (4.0). Air quality was the most significant factor determining the assessment, as, in many catering companies, the smell of the kitchen could be felt and the overall cleanliness shall be at the higher level. The WC facilities were assessed by criteria such as cleanliness, quality of equipment, accessibility for people with reduced mobility. The overall rating is the lowest in specialised cafés (3.5). In some of them, the cleaning is done regularly, as evidenced by the records in the cleaning schedule, but given the number of customers, this should be done more frequently. In general, almost in all catering establishments of this type, the WC equipment have a high degree of wear and tear. The staff assessment included a large number of evaluation criteria, but they were divided according to the type of catering company, because what is permissible in a general or specialized café is not allowed in a restaurant. These criteria included employee's skills, professional competencies, knowledge, clothing, customer service, etc. The results for all three categories of catering companies were relatively low. In general, among all 7 evaluation sections, this one shows the lowest results. This means that the companies need to consider very seriously the training of their employees and raising their qualifications. In fact, it is a critical point in the customer service. The offer was assessed by criteria such as menu, readability, content, description of ingredients, size of meal, daily or special offers, as well as the same regarding drink menu. The type of company was taken into account in the assessment. In general type and specialized cafés the result is similar (3.8 and 3.7, respectively). The results were significantly influenced by the menu contents and description of ingredients, and special offers. In fact, the rated companies have no offer for people with special dietary requirements. Food and beverage quality was assessed by criteria such as serving temperature, visual appearance, quality, taste compatibility, etc. The specialised cafés have the lowest evaluation in this category (3.8). The main drawbacks that affected the assessment results were match of dish and meal size, as well many companies do not comply with the food and beverage serving temperatures.

III. Conclusions

The prevalence of eating out is increasing in an industry offering a diverse range of outlets, commonly classified into two sectors: profit, private or commercial; and cost, public or welfare/institutional sector. The foodservice industry is an integral and growing component of most economies and therefore offers a vast number of opportunities.

Eating and dining outside involves more than simply matching meals with consumers and the consumption of food; but a myriad or other factors, which can affect choice of the catering establishment by the customer.

There are different types and names of catering establishments, still, the public catering develops its professional orientation mostly due to the development of the customers' fast-service system in its all possible manifestations.

In current market conditions (demanding and selective customers, fierce competition), creative and innovative catering companies will survive and develop. Though, for this to happen, the human resource (a team that develops and builds a catering company) with the necessary competencies in marketing, design, and management is crucial.

Therefore, as a result of this study, it can be concluded that the research hypothesis has been confirmed. A significant part of the surveyed companies have not correctly defined their type of the catering service, as a result, the offer is not properly developed and does not coincide with the expectations of the customers thus affecting the quality of service.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 267-271

Impact of Cluster Ions and Air Pollution on Human Health

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***Abstract*—Maximum permissible concentration of polluting substances in the atmospheric air is defined in the laws and regulations of many countries. The concentration of cluster ions from 400 to 3000 ions per m^3 is generally considered to be appropriate for human health. The author of this article analyses potential cases when air enrichment with air ions could enhance air purification and influence favourably human health. The author also describes possible adverse effects when air ionisation can increase the harmful impact on human body, especially in situations when the concentration of polluting substances exceeds the maximum permissible level.**

***Keywords*— air ions, air pollution, human health.**

Introduction

Air pollution is the main reason of many respiratory tract diseases and even deaths [1]. Air pollution increases the risk of respiratory diseases, such as asthma, respiratory infections, and chronic obstructive pulmonary disease, in children and adults. Maternal exposure to air pollutants mediates both short-term and long-term effects on the respiratory system. [2] Air pollution has many negative health effects on the general population, especially children, individuals with underlying chronic disease and the elderly [3]. Globally, seven million deaths were attributable to the joint effects of household and ambient air pollution. People with chronic respiratory diseases such as chronic obstructive pulmonary disease and asthma are especially vulnerable to the detrimental effects of air pollutants [4]. The problem of air pollution affects not only populated big cities, but it is also becoming more acute in smaller settlements.

It is a widespread belief nowadays that people are spending more time indoors for both work and leisure needs. Deterioration of outdoor air quality will inevitably lead to a deterioration of indoor air quality, as in many cases the quality of outdoor and indoor air is strongly correlated [5]. Indoor pollutants are different from those in the ambient air, although most of them are the same. Nevertheless, indoor air contains all the same pollutants as in the outdoor air, but the concentrations are different, usually lower. Besides the same pollutants as in the outdoor air, there are some other components in the indoor air which come from inside the building. The major sources include combustion of solid fuels indoors, tobacco smoking, emissions from construction materials and furnishings, and poor ventilation. [3],[6].

In order to fight against indoor air pollution, various air purification devices are available on the market. Many of them are based on the principle of air ionisation. Adding a charge to the pollution particles, including PM 10, promotes their formation into larger aggregates and sedimentation by the effect of gravity. Quite good results are achieved when purifying indoor air from cigarette smoke that mainly create PM 10 with a positive charge. Air enrichment with negative light air ions indoors provides good air purification results [7]. Studies on the interactions between air ions and indoor air pollution with aerosols are described in many publications, e.g. Priimann, 1984 [8], and the use of air ionisation technologies for purifying indoor air from fine aerosols is also quite popular (e.g. Shiue, 2011 [9]). Air ion therapy is even used to improve human health and well-being, cure burns, injuries and various diseases [10].

However, there are some problems in this area, for example, artificial air ionisers contribute to increased ozone concentrations indoors, which can considerably exceed levels favourable for humans [11]. Air ionisation is also used in airtight rooms where people are present, such as submarines and space ships, but the air there is always chemically cleaned too, for example by means of a special sorbents or electric membranes [12].

The content of both positive and negative air ions in the air has a significant impact on physiological processes in the human body, thus affecting the state of human health, mental and physical capacity, and well-being. Knowledge gained through scientific research about the role of air ion concentration in ensuring optimal human performance (e.g. Reinet, 1983; Hawkins, Barker, 1978; Hawkins, 1981) has already been incorporated into the national legislation of several states [13], [14], [15].

On 16 June 2003, sanitary and epidemiological rules and regulations "Hygienic Requirements for the Air-Ion Level of Industrial and Public Facilities SanPin 2.2.4

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4162

1294-03 entered into force in the Russian Federation. According to these Requirements, optimal concentration of light negative ions amounts to 3000 – 5000, while concentration of positive ions should be half as much [16].

Similar legislation has been adopted in Ukraine and Belarus. "SanPiN 2.2.4 1294-03" defines requirements for air ion content in spaces where, for various reasons, air ion concentration may not comply with the levels appropriate for human body. Environment favourable for human living should correspond to the following requirements: air ion concentration should be from 400 ions cm^{-3} to 50,000 ions m^{-3}, while the value of unipolarity coefficient should be within $0.4 \leq K \leq 1.0$, i.e. the concentration of negative air ions should be at least equal to or greater than the concentration of the positive ones.

Besides chemical and physical air pollution, the concentration of air ions and unipolarity coefficient K creates an unexplored and undervalued impact on human health. Air ionisation, if $K \geq 1$, in combination with air polluting gases, aerosols and dust, is an additional factor adversely affecting human health and well-being. Under intense air pollution conditions, as a result of chemical ion transformations, a large amount of heavy air ions may occur and have a pronounced negative impact on human health. If the molecules of polluting gases are ionised, they have a stronger negative effect on the nature and on human body.

I. MATERIALS AND METHODS

The author of this article uses and further analyses data on concentrations of light ions and on chemical and physical parameters of the air, as reflected in the doctoral thesis "Impact of Anthropogenic Pollution on Air Ion Concentration" [17]. Concentrations of light air ions, i.e. cluster ions, were measured using a bipolar light air ion counter „Sapfir-3M" whose structure and operation is described in one of the literature sources [18]. The article provides analysis of data available in literature sources concerning the effects of air ions and air pollution on human health.

II. RESULTS AND DISCUSSION

From the point of view of the protection of human health, it is very important to understand the combined impact of air ion concentration and various air pollution components on the body. According to many studies, including those mentioned above [13], [15], air ions, in appropriate proportions and required concentrations, are able to compensate for the negative symptoms caused by air pollution. Light air ion therapy is used in the treatment of respiratory and pulmonary diseases, hypertension, tachycardia, excessive nervous excitability, spasms, etc. This suggests that there is an area where the beneficial or curative impact of air ions on the body can compensate for the negative effects of pollution. For example, increased CO_2 concentration causes accelerated pulse, breathing and sweating, but these problems can theoretically be compensated by an appropriate increase in the concentration of light air ions.

On the other hand, ionisation as such can increase the harmful effects of pollutants, because, by entering the body in an ionised state, the harmful substance enters the metabolic process faster and more efficiently. The toxic effects of pollutants, both aerosols and gases in ionised state, may increase from a few percent up to several times depending on the nature and degree of ionisation of the substance [19], e.g. toxicity of manganese dioxide aerosols in ionised state increases several times [20]. By studying the harmful impact of vanadium oxides on the body, it has been found that bipolarly ionised aerosols are less harmful than the unipolarly ionised ones, besides negative heavy ions are not as harmful to the body as positive ions [20]. It is fairly safe to say that air ionisation has a positive effect if concentrations of pollutants do not exceed the maximum permissible concentration (MPC). Otherwise, formation of heavy aerosol ions at high concentrations is encouraged. For example, in order to maintain the required air ion concentration in classrooms by using artificial ionisation, the total concentration of aerosol particles (PM 10) in indoor premises should not exceed 0.1 mg/m^3, otherwise the generated light air ions, coming in contact with PM 10, will become heavy and harmful to the students' health [19]. Measuring the concentration of aerosols PM 10 also does not directly demonstrate the presence of smaller aerosol fractions in the air, because heavy air ions are formed primarily from aerosol particles of 10 to 100 nm (the so-called "Aitken mode"), but it has been proven that aerosol fractions of various sizes originated from anthropogenic pollution correlate with each other well enough [21] to assume that smaller fractions are also present in the air after having measured only the concentration of larger particles. It has been found that, when the concentration of aerosols of an average size of 10 nm in the indoor air amounts to 0.1 $mg \cdot m^{-3}$, the concentration of light air ions is very close to zero, while in the indoor air where tobacco smoke with particle size from 10 to 100 nm reaches 0.1 $mg \cdot m^{-3}$, the concentration of heavy ions is 10^5-10^6 cm^{-3}, which is considered to be harmful to human health [22].

Due to the lack of convincing data on MPCs of heavy air ions for the protection of human health and because of the fact that they are not administratively standardised, it is difficult to determine the concentration threshold beyond which a negative impact begins. Heavy air ions are always present in nature because they are natural products of cluster ion ageing. Basing on long-term measurements performed in areas free from anthropogenic pollution, 1200 heavy air ions cm^{-3} [23] can be used as background concentration. It cannot be stated that exceeding this concentration has negative consequences, but it can be assumed that heavy ions at the background concentration level do not have any effect on human health. Chemical composition of heavy air ions is another factor that requires further research, because the negative health effects significantly depend on it.

Nowadays, many different indoor air ionisation

devices are offered on the market, and their advertising usually emphasises the positive impact of air ions on human well-being, but practically none of them provides for simultaneous control of air ion concentration in indoors. Basing on a previous study [17], [24] it can be concluded that air ion concentration of in the indoor air tends to be variable under the influence of various chemical and physical factors; besides both the level of air ion concentration and unipolarity coefficient are most often in the range that is not favourable to human health and wellness, therefore, in order to improve the air quality, it is recommended to use air ionisers that increase and stabilise air ion concentrations and prevent their natural, often chaotic fluctuations.

TABLE I IMPACT OF VARIOUS COMBINATIONS INVOLVING AIR IONISATION AND CHEMICAL / PHYSICAL POLLUTION ON HUMAN BODY

No.	Ionisation degree (cluster ions)*	Degree of chemical pollution, basically CO, NO_x, SO_2	Air ion concentration, including PM 10	Impact on body
1	Optimal	No	No	Optimally favourable
2	Increased	No	No	Curative impact of air ions
3	Very high	No	No	Harmful impact of increased ionisation
4	Very low or non-existent	No	No	Harmful impact of deionised environment
5	Very low or non-existent	Exceeds the MPC	Does not exceed the MPC	Harmful impact of chemical pollution and deionisation
6	Very low or non-existent	Does not exceed the MPC	Exceeds the MPC	Harmful impact of aerosol pollution and deionisation
7	Very low or non-existent	Exceeds the MPC	Exceeds the MPC	Total harmful impact of chemical pollution, deionisation and aerosols
8	Optimal or increased	Does not exceed the MPC	No	Partial compensation of the negative impact of chemical pollution
9	Optimal or increased	No	Does not exceed the MPC	Partial air purification from aerosols – favourable impact
10	Optimal or increased	Does not exceed the MPC	Does not exceed the MPC	Partial compensation of the negative impact of chemical and aerosol pollution
11	Optimal or increased	Exceeds the MPC	Does not exceed the MPC	Additional negative impact of partially ionised pollution
12	Optimal or increased	Does not exceed the MPC	Exceeds the MPC	Formation of heavy air ions, partially negative impact
13	Optimal or increased	Exceeds the MPC	Exceeds the MPC	Negative impact of ionised pollution and heavy ions
14	Very high	Exceeds the MPC	Exceeds the MPC	Strong negative impact of increased ionisation, heavy air ions and ionised pollution

At the same time, there is a need for a daily control of the level of air ion concentration and for regulation of ionisation intensity to keep it within the required limits, because performance of various electronic devices in offices can change the level of air ion concentration, for example, intensive use of a copier significantly increases the concentration of air ions in the ambient air.

The degree of ionisation is an important additional factor that, together with the chemical and physical pollution of the air, affects the human body. Circumstances in which people are exposed to increased air pollution are often associated with a sharp decrease in the concentration of light air ions, or cluster ions. Thus, human body is exposed to the summary harmful impact of air pollution and deionised environment (see table 1, examples 5 and 6). In cases where the level of air pollution is close to or slightly above the MPC and the concentration of light air ions is optimum or slightly elevated (mainly indoors when using artificial air ionisation), partial compensation for the negative effect of pollution can theoretically occur because of the positive impact of air ions (table 1, examples 8 and 9). In order to assess adequate levels of chemical pollution above the MPC and intervals that allow compensation for the harmful effects, further research is needed in the medical and hygiene field, which is currently not sufficient. For this reason, it is not advisable to use artificial ionisation in premises where people are present if the MPC of at least one air quality parameter is exceeded, therefore air purification by ionisers should be performed only when people are not present [19]. The above statements indicate that the impact compensation area can exist when the value of PM 10 is in the range from 40 $\mu g \cdot m^{-3}$ (i.e. MPC of PM 10) to 0.1 $mg \cdot m^{-3}$ because a stable concentration of heavy air ions at a harmful level is reached only when PM 10 amounts to 0.1 $mg \cdot m^{-3}$.

The value of unipolarity coefficient K of both light and heavy air ions is an important factor. Looking at the medical and air quality aspect, it should be $0.4 \leq K \geq 1.0$, but previous studies indicate that it often exceeds the stated value as a result of daily variations, and in places with significant atmospheric pollution the value of K in the long term exceeds 1. [17], [24]

Table 1 theoretically examines various cases where K is within the normal range, but it should be taken into account that elevated or reduced air ion concentration, if K is above 1, in combination with chemical and physical air pollution causes even more harm to human body.

If air pollution consists of a physical component such as PM 10 and its concentration is from $4 \cdot 10^{-5}$ to $1 \cdot 10^{-4}$ $g \cdot m^{-3}$, it is possible to compensate for the impact of pollution by artificial air ionisation, which would facilitate air purification, besides air ions would have a positive effect on human health. In case the particular matter significantly exceeds $1 \cdot 10^{-4}$ $g \cdot m^{-3}$, the amount of heavy air ions created by the ioniser can be excessive, they cannot settle in time or stick to the walls of the premise.

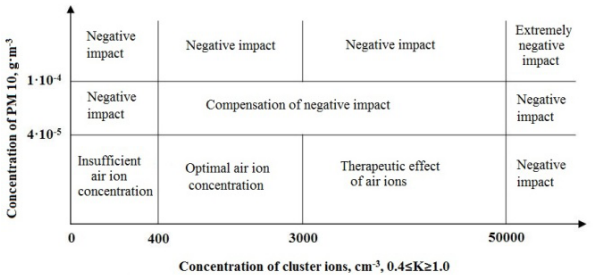
Heavy ions, inhaled in this way, get into the body and can cause specific harmful side effects (see figure 1 a)).

If air pollution consists of a chemical component such as SO_2, artificial air ionisation has a positive effect on humans only if the SO_2 concentration does not raise above the MPC, which in this case is 125 $\mu g \cdot m^{-3}$ (it depends on national legislation in each country). Where the MPC is exceeded, human body is exposed to the impact of SO_2 as a harmful gas, and artificial ionisation only reinforces this effect by making the SO_2 in ionised state easier to be absorbed by human body (see figure 1 b)). In a more realistic case when the MPC of both the physical and chemical pollution components is exceeded in the air, artificial air ionisation will naturally contribute to its purification, but it would not be desirable for a person to stay in such a room. In this case, it is difficult to predict the full range of interactions between pollutants and air ions and to foresee what semi and final products are being formed.

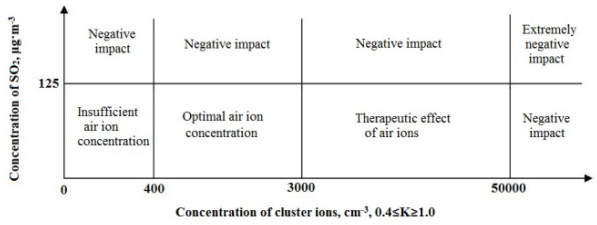
Another additional aspect is the different chemical composition of air ions of both polarities. In some studies, e.g. Patil et al., 2012, it has been found that in the process of air ion formation or artificial generation, oxygen molecules form mainly negative ions, while pollution molecules usually get a positive charge [25]. The predominance of positive air ions is in itself a negative factor for human health, but their chemical composition determines the volume of additional toxicological effects. Light air ions generated by interaction with pollution are transformed into heavy ones and their chemical composition at different stages can vary. This problem requires further in-depth research.

Conclusions

The use of air ionisers as a universal tool for purifying the indoor air and improving microclimate is still under discussion. Artificial air ionisation alone is not enough in cases where concentrations of air pollutants are significantly above the MPC. In addition to ionisation, further air purification by physical or chemical means is required. Ionisation of polluted air contributes to its purification, but this process can also generate ozone, as well as many heavy air ions with variable chemical composition, and these factors are harmful to health. The use of artificial air ionisation in premises with polluted air also requires to control the concentration of light and heavy air ions, besides the control of the chemical composition of the air is also desirable. In order to properly understand the chemical and physical transformation of air ions during the air purification process, further research under laboratory conditions is required.



a)



b)

Fig. 1. Area of the summary impact of atmospheric pollution and concentration of light air ions:

a) with compensation for the negative impact;

b) without compensation for the negative impact.

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Clastic Quaternary Sediments of the Augšdaugava Spillway Valley as Natural Resources – Grain Size Distribution and Micromorphology of Quartz Grains as Indicators for Distinguishing Alluvial and Glaciofluvial Sand Deposits

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***Abstract*—Alluvial and glaciofluvial sand and gravel deposits are the significant natural resources of the Augšdaugava spillway valley. Considering that these sediments differ in granulometric composition and degree of sorting, which in turn determine their utilisation, it is substantially to distinguish sediments of different origin. Hence the main objective of this study was to assess grain size distribution and micromorphology of quartz grains as indicators for distinguishing alluvial and glaciofluvial sands. The grain size distribution has been identified by the laser diffraction method, but the micromorphology of quartz grains has been analysed by scanning electron microscopy. The obtained data indicate that results of the granulometric composition analysis can be used for the discrimination of alluvial and glaciofluvial sediments, in contrast, micromorphology cannot be a reliable diagnostic indicator for identifying the sand of different origin.**

***Keywords*— alluvial sediments, glaciofluvial sediments, grain size distribution, micromorphological analysis.**

I. Introduction

Clastic Quaternary sediments of the Augšdaugava spillway valley, particularly alluvial and glaciofluvial sand and gravel deposits are both the important constituents of the geological structure of the spillway terraces and significant natural resources which can be utilised for economic needs [1]. However, considering that for different sectors of application it is a necessity for non-sorted, or, to the contrary, sorted material [2], it is need for identification, distinguishing and subsequent mapping of sand sediments of different origin. This is important because alluvial and glaciofluvial sediments differ in granulometric composition [3], [4], therefore using of inappropriate material increases the costs due to additional processing, e.g. sieving [5].

Vertical sequence composed of flowing-water material deposits making up terraces in the Augšdaugava spillway valley include sediments deposited by glacial meltwater streams and alluvium left by the river. Distinguishing these deposits from each other and from other similar clastic sediments, e.g., aeolian sands is an essential task in geological survey and mapping of mineral resources. Review of scientific literature reveal that significant efforts have been made on deciphering Quaternary records and elucidation of indicators suitable for discrimination of depositional environments using different sedimentary characteristics [6]-[8]. However, the conventional field studies and examination of sand samples in situ do not allow straightforward and definite distinguishing of glaciofluvial sediments from the alluvial ones. At the same time searches for the ex situ methodology and indicators appropriate for solving of this task is still under development [9].

Hence the main goal of the study presented in this article was to assess grain size distribution and micromorphology of quartz grains as indicators for distinguishing alluvial and glaciofluvial sands. The specific objectives of the study discussed herein were (1) to carry out geological field survey and to collect sand samples from different locations in the Augšdaugava spillway valley for subsequent examination at laboratory; (2) to perform granulometric and micromorphological analysis of collected sand samples; (3) to process the acquired data for obtaining grain-size statistical parameters and their graphic representations; (4) to compare applied research methods and to evaluate the reliability of related diagnostic indicators for identifying the sand of different origin.

II. Materials and methods

The sand samples were collected in different locations of the Augšdaugava spillway valley in the course of the geological field surveys in 2017 and 2018. The natural outcrops of clastic Quaternary sediments and sand-gravel quarries, as well as fluvial landforms like river point bars and mid-channel bars were selected as sampling sites, and their precise location have been georeferenced by GPS.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4094

The shallow check pits had been excavated, only sections of similar lithofacies and with comparable granulometric sediment composition had been chosen for sand sampling. Following the standard procedure described by Evans and Benn [10], one or more representative bulk samples each with a mass of about 200 g were taken from the manually cleaned sections at a depth of 0.6 to 1.2 m and stored in labelled plastic bags. In a total of 51 bulk sand samples for further analysis were collected.

All of the samples were oven-dried at 60°C. Before the grain-size analysis organic matter was removed following the procedure described by Konert and Vandenberg [11], treating the samples with 30% hydrogen peroxide H_2O_2. Pre-treated samples were soaked in a sodium hexametaphosphate $(NaPO_3)_6$ solution (5 g L^{-1}) to break cohesion and then were analyzed with a *Mastersizer 2000* equipped with *Hydro 200MU* dispersion unit in the Laboratory of Quaternary Environment, Daugavpils University. The measurement range of this laser diffraction particle size analyzer is 0.02–2000 μm.

Pre-treated sand samples were gradually suspended in deionised water until optimal obscuration range between 10% and 20% was reached. Then, the suspension was subjected to 60 s ultrasonification at stirrer speed 3200 rpm to achieve homogenous dispersion. The Mie theory was applied for calculating the particle size [12], using a refractive index of 1.333 for deionised water and 1.55 for the particles. The duration of each measurement was 30 s. Considering that possible abnormal values obtained during particle size analysis may affect the reliability of the data, each sample was measured six times to recognize and reject outliers by using of Q-criterion and hence to produce the relevant averaged result. The estimated error of replicate measurements was within 0.3%.

Subsequently obtained records on grain size composition were exported as Excel data tables. It allowed the calculations of the granulometric indicators according to the formulas reported by Folk and Ward [13], i.e., the mean grain size (M_z), the sorting coefficient (σ), and the skewness (S_k) of each sample. For this purposes, GRADISTAT module was applied [14]. The phi unit (Φ) as a logarithmic transformation of grain size metric values into whole integers was used, according to the formula: $\Phi = -\log_2 d$, where d = grain diameter in mm. For graphic representations data of granulometric analysis of each sample were plotted as particle size distribution frequency diagrams.

The micromorphology of quartz grains, i.e. analysis of roundness, relief and surface microtextures has been performed by scanning electron microscopy (SEM). Considering the high costs of SEM method, only 12 samples were selected for analysis from a total of 51 sand samples collected. At first, sand fraction samples with a particle size range of 250 to 500 μm, or from 1 to 2 Φ values, were obtained by the wet sieve method. Prior to obtaining micrographs of quartz grain by SEM, chemical pre-treatment of samples by citrate-bicarbonate-ditionate method has been performed to clean carbonates and iron oxide coatings from the grain surfaces [15]. Using an optical microscope, 25 quartz grains were taken randomly in each of the 10 samples and put on the carbon double sticky tape on top of the SEM specimen holder. The quartz grain specimens were examined by SEM *Phenom ProX* at 15 kV voltage and 400× magnification. For studies of details on the surface of quartz grains and identification of microtextures, higher magnifications up to 2500x were used. In total, 300 micrographs of alluvial and glaciofluvial sand quartz grains were obtained with a SEM. Later micromorphological analysis was performed according to the methodology described in the literature [16], [17].

III. Results and discussion

The analysis of grain size of clastic Quaternary sediments is usually applied to study the transportation and deposition processes, sedimentary environments, and provenance and sources of deposited material [18]. It also can also be used to infer the direct information on the applicability of these natural resources as raw material for using in different sectors of the economy depending on the degree of sorting, e.g. producing of concrete building elements or masonry mortars or fillers, where non-sorted material, or, to the contrary, sorted material is needed, respectively. Thus, the analysis of granulometric parameters of the sediments is the basis for both the obtaining scientific data on transportation mechanisms and the environments and ascertaining the material quality in terms of practical usefulness in the specific sectors. In order to elucidate the possibility to distinguish practically the alluvial sand from the glaciofluvial sand on the basis of granulometric composition, frequency diagrams as graphic representations of grain size distribution were analysed and compared. To illustrate the difference, some samples with grain size distribution characteristics typical for alluvial and glaciofluvial sand are shown below. Common regularity is that alluvial sandy deposits have a predominantly unimodal grain size distribution (Fig. 1A and 1B) with modes typically between 300 and 530 μm.

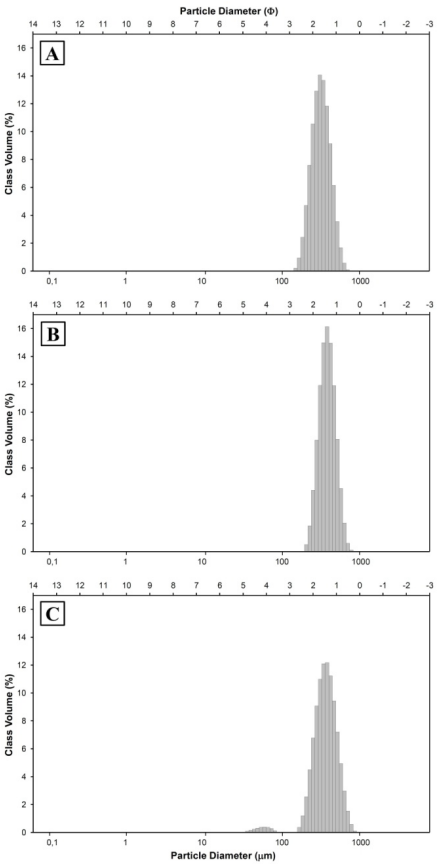

Fig. 1. Examples of grain size distribution of alluvial sediments. Most of the alluvial sand samples have the typical symmetric bell-shaped grain size distribution pattern (A and B), and some samples with asymmetric pattern indicate a presence of finer fractions (C).

Considering that the grain size distribution frequency can be expressed as a unimodal distribution diagram, it indicates that the sample is composed of the single-component deposited sediments. Only some alluvial samples indicate the bimodal distribution (Fig. 1C) associated with the presence of fine silt sediments in the sample. This fact can be explained by the sedimentation environment, determined by a fluvial deposition in relatively slow and steady Daugava river flow. The fining of sediments (bimodal distribution) could be related to gradual decreasing of stream velocity due to changes in discharge, or, to the presence of obstacles, e.g. boulders in the river channel, where sedimentation took place at their leeward side due to slower flow and microturbulence.

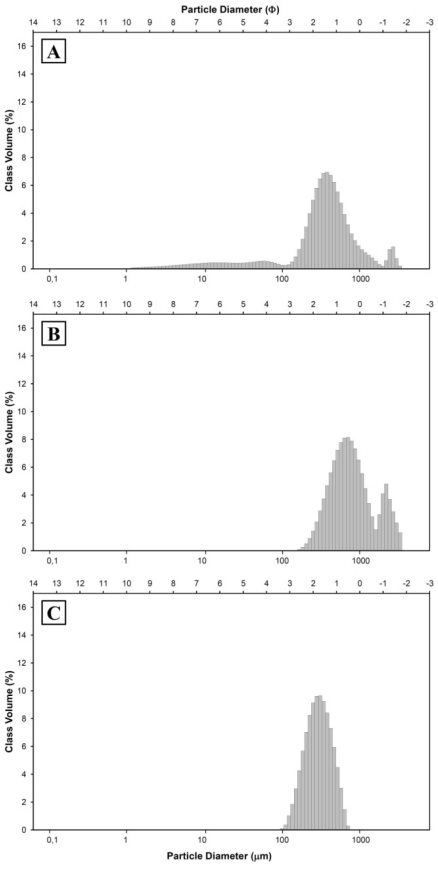

Fig. 2. Examples of grain size distribution of glaciofluvial sediments. Most of the glaciofluvial sand samples have bi- or polymodal asymmetric grain size distribution patterns (A and B), and some samples with symmetric pattern indicate a presence of well-sorted material (C).

In contrary, for glaciofluvial sandy deposits regularity is that they have a predominantly bimodal or polymodal grain size distribution related to the presence of coarser and finer fractions (Fig. 2A and 2B). Only some glaciofluvial samples indicate the unimodal distribution (Fig. 2C). Information given in scientific literature [18] reveals that if the distribution function of a particle size is polymodal, the sample is composed by the summing up and overlapping of several unimodal functions. In other words, the grain size distribution in a sample is composed of multiple fractions of clastic sediments. Hence glaciofluvial sediments tend to a bi- or polymodal grain size distribution, which in turn can be attributed to mixing of clasts of different fractions by high-energy and turbulent glacial meltwater streams.

In addition to grain size distribution analysis, the relationship and variation trends between such grain-size parameters as mean grain size (*Mz*) and sorting coefficient (σ) also was analysed. These data are clues to the deposition mechanisms and can provide insight into the sedimentation environments [19]. The sampled glaciofluvial sands range widely in their mean grain size from sandy fine gravel to fine sand (Wentworth scale) and are positively skewed or near symmetrical with skewness values -0.1 < S_k < +0.30, whilst alluvial sands range more narrowly from coarse sand to fine sand (Fig. 3) and are symmetrical with skewness values -0.02 < S_k < +0.03. The majority of glaciofluvial sand samples are poorly to moderately sorted (σ values > 0.7), with well-sorted sediments being exceptional. In contrary, the alluvial sand samples mainly are well to moderately-well sorted with sorting coefficient values 0.35 < σ < 0.5 (Fig. 3). In general, sorting values confirm the prevalence of water stream transportation and deposition mechanisms. However, there is no clear tend for σ values of both alluvial and glaciofluvial sediments to decrease as M_z values increases, hence regularity that sorting improves as mean particle size decreases had not been observed. Furthermore, significant overlapping of M_z and σ value distribution areas in the graph indicates (Fig. 3), that examination of the relationship between the mean grain size and sorting coefficient apart of other methods cannot be used as a straightforward tool for identification of sand origin; only combination of several techniques provides reliable data.

Considering the aforementioned regularities, it is apparent, that analysis of grain size distribution and statistical parameters is applicable for the discrimination of alluvial and glaciofluvial sediments. Therefore, it is proposed that the difference in granulometric composition of the sand samples could be used as the basis for identification and classifying Quaternary deposits for purposes of the extraction of natural resources.

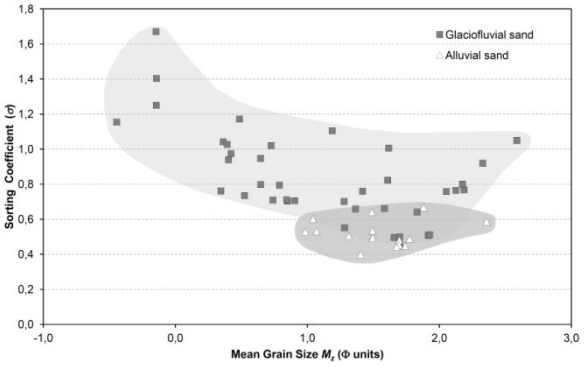

Fig. 3. Relationships between mean grain size and sorting for alluvial and glaciofluvial sands.

The micromorphological examination of quartz grains, including evaluation of their roundness, relief and analysis of surface microtextures by SEM has also been proven as tool for identification of the sedimentary environments, as well as the mechanisms of transportation and deposition of clastic sediments [17], [20]. Data given in the scientific literature indicate that on the basis of SEM analysis of microtextures observed on the quartz grain surfaces, it is possible to identify sands of aeolian origins

from other environmental distinctions [17]. Quartz grains transported in subaqueous environments are usually more rounded, with lower relief and bearing microtextural signs of impacts like V-shaped percussion marks or triangular etch pits. Considering that discharges and velocities of glaciofluvial streams can be some magnitudes higher than fluvial ones, the high-speed flowing glacial meltwater produces more intense and more frequent high-energetic collisions between sand particles than a river, resulting in cracking of grains and formation of specific microtextures. Hence SEM micromorphological analysis of quartz grains was tested as a method for distinguishing alluvial and glaciofluvial sand deposits.

First of all, rounding degree of quartz grains was estimated from SEM micrographs, distinguishing four roundness classes according to Křížek et. al. [21], i.e. angular, sub-angular, sub-rounded and rounded grains (Fig. 4). It was assumed that the higher proportion of angular or sub-angular quartz grains in sand sample could indicate the subaqueous, high-energy fluvial environment related to glaciofluvial type of material transportation. Studies performed by other scientists state that angularity is caused by grain crushing without edge rounding in high-energetic subaqueous environments with limited transport distances [21]. The results show that the proportion of angular or sub-angular quartz grains in samples varies widely from 32% to 12%, however, there is no well-expressed difference between alluvial and glaciofluvial sands.

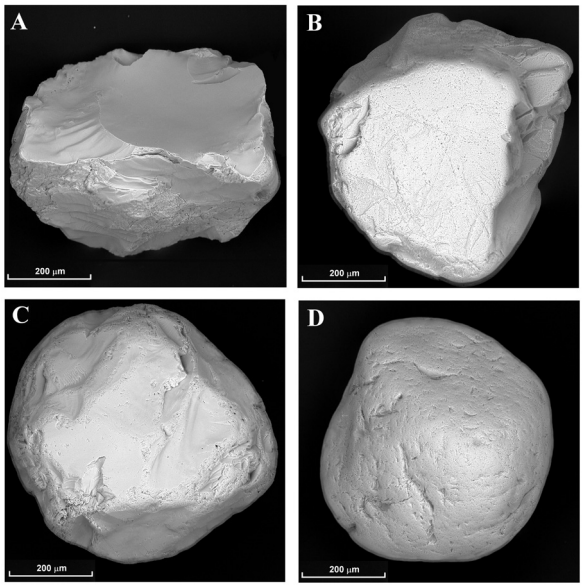

Fig. 4. Representative examples of roundness classes of studied quartz grains: angular (A), sub-angular (B), sub-rounded (C) and rounded (D).

Secondly, the following microtextures were identified on the surface of quartz grains: conchoidal fractures and V-shaped percussion marks (Fig. 5). These features are common for glaciofluvial sediments.

Conchoidal fractures (Fig. 5A) are the slightly curved microcavities with typical, shell-like breakage pattern, which are produced by a powerful impact of other hard mineral aggregates [17]. in high-energy glaciofluvial environments, where collisions between clast particles occur frequently due to high concentrations of poorly sorted sediments, formation of larger conchoidal fractures are common [21].

V-shaped percussion marks (Fig. 5B) are more or less triangular shaped depressions, with dimensions from several µm to some tens of µm. Mahaney and Kalm state that V-shaped percussion marks are formed mainly by impacts in fast-flowing, high energetic subaqueous environments with considerable grain-to-grain contact, such as in the glaciofluvial deposits [22].

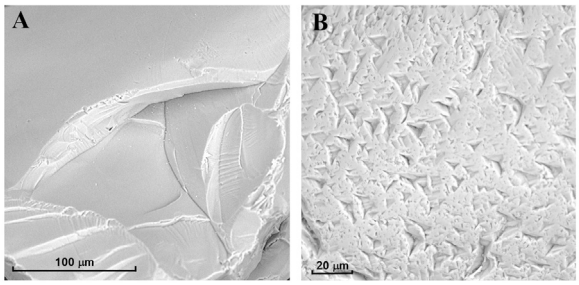

Fig. 5. Studied microtextures as indicators of high-energy glaciofluvial environment: conchoidal fractures (A) and V-shaped percussion marks (B).

Their presence of both types of microtextures was expressed according to Vos et. al. [17] "abundant", when the feature is present on 75% of the grains, "common" 50–75%, "sparse" 5–50%, and "rare" 5%. Considering that, it was expected to find in the glaciofluvial samples the high proportion of quartz grains characterised by abundantly occurring conchoidal fractures. The results of microtextures analysis reveal that both for alluvial and glaciofluvial samples this indicator in average varies from 8% to 25% (maximum 50%) without distinct prevalence in glaciofluvial sand. Hence, despite the expected, the examination of this type of microtextures did not allow to find the distinctions between alluvial and glaciofluvial sands. The similar negative result was obtained in the course of analysis of V-shaped percussion marks. These features occur less than 25% of grains of both sediment types, and, similarly to previous, there is no significant difference between alluvial and glaciofluvial samples, thus making impossible the definite discrimination of samples of different origin on the basis of analysis of V-shaped microtextures.

These findings can be explained by the fact of the geological evolution of the Augšdaugava spillway valley – widening of the valley occurs as a result or river lateral erosion, causing the detachment, entrainment and transport of glaciofluvial sediments making up terraces. During these processes, glaciofluvial sands were reworked and redeposited, and alluvial sediments were enriched by clast grains of glaciofluvial origin. Such a reworked and redeposited alluvial material in the valley can be difficult to identify on the basis of the micromorphological analysis, because the sand grains in this material still retain the indicators of the initial sedimentation environment.

IV. Conclusions

The data obtained in the result of granulometric studies of alluvial and glaciofluvial sand samples indicate

that plots of grain size distribution can be used for the discrimination of alluvial and glaciofluvial sediments. The alluvial sediments show mainly unimodal grain size distribution determined by fluvial deposition in a relatively slow and steady flow, whilst glaciofluvial sediments tend to a bi- or polymodal grain size distribution which can be attributed to mixing of clasts of different fractions by turbulent, fast-flowing glacial meltwater streams. This suggests that grain size distribution at the local scale of the Augšdaugava spillway valley is mainly governed by patterns associated with sediment sources and hydraulic sorting.

If the lithofacies or sand sedimentary structures are similar, or other characteristics are indistinct thus hindering in situ recognition of different genetic types of sandy sediments as natural resources, granulometric analysis can be very useful for distinguishing clastic Quaternary sediments. In this case the grain size distribution of alluvial sand can be described as a unimodal distribution diagram, hence indicating single-component deposited sediments. In contrary, glaciofluvial sand can be described as a bi- or polymodal distribution diagram, indicating multiple-component deposited sediments.

Evaluation of SEM as a method for distinguishing alluvial from glaciofluvial material reveal, that despite the expected, results of the micromorphological analysis indicate that neither microtextures, nor roundness or relief of quartz sand grains differ significantly for both types of Quaternary sediments. Therefore, in the case of the 300 specimens of quartz grains from 12 sand samples studied by SEM it is practically impossible to distinguish the alluvial sediments from the glaciofluvial sediments on the basis of their micromorphology. In fact, based on the different kinds of microtextures observed on the quartz grain surfaces, it is impossible to identify alluvial sands from a glaciofluvial origin. Although there are a number of scientific studies concerning the discrimination between water- and wind-transported sediments, the capabilities of scanning electron microscopy to provide an analytical distinction between two groups of similar sediments deposited in the subaqueous environment are not yet enough. In this context, the question arises of whether the micromorphology of quartz grains can be reliable both in discrimination of sediments and as a diagnostic indicator for identifying the natural resources.

In addition, it should be noted, that the data complex obtained in the result of multiproxy studies of alluvial and glacioaquatic sediments indicates significant changes in transport history and depositional conditions during the development of the Augšdaugava spillway valley. Hence further studies of these issues have to be performed.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 277-282

The Evaluation of Yield and Agronomic Traits of Flax Genotypes Under Latvian Conditions

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***Abstract*—This study aim was evaluated of flax genotypes regarding productivity, resistance to lodging and diseases as well as yield dependence relationships among phenotypic and quality traits. The 14 fibre flax genotypes were evaluated in field conditions on the background of natural infection from 2014 to 2018 for agronomically important traits and from 2015 to 2018 for occurrence diseases of flax. The data were recorded for the 15 following agronomic traits, such days to flowering, days to early yellow ripening stage, total plant height, technical height, stem yield, fibre content, 1000 seed weight, vessels per plant, harvest index, seed yield, oil content, resistance to lodging and fungal diseases during early yellow ripening stage. Genotypic and phenotypic correlations between yield and yield components were identified that total plant height, technical height and days to early yellow ripening stage played a major role on stem yield as well vessels per plant and harvest index on seed yield. The flax genotypes 'Vilani', 'L26-1', 'K9-1', 'T36-1', 'S37-1' exhibited significant highest stem yield ranging from 643.20 to 693.32 g m^{-2} and technical length ranging from 65.90 to 70.58 cm comparing to standard variety 'Vega 2'. The most perspective genotype of 'Vilani' with quit low susceptibility to anthracnose, pasmo and powdery mildew and resistance to lodging was identified.**

***Key words*—agronomic traits, correlations coefficient, diseases, fibre flax, yield**

I. Introduction

Flax a multipurpose crop cultivated for fibre and seeds. Many investigators indicated that flax genotypes significantly differed in their growth habits and their response to cultural practices as well as production of fibre and oil, of them [1] – [4].

Similar like in the Latvia, in the Europe the aims of new flax varieties are: resistance to lodging reaching 9 points of the grade, middle early vegetation period, yield potential of stem reaching 7 – 8 t ha^{-1}, yielding potential of the seeds reaching 1.10 – 1.30 t ha^{-1} in the trials [5]. Yield is the most important and complex trait in crops that show correlations with other traits [6]. Being a polygenic trait it is greatly influenced by environmental fluctuations. To obtain superior varieties with high yielding potential, the plant breeder has to deal with characters, which are governed by polygenic systems and show continuous variation [7]. Other important agronomic traits such as flowering time, plant height, plant branching, and lodging resistance may also indirectly affect yield through various physiological mechanisms [6], [8], allowing crop phenology and plant architecture to be adapted to regional growing conditions, thus avoiding yield and quality losses [9]. Knowledge of association between yield and its attributes obtainable through estimation of genotypic and phenotypic correlation helps to formulate plant breeding strategies to develop suitable genotypes [10], [11]. The positive correlation between major yield components, breeding strategies would be very effective but on the reverse, selection becomes very difficult [12].

Flax yield and profitability can be greatly affected by diseases occurrences. Pasmo, anthracnose, powdery mildew are fungal diseases of flax and attacking all aboveground parts of the plant. These diseases can reduce the yield and quality of seed and fiber raw materials, with most losses resulting from premature ripening and loss of seed during harvest, although reductions in seed number per plant can occur with early infection [13] – [15].

In recent years, it has become more difficult to breed new fibre flax varieties with a better fibre quality, increased fibre yield, and the required resistance, due to repeated use of modern cultivars as crossing parents [5]. Therefore, the aim of this study was evaluated of flax genotypes regarding productivity, resistance to lodging and diseases as well as yield dependence relationships among phenotypic and quality traits.

II. Materials and methods

A. Field Trails

The research was conducted at the Institute of Agricultural Resources and Economics, Research Centre of Priekuli, research unit Vilani since 2014 to 2018 for agronomically important traits of flax and since 2015 to 2018 for occurrence of fungal diseases during early yel-

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4161

low ripening stage. Experimental material for the study consisted of 13 fibre flax genotypes of the Latvian origin "(Table 1)" and 'Vega 2' (ST) as the standard variety of Lithuanian origin. Since 2017 the variety 'Vilani' (breeding line ('I18-1')) has been tested successfully for DUS and for VCU is still on the way.

TABLE 1
ESTIMATED FIBRE FLAX GENOTYPES

Nr.	Geno-type	Nr.	Genotype
1.	S29-1	**8.**	K9-1
2.	S29-2	**9.**	K9-2
3.	S37-1	**10.**	L26-1
4.	S37-2	**11.**	I7-1
5.	T36-1	**12.**	I7-2
6.	T36-2	**13.**	Vilani (I18-1)
7.	T36-3	**ST**	Vega 2

The experiment was set up in randomized block design in three replicates at 2 m^2 with a distance between rows 10 cm. Flax was grown in Humic Gleyic Podzols (*PZ-gl-hu*) soil [16]. The main agrochemical parameters of the arable soil layer were following: humus content – 6.5%, soil acidity (pH_{KCl}) – 6.4–7.0, available P_2O_5 – 130–145 mg kg^{-1} and available K_2O – 118–124 mg kg^{-1} soil. Complex fertilizer NPK 16:16:16 – 300 kg ha^{-1} was applied after first soil cultivation. 1700 flax seeds per 1 m^2 were sown by hand with sowing depth 1.5–2 cm at the field trial. Prior to sowing, germination tests were performed for all used genotypes. Seeds were sown during the first 10 days of May. For plants' further development a surface fertilizer - ammonium nitrate 30 kg ha^{-1} N in fir-tree like phase was applied. Insecticides (Fastac 50 0.4 L ha^{-1}, a.s. 50.0 g L^{-1} alpha-cypermethrin) were sprayed against flax flea beetles (*Aphthona euphorbiae)* as required by the instructions. The tractor-drawn sprayer "Pilmet 412" was used for insecticide application. Fungicides for flax diseases were not used at all. Plants were pulled manually at the stage of early yellow ripeness and then left on ground for air-drying for 5–8 days. The seed-vessels were removed by "Eddi" device. Seeds were cleaned with sample cleaner MLN (Pfeuffer GmbH, Germany). The yield of seeds was weighed and then re-calculated to weight by 100% purity and 12% humidity. Seed oil content was determined on grain quality analyzer "Infratec 1241" (FOSS, Denmark). The total and technical plant heights, fibre content were determined using randomly selected most typical 20 plants in each parcel area before the harvest. The yields of stem and seed were determined in each harvested parcel area. The resistance of plants to lodging, length of growth stages of flax were evaluated [17]. The harvest index (HI) was calculated in percentage as the ratio of seed yield to plant weight after plant maturity [10].

Thirty flax plants from each genotype at the 2 m^2 in the field trails were assessed during early yellow ripening stage under field conditions with natural infection background. The analyses of infected parts of the plants were done following the methodologies developed for phytopathological research [18]. The diseases were determined by morphological features were using disease descriptors [18], [19]. Percentage of the affected plants was estimated and disease severity was recorded for the whole plant for each disease following a five-point scale: 0 – healthy, 1 – weakly affected, 2 – moderately affected, 3 – heavily affected, 4 – very heavily affected or dead plants. Disease severity index "(1)" was calculated by applying formula [18]:

$$DSI = \frac{\Sigma(ab) \times 100}{A \times S}, \quad (1)$$

where DSI is disease severity index, %, a – number of infected plants, b – degree of infection used five-point scale, A – total number of plant samples (healthy and infected), S – the highest degree of infection.

B. Meteorological Conditions

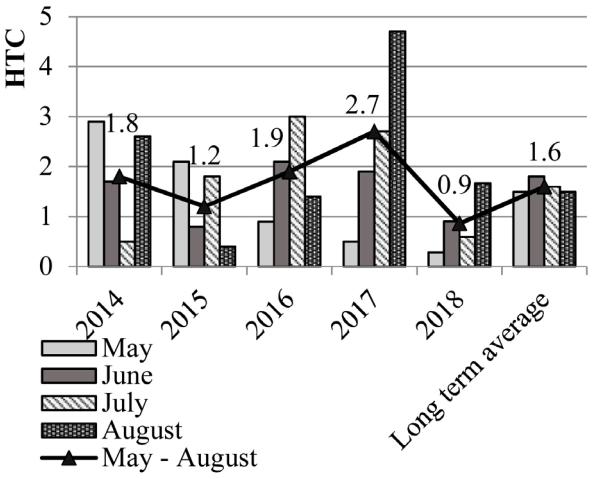

Fig. 1. Hydrothermal coefficients (HTC) during the growth period of flax from 2014 to 2018.

Agro-meteorological conditions were determined by ADCON installed meteorological stations connected to the computer program Dacom Plant Plus. The facility provides information directly to the nearby field trials. In this study hydrothermal coefficient (HTC) of each month was calculated during the growing season "(Fig. 1.)". The calculations were performed "(2)" by applying formula [20]:

$$HTC = \Sigma x / \Sigma t \times 10, \quad (2)$$

where Σx and Σt – sum of precipitations and temperatures in the period, when the temperature has not been lower than 10°C.

Ranges of values of this index were classified according to Sielyaninov in the modification of [21] as: $HTC \leq 0.4$ extremely dry; $0.4 < HTC \leq 0.7$ very dry; $0.7 < HTC \leq 1.0$ dry; $1.0 < HTC \leq 1.3$ relatively dry; $1.3 < HTC \leq 1.6$ optimal; $1.6 < HTC \leq 2.0$ relatively humid; $2.0 < HTC \leq 2.5$ humid; $2.5 < HTC \leq 3.0$ very humid; $HTC > 3.0$ extremely humid.

The hydrothermal conditions during the growing stages of flax differed "(Fig. 1.)". The relatively humid

was recorded in 2014 and 2016 (1.8 and 1.9, respectively), relatively dry in 2015 (1.2) and dry in 2018 (0.9). The very humid was recorded in 2017, especially extremely higher humidity in August, where was about 317% higher than the long-term average.

C. Statistical Analysis

MS-Excel software was used for data statistical analysis and correlations. Significant differences among the measured characteristics of flax genotypes were compared by Fisher's protected least significant difference (LSD) tests ($p \leq 0.05$). Phenotypic and genotypic coefficients of correlation for yield and agronomic traits were identified [22; 23].

III. Results and discussion

All the agronomic traits measures determined for flax were significantly ($p \leq 0.05$) dependent on genotype "(Table 2)". The significant ($p \leq 0.05$) highest total plant height was observed of genotypes 'Vilani', 'K9-1', 'K9-2' and 'L26-1' with the range

from 82.42 to 85.35 cm, the technical plant height of genotypes 'T36-3', 'I7-2', 'T36-1', 'K9-2', 'T36-2', 'Vilani', 'K9-1' and '26-1' with the range from 64.26 to 70.58 cm and the fibre content of genotypes 'T36-3', 'T36-2', 'S37-2' and 'T36-1' with the range from 32.58 to 34.88% compared with the standard 'Vega 2'(ST). A study by [4], [24] has revealed that the plant technical height, fibre percentage and plant type (height, branch number, etc.) are the essential indexes for fibre flax breeding. In this study results was observed variable genetic resources where not all genotypes with highly technical height or stem yield had a great amount of fibre contents. Results have identified the diversity of flax genetic resources with perspective to find out genotypes useful for different purposes.

The significant ($p \leq 0.05$) highest stem yield was observed of genotypes 'S37-1', 'T36-1', 'K9-1', 'Vilani', 'L26-2' with the range from 643.12 to 693.32 g m^{-2} and the seed yield of genotypes 'S37-1', 'Vilani', 'S29-2', 'I7-1' with the range from 136.08 to 147.86 g m^{-2} compared with the standard 'Vega 2'(ST). The harvest index (HI) ranged from 15.49% to 20.87% between genotypes was identified insignificant different. According to [17] the flax descriptors list all genotypes were identified medium vegetation period where average day's number from seedling to flowering ranged from 57 to 61 days and to early yellow ripening stage from 98 to 104 days.

In this study, the genotypic and phenotypic correlation coefficient was similar in directions, while in magnitude, genotypic correlations were mostly higher than corresponding phenotypic correlations "(Table 3)".

TABLE 2
Agronomic traits of flax genotypes

Genotype	ToH, cm	TH, cm	StY, g m^{-2}	FC, %	SY, g m^{-2}	OC, %	HI, %	DF	VP
S29-1	74.80	59.82	538.12	29.58	123.76	42.65	19.19	60	99
S29-2	74.60	60.30	630.46	29.28	**145.20**	43.13	19.13	61	101
S37-1	75.72	60.92	555.32	**34.02**	**136.08**	43.00	20.58	60	102
S37-2	76.86	62.74	**643.12**	29.72	133.88	42.28	17.64	60	102
T36-1	79.46	**65.90**	**643.20**	**34.88**	107.04	**44.70**	15.49	58	99
T36-2	80.78	**67.88**	600.52	**33.68**	114.96	43.85	17.27	58	98
T36-3	77.62	**64.26**	552.96	**32.58**	135.50	**44.85**	20.57	57	99
K9-1	**83.36**	**69.00**	**649.06**	28.00	121.68	43.50	17.15	61	103
K9-2	**83.28**	**67.88**	610.72	26.04	127.22	43.33	18.92	61	103
L26-1	**85.12**	**70.58**	**693.32**	29.26	125.48	43.23	16.58	63	104
I7-1	78.04	63.06	598.32	26.60	**147.86**	41.50	20.87	58	100
I7-2	80.54	**65.86**	617.12	27.48	133.36	42.73	18.40	58	101
Vilani	**82.42**	**67.96**	**668.80**	29.02	**141.06**	42.43	18.68	58	98
Vega 2	72.98	58.32	556.80	26.38	115.28	42.68	18.18	59	101
$LSD_{0.05}$	*8.67*	*5.86*	*86.19*	*3.98*	*22.06*	*0.92*			

ToH- total plant height, TH - technical height, StY - stem yield, FC - fibre content, SY - seed yield, OC - oil content, HI - harvest index, DF - days to flowering, VP - days to early yellow ripening stage; LSD values significant at $p \leq 0.05$ are marked in bold comparing with 'Vega 2' (ST)

TABLE 3
GENOTYPIC AND PHENOTYPIC CORRELATION COEFFICIENTS AMONG THE 11 AGRONOMIC TRAITS OF FLAX GENOTYPES

ToH	TH	StY	FC	SY	HI	VpP	SW	OC	DF	VP	
ToH	-	**0.98****	**0.70****	**-0.10**	**-0.13**	**-0.55***	**0.09**	**0.7**	**0.19**	**0.29**	**0.22**
TH	0.93**	-	**0.70****	**0.03**	**-0.19**	**-0.59***	**-0.05**	**0.26**	**0.30**	**0.20**	**0.14**
StY	0.62*	0.57*	-	**-0.12**	**0.02**	**-0.63***	**0.13**	**-0.29**	**-0.03**	**0.39**	**0.29**
FC	-0.28	-0.17	-0.09	-	**-0.30**	**-0.14**	**-0.65***	**0.36**	**0.64***	**-0.30**	**-0.37**
SY	-0.23	-0.06	0.00	0.17	-	**0.76****	**0.75****	**-0.19**	**-0.53***	**0.02**	**0.05**
HI	-0.54*	-0.54*	-0.80**	0.11	0.56*	-	**0.49**	**0.04**	**-0.37**	**-0.22**	**-0.13**
VpP	0.40	0.19	0.22	-0.51	-0.12	-0.19	-	**-0.36**	**-0.72****	**0.29**	**0.35**
SW	-0.21	-0.10	-0.11	0.11	0.07	0.10	-0.20	-	**0.53***	**-0.76****	**-0.58***
OC	0.17	0.26	0.09	0.34	-0.23	-0.18	-0.40	0.23	-	**-0.17**	**-0.11**
DF	0.23	0.02	0.05	0.05	-0.53*	-0.38	0.28	-0.26	-0.01	-	**0.80****
VP	0.36	0.21	0.59*	0.18	-0.18	-0.64*	0.17	-0.27	0.06	0.63*	-

Genotypic correlation coefficient are marked in bold; ToH- total plant height, TH - technical height, StY - stem yield, FC - fibre content, SY - seed yield, HI - harvest index, VpP - vessels per plant, SW - 1000 seed weight, OC - oil content, DF - days to flowering, VP - days to early yellow ripening stage; * − correlation significant at $p \leq 0.05$; ** − at $p \leq 0.01$

The similar results [7], [10], [25] were obtained that genotypic correlation coefficients were higher than their respective phenotypic correlation coefficients for most of the characters. A study by [26], [27] has revealed that genotypic correlations are higher because of environment had a small role in the expression of the traits, which suggests an inherent association between these traits at the genetic level. In the present study, stem yield showed a positive significant genotypic and phenotypic relationships with total plant height (r_g=0.70**; r_{ph}=0.62*) technical height (r_g=0.70**; r_{ph}=0.57*) and phenotypic relationship with days to early yellow ripening stage (r_{ph}=0.59*). This fact suggests that flax accessions consist genotypes were showed the productivity of stem yield when are the highest plant heights and length of vegetation period. However, in this study stem yield and days to early yellow ripening stage have only phenotypic correlation where open the possibility find out for breeding of early highly productive genotypes. [28], [29] also drew similar conclusions under low correlation between these characters. The negative significant at genotypic and phenotypic level showed relationships harvest index with stem yield (r_g= -0.63*; r_{ph}=-0.80**), total plant height (r_g= -0.55*; r_{ph}= -0.54*), technical height (r_g= -0.59*; r_{ph}= -0.54*).

The positive significant genotypic and phenotypic relationship showed between seed yield and harvest index (r_g=0.76**; r_{ph}=0.56*) and at phenotypic level with vessels per plant (r_g=0.75**; r_{ph}=0.56*) as well significant negative at genotypic level with oil content (r_g=-0.53*). Similar results a findings about seed yield at phenotypic level and at both levels have been reported by [7], [30] – [34]. This analysis was indicated that for fibre flax the highest seed yield when the highest harvest index and vessels per plant.

The inter correlation between yield components characters may affect the plant breeding for component traits either in favourable or unfavourable direction. The positive significant genotypic and phenotypic relationship showed between technical height and total plant height (r_g=0.98**; r_{ph}=93**). The oil content showed a positive significant only at genotypic level relationships with fibre content (r_g=0.64*), 1000 seed weight (r_g=0.53*) and significant negative with vessels per plant (r_g=-0.72**). The 1000 seed weight showed a negative significant at genotypic level with days to flowering and days to early yellow ripening stage (r_g=-0.76**; r_g=-0.58*).

The flax yield formation of the majority of characters depends not on one factor, but on factors system and interaction between abiotic and biotic stresses. The new flax varieties should be resistant to lodging and diseases [35]. In this study the powdery mildew, anthracnose and pasmo severity index variable between the genotypes from 2015 to 2018. The powdery mildew severity index was identified the lowest range of genotypes 'Vilani', 'T36-2', 'T36-1' and highest 'S29-2' during four years period "(Fig. 2.)". The flax genotypes were identified as more susceptible to powdery mildew in the dries years. The all genotypes were showed quite low susceptible to powdery mildew with DSI range from 2.50 to 7.92% and statistically not significant between genotypes.

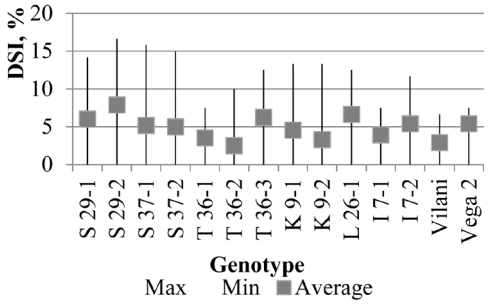

Fig. 2. Powdery mildew severity index during early yellow ripening stage of flax genotypes from 2015 to 2018 ($LSD_{0.05}$ = 8.61)

Anthracnose severity index of flax was identified the lowest range of genotypes 'Vilani', 'Vega 2', 'T36-2' and highest 'I7-2' during 4 year period "(Fig. 3.)". The flax genotypes were showed more susceptible to anthracnose in the humidity years. All genotypes were observed quit low susceptible to anthracnose with average DSI range

from 1.04 to 11.25% and statistically not significant between genotypes.

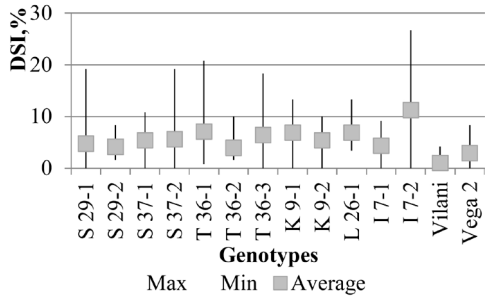

Fig. 3. Anthracnose severity index during early yellow ripening stage of flax genotypes from 2015 to 2018 ($LSD_{0.05}$ = 10.30)

Pasmo occurrence on the flax was identified more in the high humid conditions. The pasmo severity index lowest range of genotypes 'T36-1', 'T36-2', 'Vilani' and statistically significant ($p \leq 0.05$) highest genotypes 'S29-1', 'S29-2' was identified "(Fig. 4.)". The DSI average ranged from 1.46 to 13.13%.

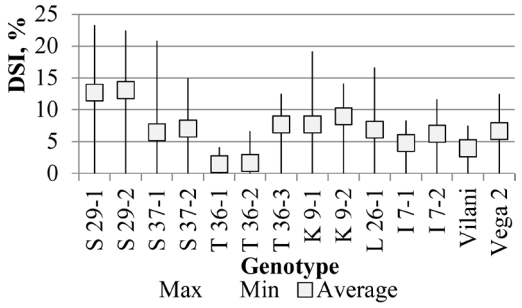

Fig. 4. Pasmo severity index during early yellow ripening stage of flax genotypes from 2015 to 2018 ($LSD_{0.05}$ = 9.60)

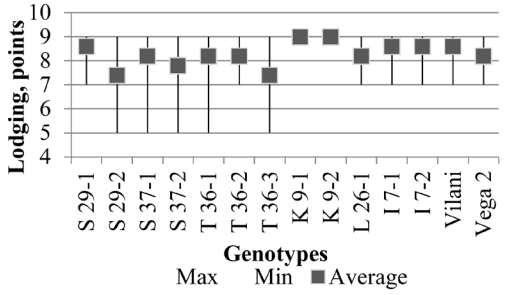

Fig. 5. Lodging during early yellow ripening stage of flax genotypes from 2014 to 2018

The resistance of flax to lodging between genotypes is variable from 2014 to 2018 "(Fig. 5.)". Highest resistance was identified of genotypes 'K9-1' and 'K9-2' as well lowest 'S29-2' and 'T36-3' and its reached up to 5 points in the certain years at the highest humidity conditions.

Summary was identified most perspective genotype of 'Vilani' with quit low susceptibility to anthracnose (1.04%), pasmo (3.96%) and powdery mildew (2.92%) and resistance (9) to lodging.

IV. Conclusions

The flax accessions 'Vilani', 'L26-1', 'K9-1', 'T36-1', 'S37-1' exhibited significant highest stem yield and technical height comparing to standard variety 'Vega 2' and are most valuable and perspective genotypes for flax breeding.

The information on the correlation of yield with related traits is the prerequisite to forming an effective plant breeding strategy aimed at its improvement. Genotypic and phenotypic correlations between yield and yield components were identified that total plant height, technical height and days to early yellow ripening stage played a major role on stem yield as well vessels per plant and harvest index on seed yield for fibre flax genotypes under Latvian condition.

Between all fax genotype were obtained most promising genotype 'Vilani' with complex highest resistance to fungal diseases and good lodging resistance.

V. Acknowledgements

This project "Evaluation of flax and hemp breeding material for integrated farming systems implementation" was financially supported by the Latvian Ministry of Agriculture.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 283-286

Traffic Flow Hypothetical Modelling for Air Quality Improvement and Planning Purposes

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***Abstract*—The main emphasis of this research was to describe air pollution level and dispersion in a typical street canyon (Valdemara Street in Riga (Latvia) city centre), afterward to postulate potential development scenarios and perform modelling in order to understand the influence on air pollution level. For this purpose special mathematical model was used - Operational Street Pollution Model (OSPM), which was developed by the National Environmental Research Institute in Denmark. Following development scenarios were tested: (1) realistic environmentally friendly - decrease of traffic flow by 50 %, as according to street interviews about 36 - 50 % of drivers are ready to change driving habits from car to bicycle; (2) strictly limited – "green light" for public transport, but restrictions for old private cars, flow speed limitations.**

Keywords*—air quality, modelling, street canyons, traffic flow.

I. Introduction

Transport, either private or public, is an integral part of civilization development. Besides with many other benefits, there are many negative aspects – traffic jams, air pollution, noise pollution, massive impact on buildings and vegetation. On the global and also European scale, on-road traffic is well known as one of the main sources of total air pollution within anthropogenic emission field. There is a tendency to introduce tighter emission control schemes and standards, work on air pollution improvement plans in order to reduce public health risks.

Many of previous studies on air quality in the built environment proves that air quality is still to be a primary health risk factor for major population in the world, for example about 54 % of world population in 2014 was overexposed to very high air pollution in urban areas. Moreover, according to tendency analysis exposed population will increase even till 66 % by 2050 [1] and traffic induced emissions are stated as the main air pollution source in cities and agglomerations around world [2, 3, 4]. Various activities concerning different green infrastructures in the urban environment has been has been offered for air quality improvement reasons and in order to develop sustainable city concept as well [5, 6, 7]. Mostly following green infrastructures were proposed: green walls or roofs, street trees, vegetation barriers which to be expected will influence dispersion and depositions processes of air pollutants, either gaseous or suspended [8, 9]. Additionally some microclimatic improvements were expected as green infrastructures potentially may mitigate dangerous impact of heat wave [10]. Some of the researchers describes design of green infrastructures, unfortunately concluding that positive and even negative impacts can occur depending on vegetation specifics. While vegetation aspects are still unclear city planners mainly focuses on traffic flow modulation, speed limitations and some other related activities.

Street canyons are very specific, air pollution is usually trapped by buildings, so the importance of buildings and the shape of their roofs is very important. Before any activities dealing with traffic organization, it is preferable to explore in detail structural specifics of traffic flow, its tendency of movement and influence of meteorological factors.

In street canyons emissions from combustion are produced, mainly in form of nitrogen oxides, particulate matter and carbon monoxide, additionally non-exhaust emissions are possible from mechanical abrasion of brakes, tires and road surfaces. And, also secondary pollutants, mainly in form of particulate matter $PM_{2.5}$, are produced in photochemical reactions between volatile organic compounds, nitrogen monoxide and tropospheric ground level ozone.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4155

II. MATERIAL AND METHODS

A. Site and model description

OSPM (Operational Street Pollution Model) mathematical model was used to estimate NO_x and PM_{10} hourly concentrations in the street canyon of Valdemara Street (Riga, Latvia). This street canyon is busy and irregular as presented in Fig. 1 and 2, has four lanes, it is 20 m wide and orientated South-West to North-East. Buildings on both sides are 25 m high, traffic flow is approximately 52 000 vehicles per day with a fraction of heavy vehicles about 2 - 5 %. Average traffic speed is around 30 - 40 km/h. Fig. 3 illustrates the diurnal variation of hourly average traffic flow for working days. Information on traffic flow, average road traffic speed, and vehicle fleet composition was obtained from local (Riga) municipality.

Fig. 1. Representation of study site, Google Map photography.

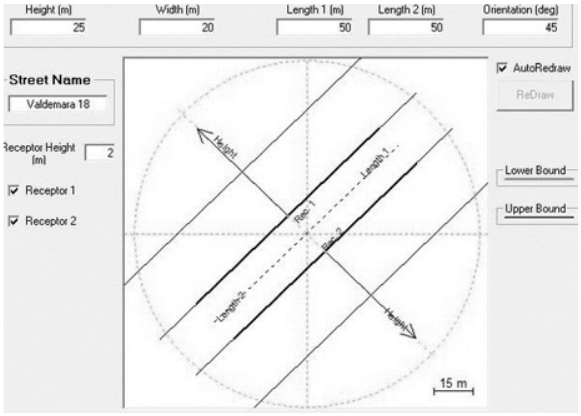

Fig. 2. Street geometry setting in OSPM model.

Used air quality model calculate pollutant concentrations and deposition fluxes using mathematical equations describing the atmospheric transport processes and chemical and physical transformation processes between the points of emissions and the receptor location(s). The main model input parameters in OSPM are summarized in Table 1.

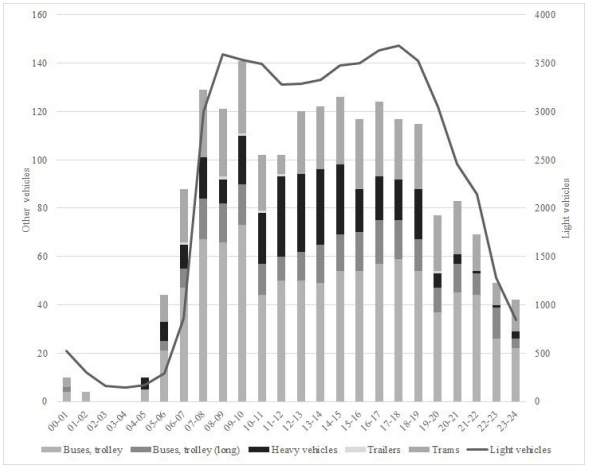

Fig. 3. Diurnal traffic flow in Valdemara Street during working day (April 21, 2010)

TABLE I. MODEL INPUT PARAMETERS

Parameter	Description
α	Slope of emission dispersion plume. Proportion between roof level wind speed and roof level vertical turbulence. Element of denominator in the calculation of chemical residence time.
c	Length of recirculation zone divided by the upwind building height for wind speeds higher than g.
L_t	Upper length of the recirculation trapezium divided by the length of the baseline.
d	Angle of integration in radians for wind speeds higher than i.
f_{roof}	Scale factor to reduce the wind speed from a meteorological mast to roof level.
h_0	Initial dispersion height in the wake of a car.
z_0	Aerodynamic roughness height used to relate roof level wind to street level wind in a logarithmic profile.
g	Wind speed where the recirculation zone reaches its full extent.
i	Upper limit for increased wind direction averaging.
j	Upper limit of interval for which the general building height is taken as the average.
H_{min}	Minimum general building height.
Sp	Aerodynamic frontal area of light duty vehicles.
St	Aerodynamic frontal area of heavy-duty vehicles.
g	Scale factor for traffic produced turbulence.
k	Scale factor to reduce the impact of traffic produced turbulence at the top of the street canyon. Element in the denominator in the calculation of chemical residence time.
γ	Scale factor for ground level wind speed reduction from parallel to perpendicular wind directions.

Following assumptions were taken in account:

(1) mathematical model consists of emissions calculated with COPERT IV methodology [11] and a dispersion model running in series. To limit the scope of the present study the focus was on the parameters related to the dispersion model.

(2) resulting hourly average pollution concentrations of specific substances at the both sides of the street were evaluated. That was calculated as a sum of direct contribution (C_{dir}) and recirculating contribution (C_{rec}) plus background concentration.

(3) the direct contribution is modelled using a simplified Gaussian plume model with a top hat distribution applied to the emission plume. The recirculating contribution is modelled using a trapezium-shaped box model [12, 13, 14].

(4) wind direction, especially for low wind speeds, cannot be assumed as constant over a full hour. To account for this, a numerical wind direction averaging procedure is implemented in the model [15].

(5) the model also contains an algebraic expression for traffic produced turbulence. The expression depends on the number of cars in the street, their respective driving speeds and traffic composition.

(6) most traffic pollutants are assumed to be inert on the time scale of the residence time in a street canyon.

Background concentration and meteorology input data are obtained from the Latvian Environment, Geology and Meteorology Centre and Riga city council monitoring programme. Intensity of traffic are mainly determinates by flow intensity on bridges, daily records during the period 2001-2014 shows that up to the year 2009 as a whole flow distribution are unchanged: average 44 % of total flow crosses the Salu Bridge, 26 – 30 % Vansu Bridge and Akmens Bridge (last two of them closely connected to city centre).

B. Scenario description

Based on a real (the year 2013) analysis several possible future traffic scenarios were analysed. To examine these cases, it was assumed that the meteorological conditions, the geometrical configuration of the street, traffic load and vehicle technology were identical to the values of 2013. Following scenarios were estimated:

(1) SCEN1: restrictions for a light vehicle (private car) flow during working days from 7:00 AM to 7:00 PM;

(2) SCEN2: restrictions for old cars, the movement is allowed for EURO5 or higher standard light cars;

(3) SCEN3: light vehicle traffic is allowed only on holidays;

(4) SCEN4: light vehicle traffic is reduced by 50 %, just two of four lines is scheduled for passenger vehicles;

(5) SCEN5: light vehicle traffic is allowed only on holidays during winter, spring and autumn season, while during summer time no any restrictions are introduced.

III. Results and discussion

Overall, modelling results were obtained for different traffic flows in typical cases; according to OSPM model guidelines, a total of 8 day-type cases were used where daily traffic flow hour-by-hour was described during working days and holidays in January-June and August-December, additionally, 4 different cases were created for July as the most popular summer holiday month.

The most effective scenario for PM_{10} and NO_x concentration decrease was identified as the second scenario (SCEN2: restrictions for old cars, movement is allowed for EURO5 or higher standard light cars), and according to results it could be expected that exhaust concentrations could decrease by 9 µg/m³ for PM_{10} and 90 µg/m³ for NO_x in average. Comparative representation of scenario results is shown in Fig.4 and Fig. 5.

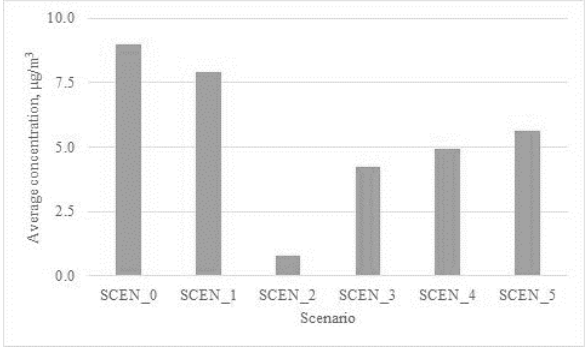

Fig. 4. Average modelled PM_{10} concentration at receptor height (2 m) in street canyon

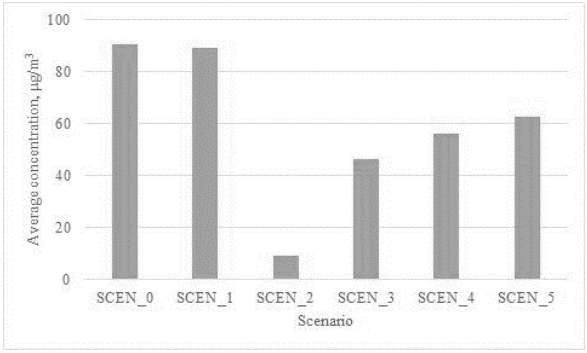

Fig. 5. Average modelled NO_x concentration at receptor height (2 m) in street canyon

IV. Conclusions

In this study, the OSPM scenario analysis methodology was used to predict pollutant levels in Riga city, thereby NO_x and PM_{10} concentration levels in the street canyon were calculated for the zero scenario (real situation) and for five different possible development scenarios in order to introduce restrictions for traffic flow regimes.

Main conclusions are:

(1) traffic flow structural analysis show prevalence of light vehicles reaching at least 96 - 98 % of total flow and 72 % of these vehicles are 11 years old corresponding to EURO3 class;

(2) analysis of PM_{10} and NO_x concentration variations show substantial weekly differences; as most polluted days were identified Wednesdays and Thursdays, while during holidays pollution levels are much lower; in case of PM_{10} concentration differences reach 12 µg/m³, but in case of NO_x even 48 µg/m³ in average;

(3) modelling results show that one of the most effective scenarios could be the scenario with restrictions for old cars when movement is allowed for EURO5 or higher standard light (passenger) cars; in this case effect for several cases could reach 9 µg/m^3 for PM_{10} and 90 µg/m^3 for NO_x in average. As a less effective was identified the scenario with restrictions for a light vehicle (private car) flow during working days from 7:00 AM to 7:00 PM.

Acknowledgements

This study was supported by the Riga City research project DMV-17-60-lī-03.02.2017. The authors wish to thank the Riga City Council and Latvian Environment, Geology and Meteorology Centre for data used in this study.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 287-290

Influence of Flooding on Leaf Cell Membranes of Three Latvian Wheat Cultivars (Triticum aestivum (L)).

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***Abstract*—Flooding occurs in many wheat-growing regions around the world. During flooding, the gas exchange between soil and air decreases and root hypoxia or anoxia is the major cause of plant growth reduction under this stress. The hypoxia stress triggers stimulate the formation of reactive oxygen species (ROS) and induce oxidative stress in plants. The wheat is one of the most important crops in Latvia and in the world. Although wheat is one of the most intolerant crops to soil flooding. To elucidate the mechanisms involved in soil flooding and the tolerance of three Latvian commercial winter wheat (*Triticum aestivum* L.) cultivars: 'Fredis', 'Reinis', 'Brencis' and the flooding induced changes in electrolyte leakage, MDA production, and carotenoid production evaluated. The results indicate, that content of MDA, which reflect the level of membrane lipid peroxidation, differ, but no significant decrease of MDA concentration in cultivar 'Brencis' caused by increased activity of the antioxidant system. The differences in total carotenoids content in investigated wheat cultivars under simulating natural flooding founded. The most active accumulation of total carotenoids observed in the cultivar 'Reinis'. The results demonstrate increased electrolyte leakage in cell membranes of the first leaves in all investigated wheat cultivars compared to control. Under flooding, the first leaf of wheat influenced by lower water temperature compared to the first leaf of the control group and that decrease the membrane fluidity, which possibly leads to decreased of membrane permeability. This preliminary data shows that one-week flooding influences to the cell membranes of some Latvian winter wheat cultivars, this influence differs, but cultivar 'Brencis' was more tolerant of the flooding.**

***Keywords*— carotenoids, flooding stress, malondialdehyde level, membrane permeability**

I. Introduction

Flooding is one of the remarkable abiotic stresses in most arable farmland for many crops and occurs over vast regions throughout the world adversely affecting approximately 10% of the global land area [1], [2]. Climate change models predict an increase in the frequency of flooding events globally. Flooding occurs in many wheat-growing regions throughout the world, especially irrigated and high rainfall environments. About 10-15 million ha of the world's wheat growing areas are affected by flooding each year [3], representing 15-20% of the 70 million ha annually cultivated for wheat production [4]. Wheat is the most important crop in the world and in Latvia as well and provides approx. 75% of the total cereal production in Latvia. Flooding negatively affect photosynthesis, wheat growth, development and cause significant reduction of their productivity, and also reduce grain yield of winter wheat by 20- 50 % [5].

Soil flooding rapidly depletes soil oxygen and lowers soil redox potential; thereby, the roots suffer a shortage of oxygen and roots aerobic respiration dramatically decreased. This will result in a sharp decline in ATP level. Insufficient energy reduces mineral elements, water absorption, and transportation, thereby, altering diverse aspects of plant metabolism such as accelerating lipid peroxidation and leaf senescence and inhibiting growth [4] − [6]. Membranes are dynamic structures that support numerous biochemical and biophysical reactions. They are also major targets of environmental stresses [7]. The changes frequently related to an increase/decrease in membrane permeability, affecting membrane integrity and cell compartmentation under stress conditions. Malondialdehyde (MDA) is one of the final products of stress-induced membrane lipid peroxidation of polyunsaturated fatty acids [8], and the content of MDA

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4084

reflects the level of membrane lipid peroxidation [9] – 12].

The hydrophobic core of biomembranes composed of polyunsaturated fatty acids is a potential target of attack of active oxygen species, which may directly lead to membrane degradation. When exposed to flooding, plant cell membranes undergo changes in lipid and fatty acid composition in order to maintain chloroplast function. A direct effect of carotenoid pigments on lipid membranes, in particular, the effect on structural and dynamic properties, seems to decrease the lipid membrane susceptibility to oxidative stress [5].

There is wider genetic diversity intolerance to soil flooding among cultivars of wheat [3], [4]. The tolerance of wheat to flooding depends on the ability to change its morphological and metabolic traits in response to the stress for its survival and growth. Therefore, evaluation of flooding conditions appears to be necessary to conserve tolerant genotypes.

The aim of this work was to evaluate the flooding-induced changes in electrolyte leakage, MDA production, and carotenoids content of three Latvian commercial winter wheat (*Triticum aestivum* L.) cultivars.

II. MATERIALS AND METHODS

Plant material and design of the experiment

The seeds of three Latvian commercial winter wheat (*Triticum aestivum* L.) cultivars: 'Fredis', 'Reinis', 'Brencis', from the "State Stende Cereals Breeding Institute", Stende, Latvia obtained.

Etiolated wheat seedlings germinated in dark, on moist filter paper at 26 °C for 24 h before being transferred to black soil. Seedlings of equal length transferred to 0.3 L polyethylene pots containing black soil, seedlings were fixed in small apertures at the top of each container and covered with 10mm thick black soil. Containers were kept in a climate chamber (Sanyo, Versatile Environmental Test Chamber) under controlled conditions (16/8h light/dark cycle at 22/22 °C day/night temperature, relative humidity 80%, and light intensity 15.6 μmol m^{-2} s^{-1}). The 1-week seedling separated into two groups: one group of three winter wheat cultivars continue growth in these conditions, but others group was subject to flooding. After one week of flooding the first leaf was cut; MDA concentration and carotenoids content were measured and the electrolyte leakage was determined.

Measurement of MDA content

The MDA content determined by the thiobarbituric acid (TBA) reaction as described by Ali et al. [19], with slight modifications. Approximately 0.1 g leaf was homogenized with 1 ml of 0.1% trichloroacetic acid (TCA) and centrifuged at 14,000 rpm for 15 min. After centrifugation, 1 ml of the supernatant mixed with 2.5 ml 0.5% TBA in 20% TCA and incubated (95 °C) for 30 min in a water bath (BioSan). Thereafter, it was cooled immediately on ice to stop the reaction and centrifuged at 10,000 rpm for 30 min. Absorbance at 532 and 600 nm was determined spectrophotometrically (Cary 50 UV/Vis Scan, Varian), and MDA concentration was estimated by subtracting the non-specific absorption at 600 nm from the absorption at 532 nm, using an absorbance coefficient of extinction (155 mM^{-1} cm^{-1}).

Determination of electrolyte leakage

The electrolyte leakage determined as described before [11]. The first leaves of three seedlings were immersed in 15 ml of distilled water in a test tube overnight at room temperature. The initial conductivity was determined using a conductivity meter. The tubes were then placed in boiling water for 15 min and cooled to room temperature. Conductivity was again determined. The electrolyte leakage was calculated as the ratio of conductivity before boiling to that after boiling: $EL\ (\%) = (C_b – C_w) / (C_a – C_w) * 100$, where C_b is the ratio of conductivity before boiling, C_a is the ratio of conductivity after boiling, and C_w is the conductivity of dH_2O.

Measurement of total carotenoids content

Leaf material (0.2 g) homogenized in 80% acetone (4 ml) with the addition of $MgCO_3$ (0.05g). After centrifugation at 14,000 rpm for 15 min (x3) absorbance of each acetone extract of pigments was determined by spectrophotometer (Cary 50 UV/Vis Scan, Varian), wavelengths: 663.0 nm; 646.0 nm; 470.0 nm. The carotenoids concentrations (mg/l) were calculated using formulas: $C_{car} = (1000D_{470}-3.27C_a-100C_b)/ 229$, where C_a – chlorophyll A concentrations ($C_a=12.21D_{663}-2.81D_{646}$), C_b- chlorophyll B, concentrations, D_{663}, D_{646}, D_{470} – optical density. Amount of total carotenoids was determined according to Lichtenthaler [14].

Statistical analysis

To determine the reliability of the results of this research by one-way ANOVA was used. The results presented as mean values ± standard error, with three replications, values of $p < 0.05$ were considered significantly different.

III. RESULTS AND DISCUSSION

To evaluate the flooding influence on some wheat (*Triticum aestivum* L.) cultivars the damage at cell membrane: membrane permeability, membrane lipid peroxidation, and carotenoids, which interact with thylakoid membrane in chloroplasts studied.

Malondialdehyde (MDA) is one of the final products of stress-induced lipid peroxidation of polyunsaturated fatty acids [10] and has been considered as a marker for evaluation of the cell membrane damage under the one-week flooding stress. Malondialdehyde concentration of three Latvian winter wheat cultivars show (Fig. 1) that lipid peroxidation, as indicated by malondialdehyde content, under oxidative stress caused by flooding varies significantly between wheat cultivars. Malondialdehyde

concentration of one cultivar – 'Brencis'– decreased after 7 days of flooding by 6% (0.03 μM g^{-1}), two cultivars – 'Fredis' and 'Reinis' – increased by 17,3% (0.09 μM g^{-1}) and 36,2% (0.15 μM g^{-1}) respectively.

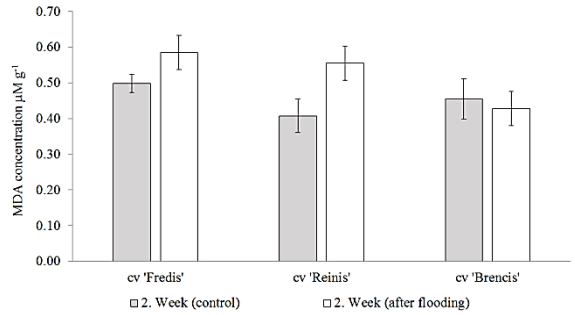

Fig.1. MDA concentration dynamics in the first leaf of three *Triticum aestivum* (L) cultivars (second week: control and after flooding).

It was shown, that one-week flooding stress decreased electrolyte leakage in cell membranes of the first leaves in all investigated wheat cultivars compared to control (Fig.2) by 14%, 51% and 25% in 'Fredis', 'Reinis' and 'Brencis' respectively. However, despite the highest membrane permeability in 'Reinis' in the control, the strongest decrease in membrane permeability was observed after one-week flooding stress in comparison with other cultivars.

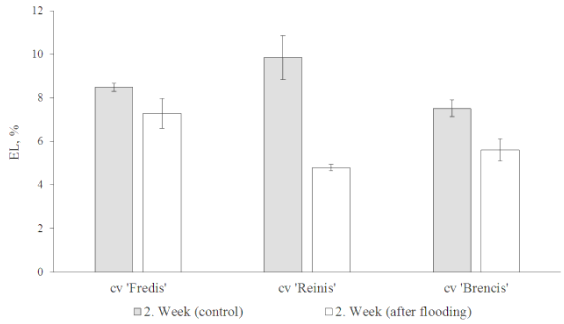

Fig.2. Electrolyte leakage (EL, %) dynamics in the first leaf of three *Triticum aestivum* (L) cultivars (second week: control and after flooding).

Carotenoid pigments incorporate to the lipid bilayer system of the thylakoid membrane in chloroplasts. At the end of the first week of modulated seasonal flooding, there was an insignificant accumulation of total carotenoids compering with water non-submerged samples in all wheat cultivars. The differences in total carotenoid content after simulating natural flooding in investigated wheat cultivars found. The changes in the sum of total carotenoids did not exceed 12% compared to control (in absolute values ranged from 3.12 to 3.54 mg/L, depending on the wheat cultivar) (Fig. 3). The more active accumulation of total carotenoids was observed in the wheat (*Triticum aestivum*, L.) cultivar 'Reinis': 11.86% compared to control (increase on 0.37 mg/L in absolute values).

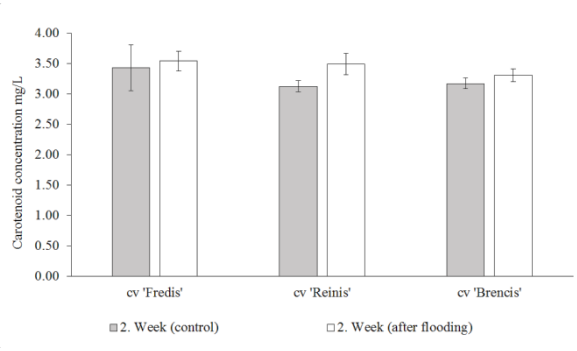

Fig.3. Carotenoid distribution (mg/L) dynamics in the first leaf of three *Triticum aestivum* (L) cultivars (second week: control and after flooding).

Flooding occurs in many wheat-growing regions around the world. During flooding, the gas exchange between soil and air decreases, O_2 in the soil depleted rapidly, and the soil may become hypoxic or anoxic within a few hours. Root hypoxia or anoxia is the major cause of reduced plant growth under flooding stress [15], [17]. Although wheat is one of the most intolerant crops to soil flooding there is wider genetic diversity intolerance to soil flooding among cultivars of wheat [4].

Exposure of plants to most adverse conditions like hypoxia or anoxia causes oxidative stress, which affects plant growth due to the production of reactive oxygen species (ROS) [16]. Increased ROS levels in plant leaves under flooding stress had been reported previously [12].

Hypoxia stress triggers the formation of ROS and induces oxidative stress in plants. Malondialdehyde (MDA) is one of the final products of stress-induced membrane lipid peroxidation of polyunsaturated fatty acids [8], [19], and the content of MDA reflects the level of membrane lipid peroxidation. Our investigation showed that MDA concentration increased in the first leaves in all investigated wheat cultivars compared to control at the end of the first week of modulated seasonal flooding. These changes of MDA concentration differ in investigated wheat cultivars from 6 % 'Brencis' to 36.2% 'Reinis'.

An increase of MDA concentration in the first leaf of two wheat cultivars – 'Fredis' and 'Reinis' – in the experimental group indicates oxidative stress caused by flooding. The decrease of MDA concentration of cultivar 'Brencis' may be caused by increased activity of the antioxidant system.

Thus can assume, that cultivar 'Brencis' has more expressing genes encoding enzymes involved in the antioxidative defense system. The tolerance to stress improved by increased antioxidant capacity and decreased membrane lipid peroxidation. Over generations, many plants have mutated and evolved with different mechanisms to counter stress effects. These include a range of different mechanisms such as accumulation of facultative inducible metabolic adaptations, induction of fatty acid desaturases and heat shock proteins, activation of phytochelatin synthase and metallothionein, activation of alternative respiratory pathways, induction of polyamine synthesis, production of antioxidant enzymes and eco-physiological (carbon assimilation)

adaptations such as increased isoprene synthesis, which includes the large and crucial group of carotenoids [5]. Carotenoids are essential for different plant processes and are potential antioxidants during plant stress. Among the various radicals formed under oxidative conditions in the organism, carotenoids most efficiently react with peroxyl radicals. They generated in the process of lipid peroxidation, and scavenging of this species interrupts the reaction sequence, which finally leads to damage in lipophilic compartments. [13], [20], [21].

The results of our study suggest that flooding insignificantly activate the synthesis of carotenoids, as a response of defensive reaction to one-week flooding [18]. The more active accumulation of total carotenoids observed in the wheat (*Triticum aestivum*, L.) cultivar 'Reinis'.

The different mechanisms effect on carotenoid pigments in lipid membranes, in particular, the effect on structural and dynamic properties, seems to decrease the lipid membrane susceptibility to oxidative degradation. Carotenoids might act as light harvesters, quenchers and scavengers of triplet state chlorophylls and singlet oxygen species, dissipaters of excess harmful energy during stress condition and membrane stabilizers. The increase in electrolyte leakage usually considered as one of the major causes of increased cell membrane permeability of plants growing under different stresses [18]. Our results did not show the increased electrolyte leakage in cell membranes of the first leaves in all investigated wheat cultivars compared to control. However, despite the highest membrane permeability in cultivar 'Reinis' in control, the strongest decrease in membrane permeability was observed after one-week flooding stress in comparison with other investigated wheat cultivars. Polar carotenoids (zeaxanthin, violaxanthin, and lutein) increase the membrane fluidity in the ordered phase of the membrane and decrease fluidity in the liquid crystalline phase of the membranes formed with phosphatidylcholines [5].

IV. CONCLUSION

Under flooding stress, the first leaf of wheat influenced by lower water temperature compared with the first leaf of the control group. That decrease membrane fluidity, which can lead to decreased membrane permeability. This preliminary data shows that one-week flooding influences cell membranes of some Latvian winter wheat cultivars. This influence differs in investigated cultivars, but cultivar 'Brencis' was more tolerant of flooding.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 291-297

Clay Detection in Lakes of Latgale Using Ground Penetrating Radar

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***Abstract*—The most common method to determine the presence of clay in lakebed is coring method. This method requires survey of the whole lake area using stratified sampling method which is time and physical labour consuming process. To lessen the amount of coring samples and narrow the area of clay survey thus making the whole process faster and more effective, research was made to determine the possibility to indentify clay and its sediments using georadar survey or ground penetrating radar (GPR) method. GPR data analysis and coring studies in lake Zeiļu were used to evaluate GPR as potential method in lake clay sediment research. GPR method was tested in summer and winter during ice-covered period.**

***Keywords*—clay, ground penetrating radar, Latgale lakes**

I. Introduction

According to data of Latvian Institute of Amelioration obtained in 1970-ies, in Latvia there are 2256 lakes with a total area of approximately 100 000 hectares, with the water surface area being larger than or equal to 1 hectare. Only 124 of these are larger than 100 hectares. Most of the lakes are located in the uplands, with a great many being in South-eastern Latvia – in the Latgale Upland [1]. That sparks interest of scientific level in terms of industrial application of lake resources.

Lake Plusons research [2] identified clay sediments, clay was located in lake Zeiļu as well. Lake sediment survey is a complicated process that consumes both time and money. Moreover, samples obtained manually provide poor survey area data. Considering this, remote sensory methods provide thorough data about survey region and cost less.

Nowadays geophysical methods for sedimentological analysis of waterbodies are being used more often than traditional methods (e.g., coring and trenching) [3]. Ground penetrating radar technology is nondestructive method that uses electromagnetic radiation in the microwave band (UHF/VHF frequencies) of the radio spectrum, and detects the reflected signals from subsurface structures. The depth range of GPR is limited by the electrical conductivity of the ground, the transmitted center frequency and the radiated power. GPR has been used successfully to aid in geophysical mapping of shallow subsurfaces and constraining problems in diverse fields such as archaeology, environmental site characterization and engineering, glaciology, hydrology, landmine/ unexploded ordnance detection, sedimentology, and structural geology. It can also be applied in groundwater and mineral exploration, forensic investigations and depth soundings through ice or water [3] – [5]. Many researches carried out using georadiolocation method in Latvia and Europe have proven its effectivity and ability to survey waterbodies [6] – [12].

The research goal is to evaluate the ground penetrating radar method data in order to detect clay sediments and their distribution in lakebed.

II. Material and Methods

The ground penetrating radar (GPR) signals could penetrate through fresh water into bottom sediments and hence provide information about geological structure [7], [13]. In addition, the advantage of GPR survey is possibility to obtain a continuous cross-sectional profile or record of subsurface features along the survey line [8], [9]. Hence the application of GPR survey was performed in lake Zeiļu with purpose to test the possibility of clay deposits identification by this shallow geophysical method. The lake is located in the north-western part of Isnaudas rural municipality, Ludzas region, 3 km southwest from Ludza town. The lake embeds in gentle terrain lowering situated in the Rēzekne depression, north-eastern part of the Latgale Upland. The altitude of its water surface is 134.6 m asl. The lake Zeiļu, considering its trophic state, is eutrophic lake with thick layer of bottom sediments, its water surface is almost entirely covered by macrophyte vegetation. The total area of lake is 44.8 ha, its average depth is 1.1 m and maximum depth is 1.6 m [14].

The *GPR Zond 12-e Advanced*, manufactured in Latvia by Radar Systems, was employed for the georadar profiling. A portable *GETAC* computer connected to the control unit allows the direct recording of geophysical raw data and preliminary visualization and monitoring

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4046

of profiles in situ. The alternate application of three transmission frequencies, using shielded 500 MHz and 300 MHz antennas, as well unshielded 75 MHz antennae, was tested to elucidate the best recognition of boundary between lake bottom sediments and bedrock. The data obtained in the course of GPR survey were post-processed and analysed by software Prism 2.60. Processing included the using of time-dependent signal gain function, removing of background signal and application of band-pass filter. GPR profiling was performed on the ice-covered lake in March 16, 2018 and on inflatable boat in June 8, 2018 (Fig. 1).

Fig. 1. GPR measurement lines lake Zeiļu in March 16, 2018 and June 8, 2018

GPR profiling transects for survey in winter, i.e. ice cover period were selected in such a way as to coincide with points where sampling of clay sediment layers in the lake was realised previously. It allows to compare results obtained by conventional geological methods and by geophysical methods. Profiling transects were marked as two lines by several 100 m-long measurement fibreglass tapes. The GPR data was acquired by moving the georadar system along these profiling lines. For the each of applied antennae system GPR profiles were obtained in the course of toward and backward survey along the same transect, subsequently aggregating these measurements into one GPR radargram by software. Besides the using of tapes for marking and measuring of profiles, the length and trajectories of GPR survey lines were fixed by electronic odometer. It allowed to record the position of GPR on the profile and the received signal in the memory of GPR control unit.

Considering that resolution of details recognizable in GPR radargram is proportional to the transmitted frequency of antennae [11], [15], theoretically, the most detailed information about the lake bottom sediment structure could be obtained by using the 500 MHz antennae system. However, due to frequency dependent attenuation and dissipation of electromagnetic waves, GPR signal of such frequency do not penetrate deep enough, allowing to obtain the data only from small depths. Hence antennas with a lower frequency (300 MHz and 75 MHz) were also applied for ensuring deeper penetration, but these antennas provided less resolution in GPR radargrams.

During the ice-free period GPR survey was performed in the southern part of lake Zeiļu, placing antennas on the bottom of a inflatable rubber boat. The dense cover of macrophyte vegetation did not allow to make regular net of GPR profiles, therefore survey lines were chosen

in places with less vegetation density. The length and trajectories of GPR survey lines were fixed by GPS, the location of GPR measurement lines is shown in Fig. 1.

III. Results and Discussions

In the processed GPR profile obtained by geophysical survey with 500 MHz antennae from the lake ice radargram show several strong reflections as horizontal lateral continuity (Fig. 2). This argues for echoes signals or reverberations of the electromagnetic waves within ice cover rather than true signal penetration in water and bottom sediments. This observation can be associated to reverberations of GPR signal in the lake ice caused by the high dielectric contrast between the ice cover in the lake (relative permittivity $\varepsilon_r = 3 - 4$) and the freshwater underneath the ice ($\varepsilon_r = 81$) [15]. The strong reverberations mask the signals from deeper reflections thus making the detection of informative signal impossible. In the upper part of the processed GPR profile obtained by geophysical survey with 300 MHz antennae from the lake ice three main types of GPR signal reflections can be identified: 1) horizontal continuous lines; 2) parabolic curves and 3) horizontal wavelet successions (Fig. 3.). The first type, i.e. horizontal reflections well-expressed in radargram, like the ones obtained by 500 MHz antennae, indicates the reverberations of GPR signal in the lake ice. The second type of reflections (sections 1-2; 3-4 and 5-6 in the Fig. 3) indicates the presence of material with a significant difference in the dielectric transmittance, which creates a parabolic reflection of the georadar signal. In this case such parabolic curves are attributed to small rises of lake bottom or shallows located near to the surface of lake. These features were identified also in the field during the GPR survey thanks to presence of *Salix sp*. bush patches, and appropriately marked in the georadar profile for the later interpretation of data. The horizontal wavelet successions depict the reflected arrivals of GPR signal within the lake water rather than reflections arose from real bottom sediment boundaries. Due to the strong attenuation of electromagnetic waves by clay sediments, the reflections from deeper layers have low intensity, hence avoiding the receiving of informative signal from the boundary between clay sediments and the lake bedrock surface.

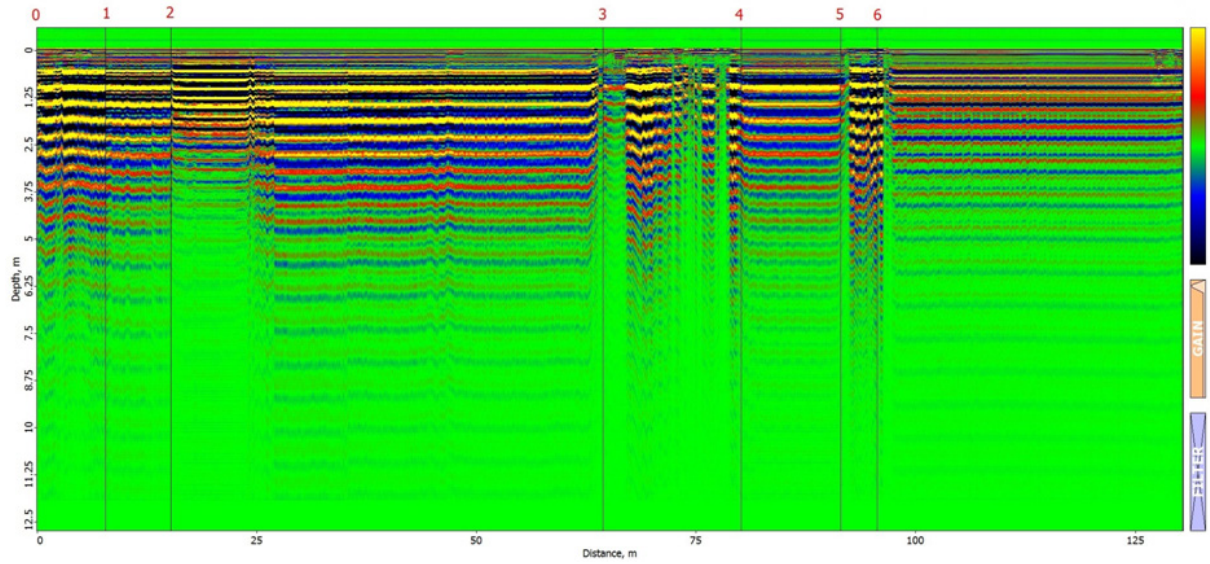

Fig. 2. Radargram showing GPR profile obtained by geophysical survey with 500 MHz antennae from the ice surface

In the processed GPR profile obtained by geophysical survey with unshielded 75 MHz antennae from the lake ice, the bottom of the lake can be identified at the depths from 1 to 1.75 m (white dashed line in Fig.4), associated with high dielectric contrast between the water and bottom sediments. However, due to low vertical resolution of antennae frequency used, the obtained quality of GPR profile is poor. At the same time, as it is aforementioned, strong attenuation of electromagnetic waves by clay sediments constituting bottom sediments avoid the receiving of informative signal and the detection of the clay layers thickness.

Hence in the course of GPR survey during the ice cover period none of applied antenna system provide adequate geophysical data, on the basis of which georadar could be used as method for identification of clay deposits in lake Zeiļu. It can be explained first of all, by thick double-layered ice cover (winter ice and spring frost ice, and layer of thawed water between them), which generates strong reverberation of GPR signal and consequently masking and attenuating informative reflections from deeper media. Secondly, despite the well-recognized fact that fresh water has relatively low attenuation of electromagnetic waves transmitted by GPR antennas, the presence of dissolved solids, as well fine suspended particles, particularly clay minerals particles in the water increase attenuation, causing a strong reduction in depth penetration. This assumption corresponds to data given in scientific literature. Although fresh water has relatively low attenuation, the presence of suspended sediments in the water will increase attenuation, causing a reduction in depth penetration [3]. Together these above mentioned factors favour very strong attenuation of GPR signal, avoiding the receiving of reflections suitable for qualitative visual interpretation and making GPR-based assessments unreliable.

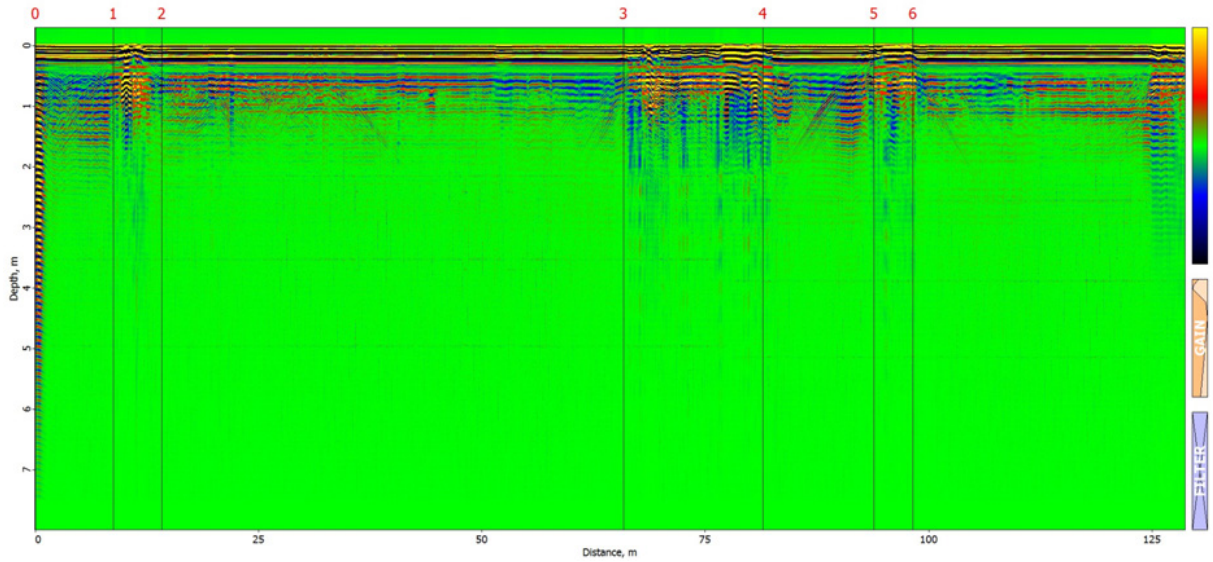

Fig. 3. Radargram showing GPR profile obtained by geophysical survey with 300 MHz antennae from the ice surface

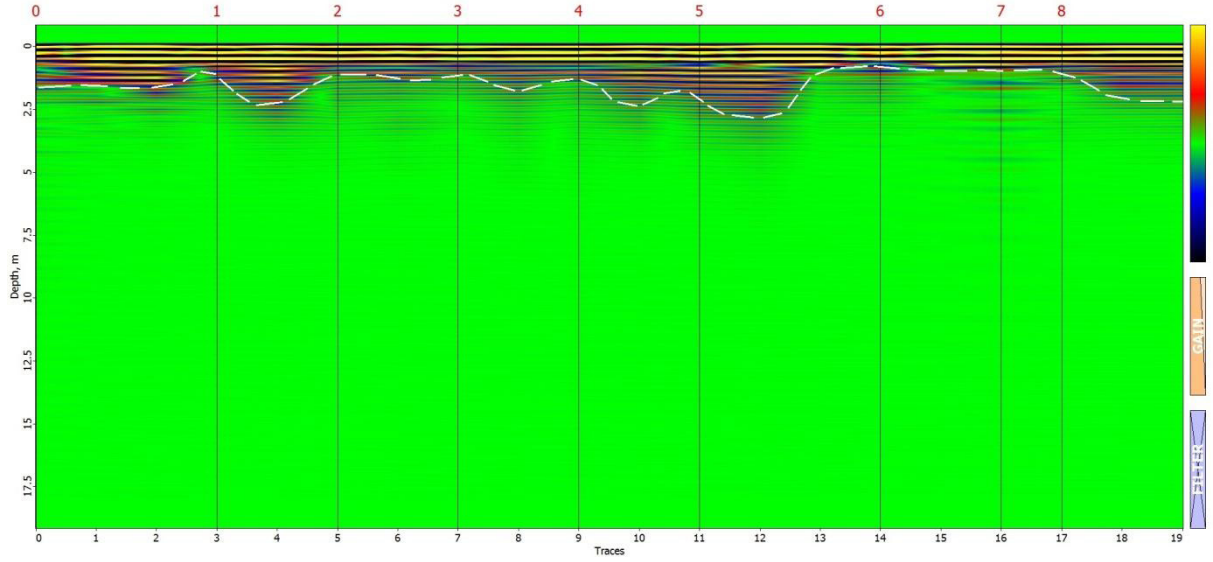

Fig. 4. Radargram showing GPR profile obtained by geophysical survey with 75 MHz antennae from the ice surface

In the processed GPR profile obtained by geophysical survey with 500 MHz antennae from the inflatable boat during summer period radargram show several strong reflections as horizontal lateral continuity and numerous overlapping parabolic curves below horizontal reflections (Fig. 5). The horizontal reflection is caused by sharp physical boundary between two media – air and water with high dielectric contrast between both of them. The parabolic reflections at depth about 1 m indicate the dense cover of submerged macrophyte plant vegetation.

The GPR profiles of the four transects obtained in the course of geophysical survey in summer period are displayed in Figs. 6 – 9. These profiles were additionally processed, using software tools for background signal removing, signal normalization and band-pass filtering. In this case, too, it can be seen reflections of objects at depth ~1 m, which according to the field observations, relate to submerged plant cover. The received signal from deeper layers is not strong enough, to distinguish the reflections from bottom sediments and noise. The assessment of geophysical data obtained during the summer period allow to establish, that lake Zeiļu is not appropriate for detection of thickness of bottom sediment layers by application of GPR survey. The factors, which limit using of georadar for this purpose, could be high density of submerged and underwater macrophytes, e.g. yellow water-lily, water smartweed, elodea etc. The submerged and underwater macrophytes generate multiple reflections at relative small depths (~1 m) and attenuate GPR signal. In addition, physical-chemical properties, i.e. high concentration of suspended sediments in water enhances attenuation of electromagnetic waves, causing a strong reduction in penetration of transmitted GPR signal by increasing of depth.

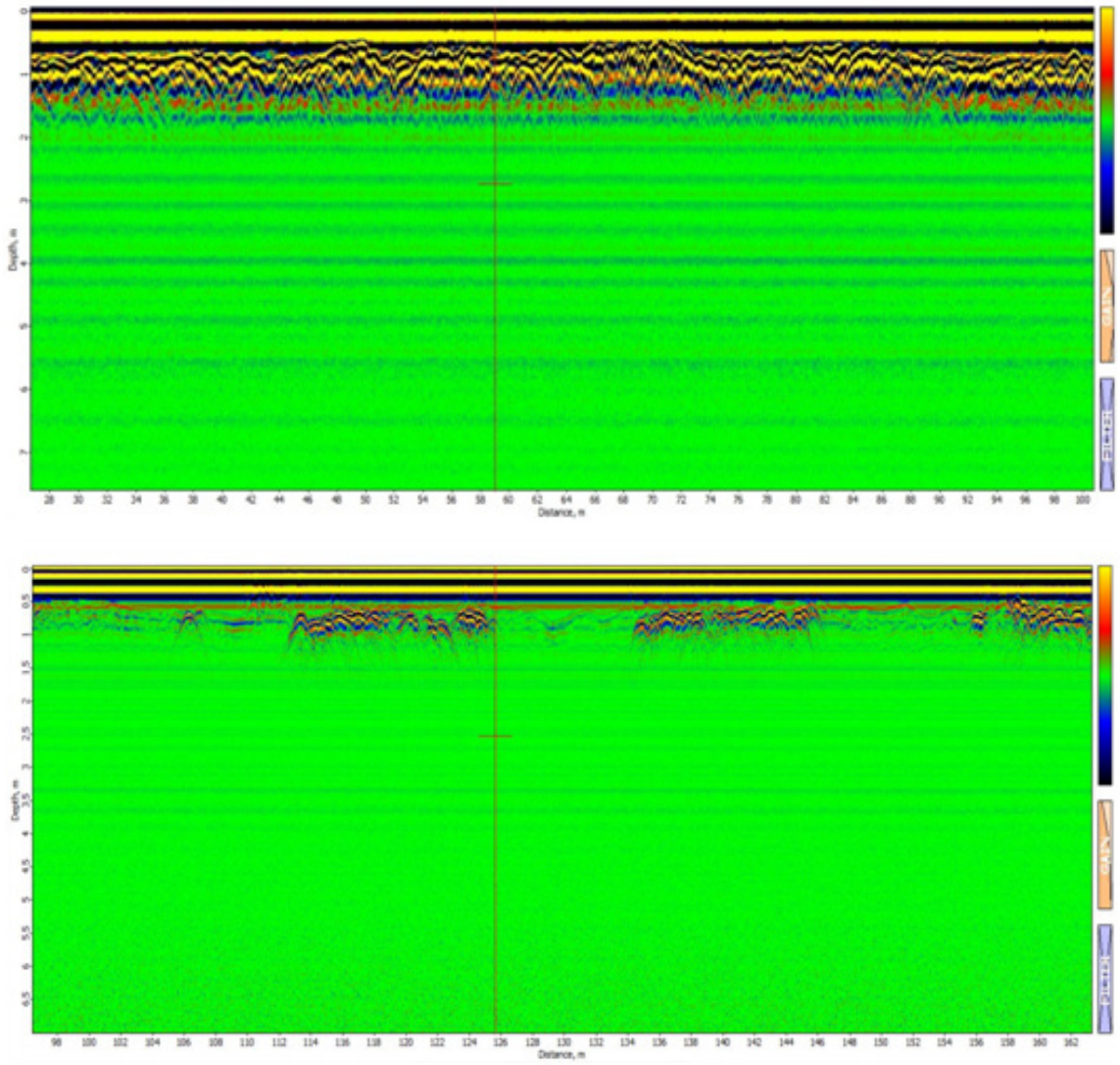

Fig. 5. Two radargrams showing GPR profiles obtained by geophysical survey with 500 MHz antennae from the inflatable boat

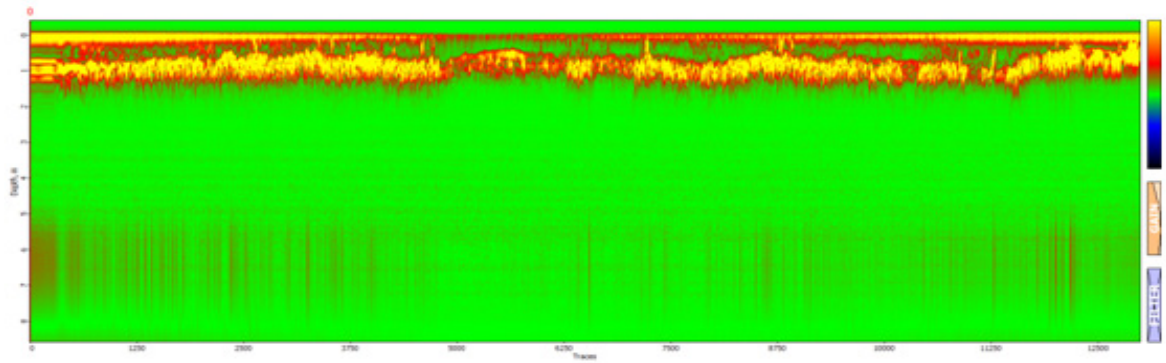

Fig. 6. Processed GPR profile obtained by geophysical survey with 500 MHz antennae from the inflatable boat along the transect No.1 in lake Zeiļu

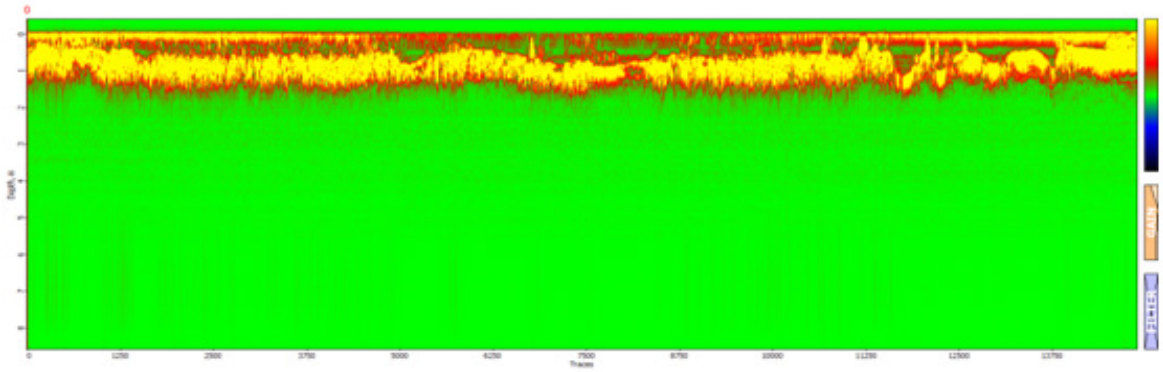

Fig. 7. Processed GPR profile obtained by geophysical survey with 500 MHz antennae from the inflatable boat along the transect No.2 in lake Zeiļu

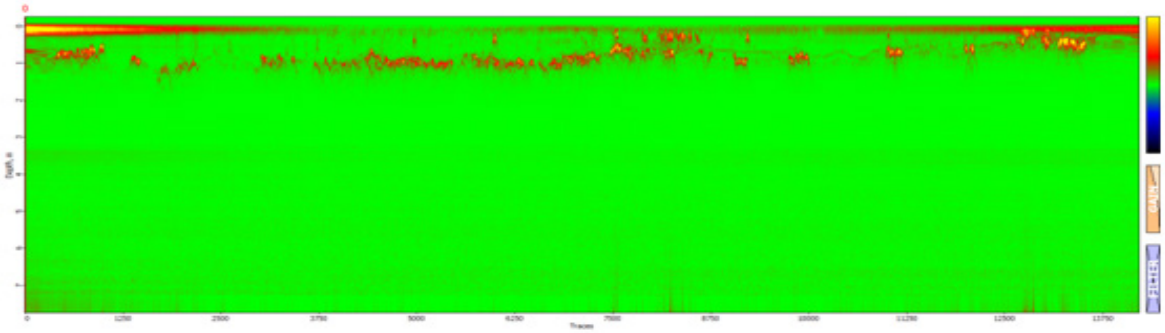

Fig. 8. Processed GPR profile obtained by geophysical survey with 500 MHz antennae from the inflatable boat along the transect No.3 in lake Zeiļu

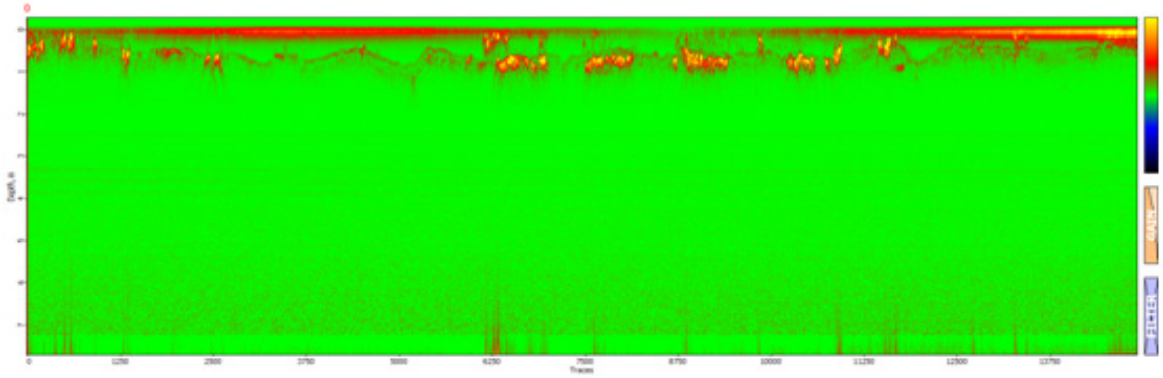

Fig. 9. Processed GPR profile obtained by geophysical survey with 500 MHz antennae from the inflatable boat along the transect No.4 in lake Zeiļu

GPR is a non-invasive and non-destructive, environmentally safe technique for high-resolution geophysical mapping of the near-surface structure of sediment layers. It has many applications, including groundwater and mineral exploration, archaeological and forensic investigations and depth soundings through ice or water. The source for GPR data is a high-frequency (10 – 1000 MHz) electromagnetic pulse which is transmitted into the ground at regular intervals along a survey line. This pulse is reflected back to the surface at subsurface boundaries where electrical properties change. In low conductivity materials such as sands, gravels and bedrock, GPR can sound to depths of 50 m, in general, GPR works well to a depth of about 25 m. Speaking about fresh water, it has relatively low attenuation, however, the presence of suspended sediments in the water can increase attenuation, causing a reduction in depth penetration. Issac and MacCulloch conclude, that 25 MHz, 100 MHz and 200 MHz antennas image the bottom of the lake very well to about 12 – 15 m, 8 m and 7 m, respectively [5]. GPR was applied for mapping sediments and topography of Latvian lakes Engure and Pape using the similar equipment - *Zond-12e GPR Advanced* [3]. Purmalis et al. [3] conclude that high content of mineral compounds (also clays) and minor differences among layers in Pape Lake causes problem to analyse and even see the GPR signal. Most of the signal dissipates in sediments and deeper layers cannot be seen. Problems of permittivity in that kind of material correspond to results in literature, where is suggested that GPR is not a viable choice for surveying in clay rich areas where 5 – 10% clay content can reduce penetration depth to less than 1 m [16].

IV. Conclusions

None of applied GPR antenna systems (500 MHz, 300 MHz, 75 MHz) have provided sufficient geophysical data to detect clay in the lakebed of Zeiļu. The factors, which limit using GPR for this purpose in lake Zeiļu, could be high density of submerged and underwater macrophytes, high concentration of suspended sediments in water and thick double-layered ice cover in winter. Therefore, the recommended method to detect clay and its layer thickness is the conventional method – the analysis of geological core samples, but the completed study opens new research directions. The combination of sonar and GPR survey can be applied as well. Considering the property of clay to absorb transmitted GRP signals, the absence of reflections from the lake bottom can be used as an indirect indicator, which specifies possible presence of clay deposits at the lake bottom.

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Acknowledgments

European Regional Development Fund Postdoctoral research aid Nr.1.1.1.2/16/I/001 research application "Identification of blue clay in lakes of Latgale region and possibilities of its application, Nr.1.1.1.2/VIAA/1/16/131".

Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 298-303

Investigation of Structure and Composition of Clay in Lakes of Latgale for Practical Use

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***Abstract* — Sedimentary clay of three Latvia region of Latgale lakes – Zeiļi, Pauguļi and Plusons – was investigated. Mineral composition was determined by X-ray diffraction, the average size and size distribution of particles by dynamic light scattering method, specific surface by Brunauer-Emmett-Teller method, and adsorption characteristics after methylene blue: adsorption capacity and adsorption isotherms. The samples contained typical clay crystalline phases – illite, kaolinite – and rock forming minerals – quartz, dolomite, calcite, plagioclase, albite, and enstatite. The granulometric content of samples is mostly characterised by silt (2 – 63 μm) and clay (< 2 μm) fractions. Specific surface area varied from 9.45 to 20.68 m^2/g. The adsorption capacity of lake clay was in the range of 25.8 – 45.8 mg/g. Clay adsorption isotherms were represented by the second and fifth type curves according to the International Union of Pure and Applied Chemistry (IUPAC) classification, indicating the presence of micro- and macroporous space in samples and strong intermolecular interactions. The difference between properties of clay in different lakes and at different depths and their influencing factors have been clarified. The information obtained enables to predict the areas of use of clay in cosmetics and medical treatment.**

Keywords*—lake clay, mineral composition, granulometric content, adsorption capacity.

I. Introduction

Clay is one of the most frequently found and accessible mineral deposits. Latvia is one of the European countries that is richest in clay, calculating per resident [1]. However, the potential of local clay is not being used sufficiently; for example, the prevailing amount (40.8 %) of cosmetic products containing clay that can be purchased in Latvia is produced in France and only 3.2 % is produced in Latvia [2].

Latvia is rich in waters; its territory contains 2256 lakes with the water surface area over 1 ha and the total area about 1001 km^2, which is 1.5 % of the territory of Latvia [3]. The natural resources of the lakes – the sapropel – have been studied extensively, and under the sapropel layer, layers of clay deposits have also been found. There are about 1000 lakes in Latgale with the properties of their clay deposits unstudied. Having analysed the reports of SIA "Geo Consultants" on the search of lake sapropel deposits in 199 lakes studied in the former Preiļi, Ludza and Rēzekne regions, lake clay has been found in the soil of 109 lakes. The study and scientific substantiation of the opportunities for the use of lake clay as a local resource will create a foundation and a favourable environment for the design of new products and services.

All types of clay minerals have been reported in soils. Recent sediments include lake clay as well. Smectite, illite, kaolinite and chlorite are major components found both in nonmarine and marine sediments [4].

The use of clays (probably smectite) as soaps and absorbents was reported in Natural History by the Roman author Pliny the Elder (c. 77 ce) [4]. Nowadays clay has a wide range of application. The effectiveness of the use of clay in cosmetology and dermatology has been proven [5] – [11]. French clay, which is obtained in pits from the deepest layers of the lithosphere, has been studied extensively. The opportunities for the use of French green clay in cosmetology and dermatology have also been proven [8], [12]. Clay hydrates the skin and makes it smooth, restores its elasticity, normalises the activity of sebaceous glands, cleans, nourishes, disinfects, treats the skin [11], [13] – [17]. Latvian illite clay can be used as one of UV filters in sun protection creams, in addition giving the cream a light brown tint. A prototype cream with SPF about 9 has been created [18].

Clay is used in cosmetics for its large specific surface, granulometric content, sorption, adhesion, neutral pH, high thermal capacity, tissue astringent properties [19] – [22]. The sorption properties of clay are used in the treatment of different dermatological diseases such as acne, rash, ulcers and seborrhea [23].

There are many studies on clay found in the overland lithospheric layers; lake clay is understudied globally; whereas in Latvia there are no such studies at all. Transformation of lake clay located under the layer of sapropel has occurred under the influence of organic substances, and due to the different biochemical processes

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4069

its properties may be different from lithospheric clay.

The most important parameters that determine the properties of clay and thus also its application opportunities are the mineral and granulometric content of clay [24], thus the aim of this study is to determine the mineral content, granulometric content, specific free surface, adsorption level and adsorption isotherms of lake clay.

II. Materials and methods

Sediment samples were taken in winter from the ice of lake Zeiļi, Pauguļi, and Plusons (Latvia). In lake Zeiļi the samples were taken from 2 control boreholes – *Z2* and *Z4*. In control borehole *Z2* the samples were taken from 4 depths measuring from the water surface – *Z2.6* (6 m depth), *Z2.7* (7 m depth), *Z2.8* (8 m depth), *Z2.9* (9 m depth), in control borehole *Z4* – from 1 depth *Z4.8* (8 m depth). In lake Pauguļi the samples were taken from 1 control borehole at the depth of 3.5 m, in lake Plusons – from 1 control borehole at the depth of 8 m. The equipment used to obtain clay was designed analogous to a sampler (the "Eijkelkamp" type) with 2 l camera. Samples are placed into sterile plastic packaging.

A qualitative analysis of the crystalline phases of mineral content was performed using Rigaku's Ultima + *X*-ray diffraction system [25]. Copper cathode radiation was used, scan speed 1°/min, voltage 40 kV, current intensity 5 mA, 2θ scan angle range 5-60°. Data processing software – *Jade MDI9*. Electronic ICDD databases – *PDF-4Organics/Organics2017* were used for results interpretation and crystal identification.

To determine the granulometric content, dynamic laser diffraction analysis with *Broohaven Instruments* device with *BI-APD* photodiode detector was used. The device can determine particles of radius from 1.5 to 3 µm. The method is based on the relation between particle diffusion rate D undergoing Brownian Motion and their size *d*, expressed by the Stokes-Einstein equation

$$d=kT/3\pi\eta D, \quad (1)$$

where k - Boltzmann's constant, T - temperature, η - viscosity.

For the measurement of the sizes of the samples and their distribution, 0.5 % clay mass and water suspensions were created. To stabilise the system, the surface active ingredient poly-I-lysine was added. The solution was first stirred for one hour and subjected to a 10-minute ultrasonic treatment. The measurements were performed at the temperature of 25°C with laser radiation power 15mW and wavelength 658 nm, and scan angle 90°.

To calculate the specific free surface area S_t, the *BET* (Brunauer, Emmett and Teller) method was used. The specific surface S_t of granulated material is determined by physically absorbing gas on solid particle surfaces and calculating the amount of adsorbate gas W_m, which corresponds to the monomolecular layer on the surface [26]. Nitrogen was used as the adsorbate.

$$S_t=W_m \cdot N \cdot A_{cs}/M, \quad (2)$$

where N - the Avogadro number (6.022×10^{23} mol^{-1}), M - the molecular mass of the adsorbate (nitrogen), A_{cs} - the cross-section area of the adsorbate molecule (for nitrogen at $T = 77$K $A_{cs} = 16.2 \times 10^{-18}$ m^2), W_m - the monolayer mass of the adsorbate (nitrogen) at relative pressure P/P_0.

To determine the adsorption capacity of clay, the methylene blue test was used [27], [28]. The dependence between the optical density of the methylene blue solution and the methylene blue concentration in ranges 20 – 100 mg/l and 100 – 700 mg/l was determined experimentally with the spectrophotometer, light wavelength 400 nm. Calibration charts were constructed on the basis of the experimental data.

To measure the adsorption level of clay, the standard methylene blue solution (MB) with the concentration of 1 g/l was prepared. Clay samples were dried and granulated. For measurement, 1 g of the corresponding clay was poured into a flask, 50 ml of standard MB solution were added and subjected to stirring for 30 minutes. Then the suspension was centrifuged, and samples were taken to determine the optical density in cuvettes in 1cm layer of the analysed solution.

Using the calibration curves of the corresponding range, the MB concentration was determined in these solutions subjected to adsorption. The adsorption level of clay A_d was calculated using the formula

$$A_d = (C_0 \quad C_1) \ \frac{V}{m}, \ \text{mg/g}, \quad (3)$$

where C_0 - initial MB concentration (1000 mg/l), C_1 - MB concentration after adsorption, mg/l, V - volume of the solution (50 ml), m - mass of the clay sample (1 g).

Each measurement was repeated three times – in all cases the difference between measurements did not exceed 0.5 – 0.7 %. Considering the natural nonhomogeneity of clay, the precision of these data is fully satisfactory. For further calculations, the average numbers from these measurements were used. To determine the effect of the stirring time of the suspension on the adsorption level, parallel experiments were performed with 5-hour sample stirring time, which showed that the adsorption level increases but very insignificantly – by 5 % only (e.g., 44.5 mg/g to 46.8 mg/g). This means that the 30-minute sample stirring time is sufficient for the assessment of the adsorption capacity of clay.

Adsorption isotherms were also determined using methylene blue. Initial adsorbate – MB concentrations were selected as follows: 0.05, 0.1, 0.5, 0.7 g/l. For comparison, according to an analogous method, the adsorption isotherm was also determined for two clay samples from Kuprava clay deposit.

III. Results and discussion

The experimental data obtained are summarised in Table I.

According to granulometric content, sediments are divided into two groups – lake Zeiļi clay (*Z2.8*) from the depth of 8 m and lake Plusons sediments are characterised by the monomodal particle distribution curve according to size with rather narrow scattering of sizes (Figure 1) but very different effective diameter of the particles; the size of the particles of lake Plusons sediments is almost 4 times greater than the size of the particles of lake Zeiļi sediments (Table 1).

The comparison of the other sample particle sizes has a drastically pronounced bimodal character with the effective diameter of the particles within the limits of 568.3 – 948.6 nm (Figure 2 and 3).

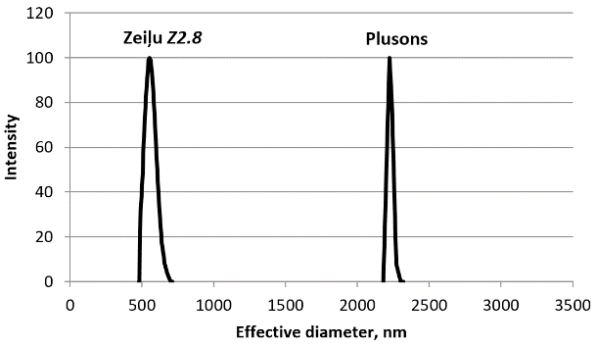

Fig. 1. Comparison of the monomodal granulometric content curves of lake Zeiļi sample *Z2.8* and lake Plusons sediments

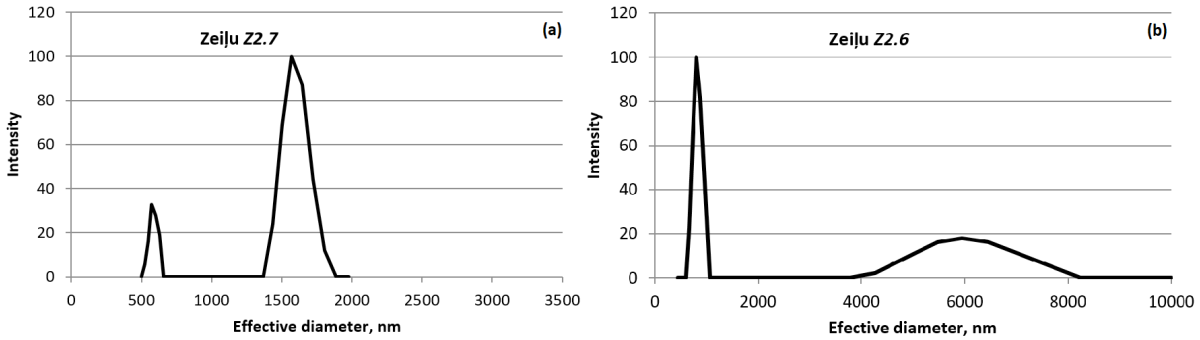

Fig. 2. Bimodal clay particle distribution in lake Zeiļi samples *Z2.7* (a) and *Z2.6* (b)

TABLE I. Lake Sediment Properties

Samples	Granulometric content, nm			Specific surface area, m^2/g	Adsorption level MB, mg/g	Mineral content
	Average diameter d_v	Effective diameter d_{ef}	Typical ranges			
Pauguļi	918.6	675.0	498.9 – 716.6 2122.7 – 3048.7	15.80	37.5	*Q, I, D, C, P, K*
Plusons	2228.3	2245.5	2194 – 2255	9.45	41.5	*Q, D, C, A, E*
Zeiļi *Z2.6*	1853.2	993.7	658.4 – 971.1 4261.8 – 7024.2	20.21	–	*Q, I, D, C, P, K*
Zeiļi *Z2.7*	1358.0	998.6	523.1 – 568.4 1433.8 – 1803.1	20.32	45.8	*Q, I, D, C, P, K*
Zeiļi *Z2.8*	558.3	568.3	485.4 – 683.7	20.68	30.5	*Q, I, D, C, P, K*
Zeiļi *Z4.8*	991.3	800.7	594.7 – 783.8 1794 – 2364	17.41	41.0	*Q, I, D, C, P, K*
Zeiļi *Z2.9*	–	–	–	–	25.8	*Q, I, D, C, P, K*
Kuprava *K1*	–	–	–	–	48.8	*I, Q, O, C, K*
Kuprava *K2*	–	–	–	–	48.4	*I, Q, O, C, K*

Q – quartz, *I* – illite, *D* – dolomite, *C* – calcite, *K* – kaolinite, *O* – orthoclase, *P* – plagioclase, *A* – albite, *E* – enstatite

Specific free surface of all lake Zeiļi clay with the exception of sample *Z4.8* is almost equal to 20.20 – 20.68 m^2/g (Table 1). For lake Pauguļi and *Z4.8* samples it is lower (15.08 – 17.41 m^2/g), but for lake Plusons sediments it is the lowest (9.45 m^2/g), which can be explained by the significantly higher coarseness level of these sediments.

Adsorption capacity measurements show that it does not correlate with the size of the sediment particles or the specific surface. Thus, one of the highest MB adsorption capacities (41.5 mg/g) was demonstrated by the coarsest sediments of lake Plusons. Lake Zeiļi samples *Z2.7* and *Z4.8* demonstrated the highest adsorption capacity (45.8 – 41.0 mg/g). The adsorption capacities of the other samples is between 25.8 and 37.5 mg/g. The adsorption isotherms of the lake sediments studied can also be divided into two groups. Lake Pauguļi and lake Zeiļi clay sample *Z2.9* and *Z2.8* isotherms correspond to type IV, but *Z4.8*, *Z2.7* and lake Plusons sample isotherms correspond to type II according to IUPAC classification [29] (Figure 4).

The results of the study have shown that lake Pauguļi and lake Zeiļi sediments have identical mineral composition, which includes two clay minerals – illite and kaolinite (Table 1) and non-clay fractions – quartz, dolomite, calcite, orthoclase, plagioclase, albite, enstatite. Mattioli et al. 2016 also note in their studies that commercial clays used in cosmetics none are pure clay and are characterized by the presence of a significant non-clay fraction dominated by calcite and quartz, and to a minor extent by dolomite, feldspars and gypsum [30].

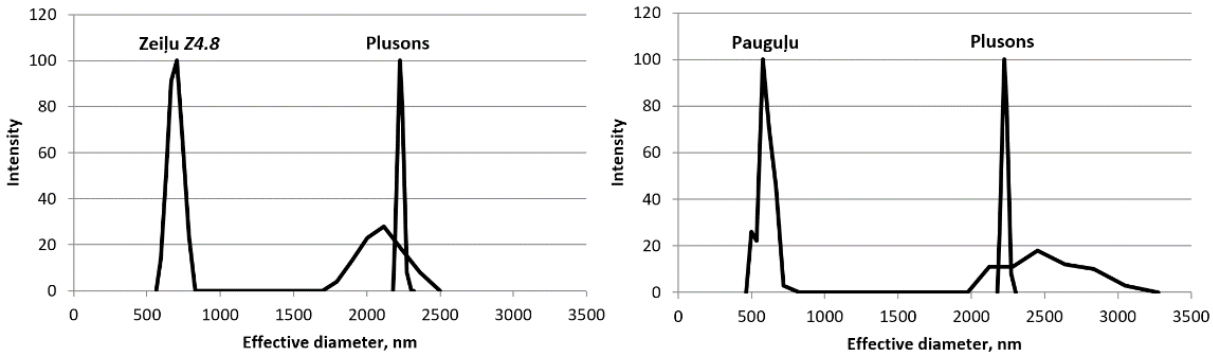

Fig. 3. Comparison of lake Zeiļi and lake Pauguļi sediment granulometric content with lake Plusons sediment monomodal distribution

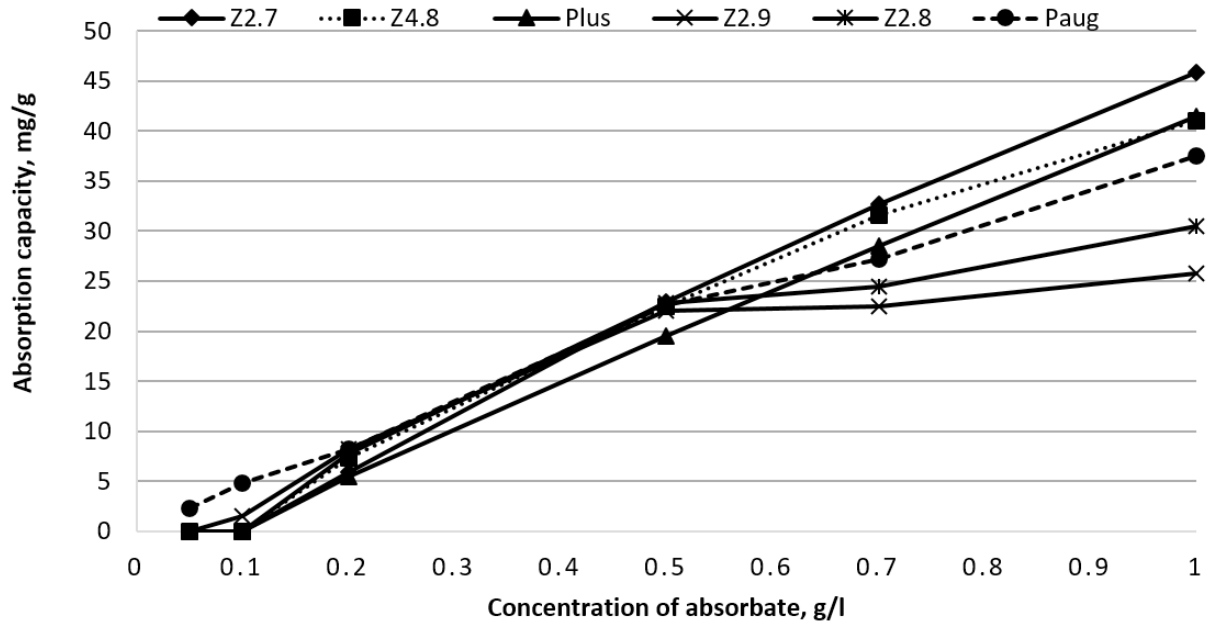

Fig. 4. Lake sediment type IV and type II adsorption isotherms

Lake Plusons sediments are different. Since these do not contain any clay minerals, they cannot be considered clay sediments. They are also characterised by other differences in properties – a significantly higher particle coarseness level – up to 0.23 μm, very high homogeneity of the particles according to size (homogeneity coefficient 0.99, polydispersity 0.005), drastically smaller specific surface area in comparison to the sediments of other lakes (9.45 m^2/g). However, these sediments show an unexpectedly high adsorption level – 41.5 mg/g compared to other samples which have a significantly smaller effective diameter of particles and a larger specific surface (e.g., A_d of sample *Z2.8* is 30.5 mg/g, where d_{ef} = 568.3 nm and S = 20.68 m^2/g). This means that the difference of the adsorption level is related to the chemical composition of these adsorbents. Since the crystalline phase content, determined using the diffractometric method, has qualitatively shown the identity of these samples (with the exception of lake Plusons sediments), the determining factor in difference of adsorption capacity becomes the physical and chemical nature of the interaction with the adsorbate, including the amount and content of organic matter in these sediments. The other clay samples are characterised by the nonhomogeneity of the size of different particles from 1.00 to 1.86 (Table II).

From the analysis of the data for all samples, a small tendency for the increase of the specific surface with the decrease of the particle size can be observed (regression coefficient R^2 = 0.3). From the analysis of the samples of particular groups (e.g., lake Zeiļi samples *Z2.6*, *Z2.7*, *Z2.8*), a much stronger correlation between the depth of the deposit and dispersity can be observed – with greater depth, a greater percentage of fine particles is found in the sediments (R^2 = 0.96). The highest particle size scatter was demonstrated by top layers of lake Zeiļi sediments – 1.36 – 1.86. Adsorption isotherms (Table 2) in lake Zeiļi clay taken from greater depth (8, 9 metres) are type four curves showing an increase of adsorption capacity directly proportional to the increase of adsorbate concentration up to 0.5 g/l, followed by the zone of saturation within the adsorbate concentration limits 0.5-0.7 g/l, then again followed by a directly proportional but less intensive increase of adsorption capacity (Figure 4). Zone of saturation means that in this range the formation of the adsorbed monomolecular layer on particle surfaces ends, at higher concentrations next adsorption layers begin to form. In accordance with the literature data, such isotherm nature is characteristic of mesoporous adsorbents with strong affinities between the adsorbent and the adsorbate [31].

The other sample (*Z2.7*, *Z4.8*, Plusons) isotherms can be attributed to type II curves, which do not have

the intermediate saturation stage. These curve types indicate the macroporous structure of the adsorbent with a homogenous particle surface and strong affinity between the adsorbent and the adsorbate. It is noteworthy that the adsorption levels up to adsorbate concentration 0.5 g/l almost coincide. The differences start at higher concentrations, and at the maximum adsorbate concentration 1 g/l studied, it is lower for type IV clay (Figure 4). Adsorption isotherms from Kuprava clay deposit show no principal difference from lake sediment isotherms; these are attributed to type II isotherms and are also characterised by a higher adsorption level, and their adsorption level at adsorbate concentration 1 g/l is higher than that of lake sediments and exceeds 49 mg/g. Kuprava clay diffractogram shows that its composition is primarily formed by illite [32], which determines its increased adsorption capacity. Other studies [33] have found that clay adsorption level is 90 – 125 mg/g. Whereas clay from other deposits shows a significantly lower adsorption level; Nīcgale clay deposit studies [34] have demonstrated the MB adsorption level of 14.3 – 19.8 mg/g with the specific surface of 23.8 m^2/g. The adsorption capacity of the lake sediments studied is not great in comparison, for example, with clay used in medicine, which contains montmorillonite, which has a specific area of 173 m^2/g and a sorption capacity of 370 mg/g [35, 36].

Clays used in pharmaceutics and cosmetics should have a high specific surface area [30], [37]. However, in comparison with cosmetic clay used, the specific surface area of which does not exceed 2.4 m^2/g [38], the specific surface area of lake clay is suitable for use for cosmetic and medical purposes. According to granulometric content, clay from the lakes of Latgale also corresponds to the therapeutic clay already used in treatment procedures [39]. The average particle size of commercial cosmetic clay varies from 2.4 to 12.0 μm [2].

TABLE II. CLAY PARTICLE DISTRIBUTION TYPES, DISPERSION LEVEL AND ADSORPTION ISOTHERM TYPES

Samples	Granulometric content curve type	Particle nonhomogeneity coefficient, d_{vid}/d_{ef}	Polydispersity	Isotherm type
Pauguļi	Bimodal	1.36	0.139	Type IV
Plusons	Monomodal	1.00	0.005	Type II
Zeiļi *Z2.6*	Bimodal	1.86	0.209	-
Zeiļi *Z2.7*	Bimodal	1.36	0.137	Type II
Zeiļi *Z2.8*	Monomodal	1.00	0.005	Type IV
Zeiļi *Z4.8*	Bimodal	1.16	0.129	Type II
Zeiļi *Z2.9*	-	-	-	Type IV
Kuprava *K1, K2*	-	-	-	Type II

IV. Conclusions

Lake clay contains typical clay *crystalline* phases – illite, kaolinite, and rock forming minerals – quartz, dolomite, calcite, plagioclase, albite, and enstatite. The granulometric content of lake clay is mostly characterised by silt (2 – 63 μm) and clay (< 2 μm) fractions. Specific surface area varies from 9.45 to 20.68 m^2/g. Adsorption capacity of lake clay varies from 25.8 to 45.8 mg/g. Lake clay, considering its mineralogical and granulometric content, specific surface area and adsorption capacity, is suitable for use in cosmetics and medical treatment.

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ACKNOWLEDGMENTS

European Regional Development Fund Postdoctoral research aid Nr.1.1.1.2/16/I/001 research application "Identification of blue clay in lakes of Latgale region and possibilities of its application, Nr.1.1.1.2/VIAA/1/16/131".

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 304-306

Mineral Composition of Some Latgale Lake Sediments

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***Abstract*—Our research is focused on sedimentological conditions and postdepositional changes of recent fine grained lake sediments. We used bulk sediment mineralogical composition and grain size distribution as indicators to identify sediment source areas and possible changes during Holocene. We analysed fine grained (clayey) sediments from three Latgale lakes - Zeili, Pauguļi and Plusons, situated in Latgale upland. Lake sediments cover Late Pleistocene glacial deposits – loam and sandy loam. Bulk mineral composition of 6 sediment samples was determined by X-ray diffraction (XRD). Sediments contained typical minerals found in surrounding glacial sediments: rock-forming minerals as quartz, plagioclase, albite, enstatite, dolomite, calcite, and clay minerals - illite, kaolinite. To identify postdepositional changes in lake sediments of Holocene age clay minerals in clay fraction (<2 mkm) should be analysed. Particularly illite, smectite mixed layered minerals - illite/smectite (I/Sm) and chlorite. Additionally, grain size distribution of studied lake sediments was analysed. Accordingly, our studied sediments are clays, silty clays and clayey silts with bimodal particle distribution, except two samples from Zeiļi and Plusons with unimodal distribution.**

Keywords — lacustrine sediments, minerals, clay, XRD, Latgale.

I. Introduction

Recent (Holocene) lake deposits in Latvia are widely studied, but most of research covers organic deposits – sapropel and peat [1], [2]. On the other hand, much research has been done on lacustrine mineral sediments, but mostly glacial lake sediments [3], [4]. Sediment grain size distribution [5], mineral composition and clay minerals alone [6], [7] or combined with other parameters are widely used to reconstruct past climates from marine and lacustrine sedimentary record [1]-[4], [8]-[10]. Better than bulk mineral composition, clay minerals may serve as effective tools to establish the origin of fine-grained terrigenous sediment of seas [11, 12] and lakes [13]. Review of scientific literature revealed that clay minerals, their ratios and variety of mineralogical indices, as crystallinity degree of illite (Kübler index), crystallinity degree of chlorite (Àrkai index), P index (describes mutual relations between neoformed and detrital mineral phases) as well as others may be applied for sedimentological and paleoclimatic reconstructions [6, 7], [15, 16].

The goal of this study is to assess clay mineral composition and grain size distribution of fine grained recent lacustrine sediments as indicators for sedimentological conditions, and postdepositional changes of recent fine grained lake sediments. In this article, we are presenting pilot stage of the study where mineralogical composition, with particular interest in clay minerals, of lake sediments were analysed. Hence, amount of samples was insufficient for further analysis, grain size analysis served mostly for classification purpose.

II. Materialas and methods

We analysed lacustrine sediments from 3 Latgale (historical and cultural region in eastern part of Latvia) lakes - Zeili, Pauguļi and Plusons (see Fig. 1). Studied lakes are situated in marginal zone of Latgale upland which is an insular accumulative-glaciostructural upland. Zeili and Pauguļi lakes are situated in morainic hummocky area, in the north of Latgale upland. Plusons on the other hand is situated in area dominated by kames and eskers formed of glaciofluvial and glaciolimnic sediments. According to database of Latvian lakes [17] studied lakes are shallow, with mean water depths from 1.1 to 2.5 metres. Area of water surface of Zeili and Pauguli is 44.8 ha and 22.0 ha accordingly but Plusons – 480 ha [17]. Lake beds are formed in Weichselian age glacigenic and glaciofluvial sediments and filled with mainly fine grained sediments. Clays and silty clays in Zeili and Pauguli and fine sand, silt and clayey silt in Plusons. In all studied lakes inorganic sediments are covered by organic mud and sapropel up to 4 metres thick (in Zeili).

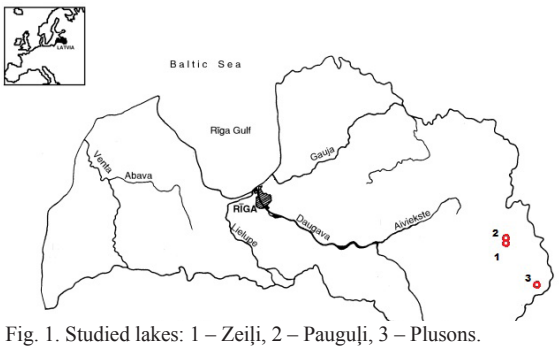

Fig. 1. Studied lakes: 1 – Zeiļi, 2 – Pauguļi, 3 – Plusons.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4146

In total 6 samples of fine grained lacustrine sediments were analysed. Zeiļi represents four samples from two boreholes at various depths (6 to 8 m) and two from lakes Pauguļi (3.5 m) and Plusons (8.0 m) accordingly. Sampling was carried out in winter with help of geological hand auger (the "Eijkelkamp" type). Clay samples were placed into sterile plastic zip lock bags and stored refrigerated. Grain-size and mineralogical composition within the clay samples is analysed in Riga Technical University Institute of Silicate Materials, Faculty of Materials Science and Applied Chemistry.

X-ray diffraction (XRD) analyses [18] of samples were run by *Rigaku – Ultima +* diffractometer with Cu tube at 40 kV and 5 mA in spinning mode. The analyses range was from 5º to 60º 2θ and scanning speed 1º /min. Data processing was carried out by MDI Jade 9 software and identification of minerals using ICDD data base (PDF-4 Organics2017) [19].

Grain size analyses were run by Broohkaven Instruments particle size analyser based on the principles of Dynamic Light Scattering (DLS). Instrument allows to detect particles in range from 1.5 nm to 3 mkm.

III. Results and discusion

Mineralogical (XRD) analyses of some Latgale lakes fine grained sediments shows that their mineralogical composition is similar. Mineral composition of quaternary clay (fraction <2 µm) in Latvia is quite uniform, most abundant clay mineral is illite (75-80%) followed by kaolinite (until 20%) and chlorite (5-10%) [20].

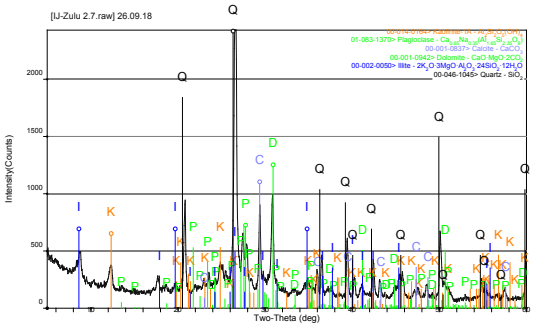

Fig. 2. X-ray difraction pattern of clayey sample from lake Zeiļi, sampling depth 7 m. Minerals: Q – quartz, P – plagioclase, C – calcite, D – dolomite, I – illite, K – kaolinite.

Studied lake sediment mineral assemblages consist of rock forming minerals as quartz, plagioclase, albite, enstatite, dolomite, calcite, and clay minerals – illite and kaolinite (Fig. 1 - 3). In lake Zeiļi we analysed mineralogical composition from two cores - 6 to 8 m and 1 sample from 8 m. Depth wise bulk mineral composition does not change – quartz, feldspars, illite and kaolinite. But if analysed low angle (2Θ <20º) area of diffractograms, particulary illite peak at 2Θ = ~7º (Fig. 1 and Fig. 2) there are some features in XRD spectra indicating changes in illite. Our hypothesis is that there is a mixed layer of illite/smectite as well as illite with various degree crystallinity. To confirm our hypothesis more detailed sampling and analysis of mentioned features as well as quantitative analysis of clay minerals is needed.

Mineralogical composition of fine grained sediments of lakes Pauguļi and Zeiļi is similar (Fig. 1 and Fig. 2). Similarly to case of Zeiļi, sediments of Pauguļi hypothetically may contain illite with various degree of crystallinity and admixture of interlayer illite/smectite (I/Sm).

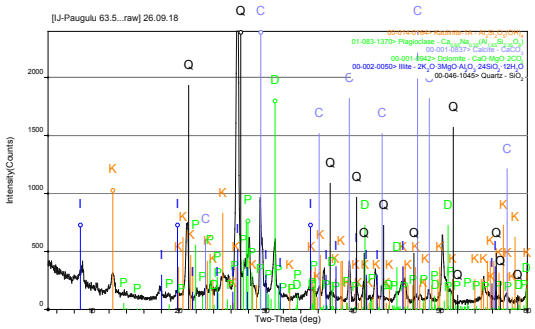

Fig. 3. X-ray difraction pattern of clayey sample from lake Pauguļi, sampling depth 3.5 m. Minerals: Q – quartz, P – plagioclase, C – calcite, D – dolomite, I – illite, K – kaolinite.

In contrast, fine grained sample from Plusons contained no clay minerals, but it contains calcite, dolomite, quartz, albite and pyroxene mineral – enstatite (Fig. 3). Pyroxenes are one of first silicate minerals to be dissolved and that why are rear in sediments [21]. Lack of clay minerals might reflect grain size distribution of sample. According to grain size analysis, Plusons is the coarsest of all samples and still consists of very fine silt particles. Hence there is only one sample from Plusons it is not possible to draw any more conclusions.

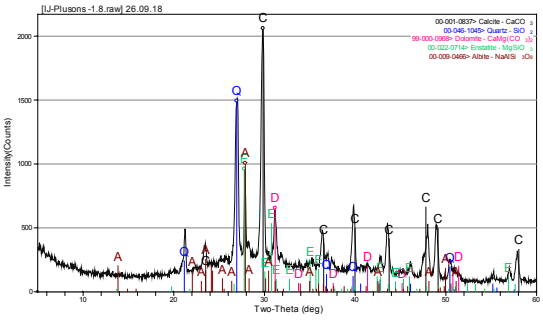

Fig. 4. X-ray difraction pattern of clayey sample from lake Plusons, sampling depth 8 m. Minerals: Q – quartz, A – albite, E – enstatite, C – calcite, D – dolomite.

Grain size distribution of studied lake sediments allow to classify them as clays, silty clays and clayey silts. Most of analysed sediments are characterized by bimodal particle distribution except two samples from Zeiļi and Plusons accordingly by unimodal distribution. Hence we have only 6 samples, no further analysis is reasonable. Scientific literature review indicates that there is still uncertainty in explaining genesis of lake sediment grain size components due to complexity of their bi- and polymodal distributions [22, 23].

IV. Conclusions

Our study let us to draw some conclusions and envision further development of the study. The bulk

mineral composition of studied lake sediments reflects mineral composition of typical Quaternary glacial sediments of Latvia. Mineral assemblage of studied sediments is overall similar, except of Plusons because of lack of clay minerals. We detected some features in XRD spectra indicating changes in illite. We advanced a hypothesis that there is a mixed layer of illite/smectite as well as illite with various degree crystallinity. To confirm our hypothesis more detailed sampling and analysis of mentioned features as well as quantitative analysis of clay minerals is needed. According to grain size distribution, studied lake sediments are clays, silty clays and clayey silts. Analysed sediments are characterized by bimodal and unimodal particle distribution.

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Acknowledgments

European Regional Development Fund Postdoctoral research aid Nr.1.1.1.2/16/I/001 research application "Identification of blue clay in lakes of Latgale region and possibilities of its application, Nr.1.1.1.2/VIAA/1/16/131". We are grateful to anonymous reviewer for constructive criticism and suggestions.

Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 307-310

Spectral Imaging and Clay Detection in Latgale Lakes

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***Abstract*—the survey of lake sediments is complex, time consuming and costly process with risks to human health. Additionally, manually obtained sediment samples provide incomplete data about a survey region. In turn, remote sensing methods are cost-effective and can provide continuous data about a survey region. Therefore, authors decided to perform a pilot experiment with a remote sensing method in order to detect clay sediments deposited in lakebeds. The evaluated method is the analysis of spectral images of *Sentinel-2*. *Pearson coefficient* and *C4.5* datamining methods were applied for data analysis. Survey objects are Latgale lakes with and without clay sediments. The pilot experiment showed, that spectral imaging of lake water is not applicable method to detect definitely clay sediments in lakes, however, research results provide ideas about indirect methods, which must be studied in the future.**

***Keywords*—clay, Latgale lakes, Sentinel-2, spectral imaging.**

I. Introduction

Clay minerals (also referred to as phyllosilicate minerals) are crystalline aluminosilicate minerals organized in a layered structure. The crystal structure consists of two basic units: the *Si* tetrahedron, which is formed by a Si^{4+} ion surrounded by four O^{2-} ions in a tetrahedral configuration, and the *Al* octahedron, which formed by an Al^{3+} ion surrounded by four O^{2-} and two OH^{-} ions in an octahedral configuration. These structural units are joined together into tetrahedral and octahedral sheets, respectively, by adjacent *Si* tetrahedral sharing all three basal corners and by *Al* octahedrons sharing edges. These sheets, in turn, form the clay mineral layer by sharing the optical *O* of the tetrahedral sheet. Layer silicates are classified into eight groups according to layer type, layer charge, and type of interlayer cations. The layer type designated 1:1 is organized with one octahedral and one tetrahedral sheet, whereas the 2:1 layer type is organized with two octahedral and one tetrahedral sheet [1]. Clay is applied and used in a pharmacy and cosmetics, as well as in an environmental technology. Clay minerals can be used for the removal of organic pollutants from water. In order to remedy environmental damages caused by polluted gases clays and clay minerals can be used as adsorbents in natural form or after specific modification [2] – [4].

The previously implemented research of the lake Plusons identified clay sediments [5], clay locations were found in lake Zeiļi as well. There are 2256 lakes in Latvia with the total area equal to 1001 km^2, which stands for 1.5% of the territory of Latvia, that provides great scientific interest in terms of resource application in industry. However, the survey of lake sediments is complex, time consuming and costly process. Additionally, manually obtained sediment samples provide incomplete data about a survey region. Recently, it is common to apply geophysical methods like remote sensing to explore Earth resources. In turn, remote sensing methods are more cost-effective and can provide continuous data about a survey region. The research goal is to evaluate the method of spectral analysis of satellite data in order to detect clay sediments in lake bottom.

II. Material and Methods

Analysing SIA "Geo Consultants" reports about sapropel search, the clay sediments are found in 109 of 199 lakes in Preili, Ludza and Rezekne regions. This data was applied to construct the dataset of samples. The constructed dataset contained 31 samples of Latgale lakes, from which 15 lakes contained clay sediments and 16 – did not. The dataset did not contain all 199 lakes due to two reasons: firstly, lakes must be sufficiently large to be visible in *Sentinel-2* image, secondly, it is pilot/ envision research. Considering the spectral features of water (the reflectance of water above 1150 nm is close to zero [6]), the bands *B2-B8* are applicable and they have the minimal resolution of 20 m/px, which requires the minimal area of lake to be equal to 40x40 m^2 (0.16 ha) and water must be with no vegetation. And "the rule of 30" is commonly applied to define the minimal amount of samples for a reliable statistical analysis.

The mean values of lake reflectance were calculated for each spectral band using *Sentinel-2* multispectral image and *SNAP* software. Only the regions of water without vegetation were processed, that was achieved using the color-infrared (CIR) image to detect vegetation. The example of data is depicted in Fig.1.

The information about clay sediments of lake was coded using following system: if a lake contains clay sediments – code "one", otherwise – "zero". Using this

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4189

encoding system, it was possible to measure *Pearson correlation* between the reflectance of band and the presence of clay sediments. *Pearson correlation* shows only direct relation between the one spectrum and the object. Therefore, the machine learning and classification algorithm *C4.5* was applied to detect the logical relations among the bands and the presence of clay sediments.

III. Results and Discussions

Remote sensing methods detect objects analyzing their direct and indirect physical features. Spectral imaging was verified using *Sentinel-2* images. The idea of spectral imaging application was based on the hypothesis about the correlation between the clay sediments and the chemical and microbiological content of lake water.

Spectral imaging, or imaging spectroscopy, combines the power of digital imaging and spectroscopy, providing a vastly improved ability to classify the objects in the scene based on their spectral properties [7]. Clay content and mineralogy have influence on the *SWIR* portion of the spectrum (1300-2500 nm), with the 2200 absorption feature being the characteristic of clays [1]. The topsoil mapping using satellites was previously studied and satellite multispectral sensors achieved results with the range of R^2 from 0.26 to 0.83 [8]. *Landsat TM* category belongs to the range of R^2 from 0.44 to 0.67 [8]. For example, the significant linear correlation between *MID*-infrared index and topsoil clay content (%) was experimentally proved in publication [9] showing that the *MID*-infrared index over the driest bare soils allows separating sandy soils from clay. Bartholomeus et al. mention, that estimation of soil properties such as clay content is hampered, if the pixels have a vegetation cover over 20% and also if the pixels are covered by crop residues [10]. Garfagnoli et al. evaluated hyperspectral scanning with airborne platform for clay detection considering the illite and montmorillonite absorption feature at 2210 nm, which is diagnostic indicator for these minerals [7].

The clay detection in the suspense of water is complicated mainly due to complex interactions of three optically detectable substances: algal chlorophyll, suspended sediments and dissolved organic substances. These substances have significant impact on the water quality. Each substance has its own reflectance and absorption trends complicating the derivation of the clay concentration estimation algorithms based on the remotely sensed data [6].

It is common to complete spectral reflectance measurements using a spectroradiometer in a laboratory before trying to detect Earth objects using multispectral satellites. The similar research structure can be found, for example, in the article [8]. If a clay presence influences the spectrum 1300-2500 nm of soil [1], the reflectance of water above 1150 nm is close to zero [6]. By analyzing the reflectance of water suspense with clay particles (Fig.2), Tuominen et al. found the best correlation between the amount of added clay and the band ratio R709 / R585 [6], that contradicts with the band ratio R595 / R754 proposed by Gin et al. [11], that Tuominen et al. explained by the different type or the particle size of the added clay in two independent researches.

At the same time, the source [12] provides the chart with water reflectance depending on its quality (Fig.3). The water with high or moderate sediment concentration (not exactly clay) has similar parameters as the water with added clay (Fig.2 and Fig.3). Therefore, hyperspectral analysis of water samples using portable spectrometer is realistic, however, the clay detection using satellite images is controversial. This was proved by the results of pilot experiment – the *Pearson correlation* of all bands are smaller than the moderate relation ($x < 0.5$). The algorithm *C4.5* provided the precision equal to 55.6%, which is close to the probability of task to guess one value from two possible. The scatterplots of bands and clay sediments are depicted in Fig.4. The decision tree of *C4.5* is depicted in Fig.5.

	HasClay	B1	B2	B3	B4	B5	B6	B7	B8
Razna	1	0.0169	0.0148	0.0148	0.0078	0.0074	0.0089	0.0094	0.0082
Sorockas	0	0.0173	0.0139	0.0134	0.0114	0.013	0.0165	0.0186	0.0175
Vertuksnas	0	0.0174	0.0129	0.0149	0.012	0.012	0.0105	0.0113	0.0113
Veveru	1	0.0176	0.014	0.0174	0.0126	0.0131	0.0136	0.0154	0.0158
Tiskadu	0	0.0207	0.018	0.0256	0.0196	0.0177	0.0095	0.0102	0.009
Skenovas	1	0.0126	0.011	0.0135	0.012	0.0127	0.0122	0.015	0.0148
Paugulu	1	0.0139	0.0122	0.0132	0.0123	0.0112	0.0087	0.0107	0.0101
Vecanu	1	0.0121	0.0102	0.0104	0.0099	0.0107	0.0112	0.0132	0.0126

Fig. 1. Reflectance of lake water and data about clay sediments

Considering the Fig.2 and Fig.3, clay added to water does not provide specific change of reflectance, that corresponds to the low *Pearson correlation* of all bands (Fig.4). The constructed decision tree uses the condition "$B2 > 0.01$" as the main feature for recognition (Fig.5), where *B3* is equal to 490 nm wavelength. According to the Fig.4, *B3* is the spectral band, where clear water decreases its reflectance, but water with sediments increases its reflectance. *B6* (740 nm) is point, where the reflectance of clear water is close to zero, but water with added clay has strong reflectance decrease. *B6* is close to bands found by Tuominen and Gin (709 nm and 754 nm respectively). Therefore the range 700-800 nm is important for clay detection, but detection bands are specific for each water body. The subject of Tuominen's research was coastline water, where sediments are continually mixed with water, but a clay must sink to the bottom in static water. So, the category "water with sediments" of Fig.3 is the more correct description to the range 700-800 nm. Algorithm *C4.5* has tried to identify the reflectance ranges of bands to complete classification, however, the usage of ranges is controversial too, because satellite images have errors caused by atmospheric effects and the values of pixels are averaged due to an image resolution. Additionally,

Tuominen mentions many factors, which can influence water spectral characteristics [6].

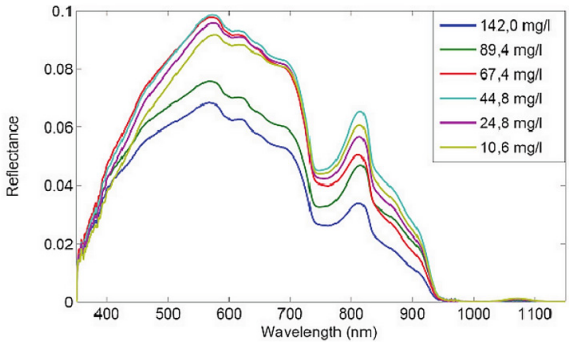

Fig. 2. Reflectance spectra of water samples containing varying amounts of added clay [6]

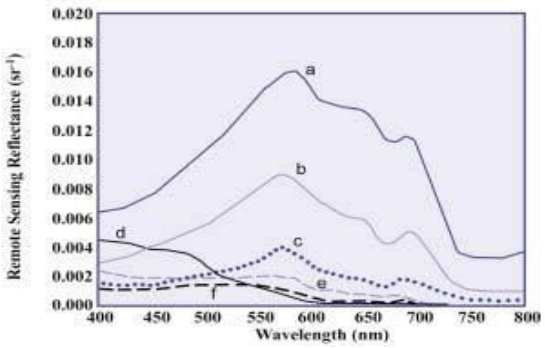

Fig. 3. (a) waters with very high sediment and gelbstoff concentrations, (b) high sediment and gelbstoff concentrations, (c) moderate sediment and gelbstoff with some phytoplankton, (d) clear water, (e) waters with moderate chlorophyll and sediment concentrations, (f) waters with moderate chlorophyll concentration [12]

IV. Conclusions

The literature analysis identified, that spectral imaging of lake water is not useful to detect clay sediments in lake bottom. That is proved by two facts: firstly, clay particles sink to the bottom in static water, secondly, shape of spectral reflectance of clay suspension is similar to suspension with other sediment particles. The completed pilot experiment provided a similar conclusion. However, it does not contradict with Tuominen et al. [6] and Gin et. al [11] results, who studied suspended clay of coastline using field spectrometer.

Further research can include studies of indirect indicators, for example, - phytoplankton. Due to their turbidity the clay particles due reduce Solar energy available to the grazers or bacteria, but they may, however, contain nutrients and trace-elements that can be utilised by phytoplankton or bacteria [13]. In lakes, the clay-related turbidity has shown to have serious effects on the food web and an ability to prevent the improvement of the lake condition due to the restoration methods [14].

If clay sediments are related with the retreat of glaciers and common to glacier lakes, the geospatial analysis can be applied to detect geospatial relations among cleyey lakes.

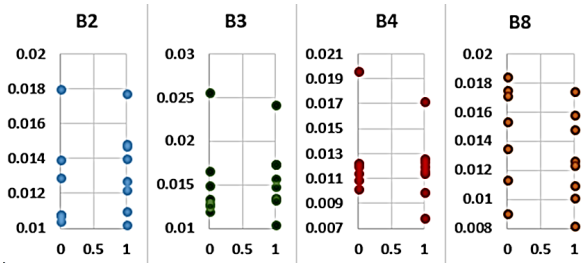

Fig. 4. Scatterplots of *RGB* and *NIR* bands, where points are clustered by the presence of clay sediments"

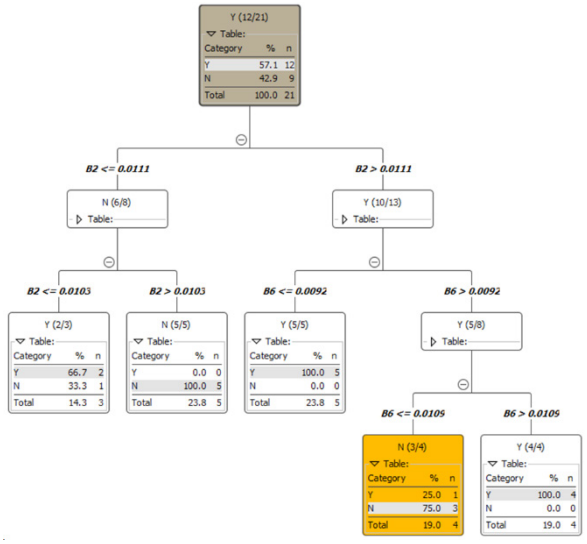

Fig. 5. Decision tree constructed by *C4.5*

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ACKNOWLEDGEMENTS

European Regional Development Fund Postdoctoral research aid Nr.1.1.1.2/16/I/001 research application "Identification of blue clay in lakes of Latgale region and possibilities of its application, Nr.1.1.1.2/VIAA/1/16/131".

Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 311-314

Positive Relationships Between Human Impact and Biodiversity: the Case of the Fire-Bellied Toad (Bombina bombina) in Europe

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Abstract*—Habitat modification affects amphibians indirectly by reducing energy reserves and energy allocated to growth and reproduction, and by affecting population dynamics and viability. Marginal populations of amphibians in Latvia and Ukraine are particularly vulnerable. On the other hand, several studies have shown a positive relationship between human density and biodiversity, indicating that species-rich areas and human enterprises quite often co-occur. Therefore, both positive and negative correlations between human population and species richness may be expected. For a better understanding of what constitutes suitable habitat we used a habitat modeling approach, where modeling can be used for revealing species ecological requirements and relationships between the distribution of species and predictive variables, as well as the importance of each variable in model building. Here we employed maximum entropy (MaxEnt) niche modeling, as a tool to assess potential habitat suitability (HS) for amphibians in Europe, making special emphasis on anthropogenic impact. We used 2474 georeferenced point data (783 - B. bombina occurrence, and to compare results 1691 - L. vulgaris), including results of our field investigations in Latvia and Ukraine. The predictor variables used for modelling the toad species HS suitability were of climate derived from the WorldClim database (19 bioclimatic variables). Human impact was assessed by the Human Footprint (HF), produced through an overlay of a number of global data layers that represent the location of various factors presumed to exert an influence on ecosystems: human population distribution, urban areas, roads, navigable rivers, and various agricultural land uses. Using the Spearman rank correlation, a low, however statistically significant positive correlation ($p<0.05$), was found between the predicted HS and the HF.

Keywords*—Bombina bombina, niche modeling (MaxEnt), Human Footprint (HF).

I. Introduction

Human civilization has had a negative impact on biodiversity, particularly since the industrial revolution. Overfishing and hunting, the destruction of habitats through agriculture and urban encroachment, the use of pesticides and herbicides, and the release of other toxic compounds into the environment have all been damaging, particularly for vertebrates [1]. Amongst the vertebrates, amphibians, because of their sensitivity and general dependence on both terrestrial and aquatic habitats, are considered to be particularly vulnerable [2]. Habitat modification affects amphibians indirectly by reducing energy reserves and energy allocated to growth and reproduction, and by affecting population dynamics and viability [3, 4].

On one hand, human activities, in particular the alteration of habitats [5] are major causes of biodiversity loss [6], but on the other several studies have shown a positive relationship between human density and biodiversity, indicating that species-rich areas and human enterprises quite often co-occur [7]. This relationship can be mediated by productivity, because high primary productivity is correlated with both species richness and human settlement. Therefore, both positive and negative correlations between human population and species richness may be expected.

For a better understanding of what constitutes suitable habitat and how this could be related to human impact we used a habitat modeling approach [8], where modeling can be used for revealing species' ecological requirements (quantified in terms of habitat suitability, HS) and exploring the relationships between HS and human impact. In this paper we exemplify our approach by focusing on the European fire-bellied toad, *Bombina bombina* (Linnaeus, 1761) for which the destruction of wetlands by human encroachment is the most serious threat to populations, leading to decline or extinction of this species from many areas of West and Central Europe [9]. The IUCN (Red List) Status of the species is "Least Concern (LC)", it is listed under the Bern Convention (Annex 2), included to the Red Data Books of Lithuania and Latvia under the category "Rare".

For comparative purposes we also consider the and the Common newt, *Lissotriton vulgaris* (Linnaeus, 1758). On large areas, *L. vulgaris* is not threatened, however, some populations are declining or extinct due to anthropogenic causes, especially under urban conditions

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4099

[10]. The IUCN (Red List) Status of the species is "Least Concern (LC)" and it is listed under the Bern Convention (Annex 3).

II. Materials and methods

Occurrence data collection

We digitized presence survey data, including results of our field investigations in Latvia and Ukraine, to generate the occurrence data used in the modeling. Georeferencing (in Google Earth) was accomplished for 783 point data of *B. bombina* occurrence, and 1691 for *L. vulgaris*.

Environmental data

In most cases environmental predictors are selected based on the availability and experience that the variables show correlation with the species distribution [11]. Biotic factors, which are challenging to model explicitly, may nonetheless be implicitly represented in the model because they strongly correlate with abiotic factors [12]. In such circumstances it is reasonable to assume that biotic processes, that lead to the species realized distribution, may be captured by the relationship between the environmental predictor variables of abiotic character and the modeled species' occurrence patterns and it is reasonable to consider modeling the distribution only with selected environmental variables and meaningful climatic factors identified to be of most importance to amphibians [13]. In this work, we used climatic predictor data, sourced from the Worldclim dataset [14]. The Worldclim variables represent annual trends (e.g. mean annual temperature, annual precipitation) and extreme limiting environmental factors (e.g. temperature of the coldest and warmest months, precipitation of the wettest or driest quarter) and are known to influence species distributions.

As proxies for human disturbance of natural systems we used Human Footprint (HF) maps compiled from remotely-sensed and bottom-up survey information on eight variables measuring the direct and indirect human pressures on the environment globally [15]. Data on human pressures were acquired or developed by the authors for: 1) built environments, 2) population density, 3) electric infrastructure (night light), 4) crop lands, 5) pasture lands, 6) roads, 7) railways, and 8) navigable waterways. Pressures were then overlaid to create the standardized HF maps.

Model building

The Maxent software (v.3.3.3k) was utilized for modeling, using the default settings. Maxent, unlike other distributional modeling techniques, uses only presence and background data instead of presence and absence data. This method has been shown to perform well in comparison with alternative approaches [16]. Logistic output format was used to describe the probability of presence [17], which is a continuous HS range between 0 (unsuitable) and 1 (the most suitable). Statistical data was analyzed using the PAST software package [18].

III. Results and discussion

Using the Spearman rank correlation, low, however statistically significant positive correlations ($p<0.05$) were found between the predicted for the toad and newt species HS and the standardized HF index, and some of the pressures mentioned above (Table I). The ascending logarithmic trendline in Fig. 1 shows this positive relationship in the case of the HF index for *B. bombina*.

TABLE I. SPEARMAN RANK CORRELATIONS BETWEEN PREDICTED FOR BOMBINA BOMBINA AND LISSOTRITON VULGARIS HABITAT SUITABILITY AND HUMAN DISTURBANCE

Human disturbance	**Species**	
	Bombina bombina	*Lissotriton vulgaris*
HF index	0.167	0.302
Built environments	n.s.*	0.238
Night light	n.s.	0.337
Population density	0.150	0.500
Pasture lands	-0.166	0.141
Crop lands	0.181	n.s.
*n.s. – statistically not significant		

A fairly large correlation of 0.5 was found between the *predicted* habitat suitability for the newt and population density. A graph built by using the method of the least squares curve fitting shows this relationship (Fig. 2), where increasing scores of human population density (at least up to the score of 8) enhance the HS for the species. In other words, places more densely populated by humans are more favourable for the well-being of the Common newt, although the most heavily populated places (characterized by scores 9 and 10) seem to be losing some of their attractiveness.

The relationships between human factors and biodiversity are important to assess the risk of extinction as human pressures are often related to large changes in biological diversity. However, the literature often shows contradictory results. Previous studies report that human influence may affect species' spatial distribution both negatively and positively [19].

For the considered in this study amphibian species a positive association with human-impacted areas was found. However, according to AmphibiaWeb [9, 10], the European fire-bellied toad in comparison to the Common newt differ in their ability to cope with human pressure. The fire-bellied toad is rare in urban environments and the lack of significant correlations of HS with built environments and the intensity of nighttime lights (a correlate with socioeconomic indicators and economic development) supports this view. Other established by correlation relationships point out the importance of rural areas for the toad, namely crop land (the association is positive), but the association is negative in the case of pasture land. Indeed, landscapes dominated by pasture

can be harsh environments for amphibians. The absence of sheltering and shading structures (e.g. trees and shrubs) can increase air and soil temperature and decrease humidity, directly and negatively affecting amphibian performance [20]. In addition, cattle graze shoreline and terrestrial vegetation and deposit nitrogenous waste in wetlands. There is growing evidence that agricultural practices that allow cattle access in wetlands may negatively affect some amphibian species [21, 22], and this may apply to the European fire-bellied toad.

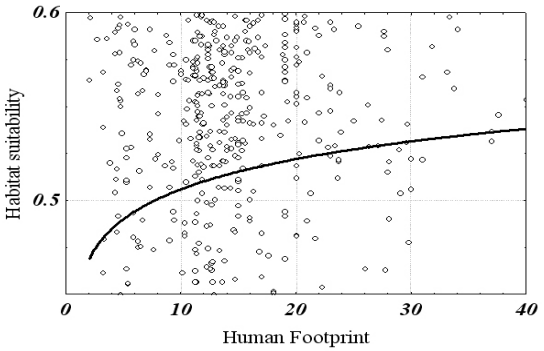

Fig. 1. A logarithmic trendline showing the relationship between the Human Footprint index and predicted habitat suitability for *B. bombina*.

Contrary to the toad, the Common newt often is found in landscapes altered by humans, including large cities, and its ability for synanthropization is considered moderate. In fact, this difference is reflected in the established Spearman rank correlations, showing a greater association of the newt with human-impacted areas, primarily with densely populated areas, night light and built-up environments, and in the last turn with pasture land, and no significant association with crop land.

The reason for co-occurrence of suitable habitat and human enterprises may be that though human population is concentrated in regions critical for amphibians, there is still a substantial amount of intact habitat in many of these regions. On the other hand, amphibians have been found breeding in a variety of habitats that are substantially different from their former pristine breeding habitats [23], so native wildlife can often adapt to novel and altered habitats, given suitable conditions. In North America and in Australia, for instance, human infrastructure provided beneficial environments to some amphibian species [24].

Our assumption is that human-constructed habitats such as ponds, fish farming facilities etc., housing, roads and waterways can enhance biodiversity. According to our observations, in dry areas, the presence of artificial, man-made ponds and reservoirs is of great importance (Fig. 3) for the hosting of such synanthropic amphibian species as *Bufotes viridis* [25] and pioneer species as *B. bombina* [26, 27, 28] etc.. Besides the synanthropization of animals, an increase in the number of anomalies in amphibians has been observed for over more than a 20-year period in Ukraine (1996–2018), and a statistically significant correlation of the number of anomalies in amphibians with the anthropogenic impact (assessed by the HF) was found [29, 30]. Finally, *B. bombina* and other amphibians can be subjected to invaders, for instance the Chinese sleeper [31, 32, 33, 34] and alien freshwater turtles [35].

Human infrastructure can encourage species to colonize urban areas by creating ecological corridors and networks to circumvent obstacles, thereby providing access to favourable habitats [1, 28]. This is a phenomenon that perhaps is much more widespread than thought before.

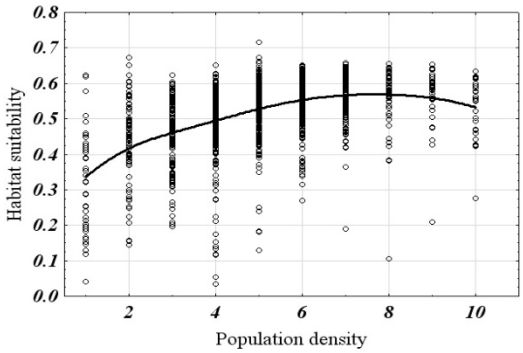

Fig. 2. Relationship between scores of human population density and predicted habitat suitability for *L. vulgaris*.

Fig. 3. Amelioration channel - breeding habitat for *B. bombina* (River Trubizh, Kyiv region, Ukraine: biotope and juv. *B. bombina*).

IV. Conclusions

We used a habitat modeling approach where modeling has successfully been used for revealing species' ecological requirements and exploring the relationships between habitat suitability and human impact. For both considered in this study amphibian species (the European fire-bellied toad and the Common newt) a positive association with human-impacted areas was found. From conventional knowledge it is clear that both species differ in their ability to cope with human pressure and in our approach we have arrived with the same conclusion, but in a quantified manner. Our assumption is that human infrastructure can enhance biodiversity, a phenomenon that perhaps is much more widespread than thought.

V. Acknowledgments

The study was conducted in accordance with legislation of Latvia and Ukraine. We thank Daugavpils University for support and A. Pupina for her many-years leadership in research of *B. bombina* in Latvia.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 315-319

Assessment of Ecosystem Services for Planning of Green Infrastructure at the Regional Level

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***Abstract*—Ecosystem services (ES) are defined as the benefits that human beings derive from ecosystem functions. Assessment and mapping of these benefits are crucial for sustainable environmental planning and future natural capital. Green infrastructure (GI) is natural or semi-natural territories that provide wide range of ES. Human affected ecosystems tend to fail to provide certain sets of ES due to the trade-offs among those services, which could be mitigated through implementation of GI. Mapping of ES, as well as assessing the interactions among various ES and analysing their supply potential's cold/hot spots considerably enhances and substantiates the planning process of GI, particularly at the regional scale and for the territories with diverse landscape potential.**

The aim of this paper is to discuss the assessment of ES supply potential and analyse its spatial distribution to reveal cold/hot spots of ecosystem capacity to provide wide range services and functions for GI. The study presents GIS based assessment of ES in a case study of Zemgale Planning Region. ES supply potential was assessed for 27 Corine land use classes (CLC2018) together with 10 regulatory, 12 provisioning and 6 cultural ES. An expert-based ranking approach using a two-dimensional ES matrix and a geospatial analysis was applied to determine total ES supply potential, spatial patterns and relations among multiple ES. Additional statistical analysis (Getis-Ord Gi*) was performed on spatial distribution of regulatory ES to disclose statistically significant capacity of ecosystems to function as GI in given surroundings. Preliminary results show uneven distribution of ES, trade-offs between regulatory and provisioning ES and landscape dependent spatial clustering of these trade-offs supported by result of Getis-Ord Gi* analysis, thus laying a foundation for further planning of GI at the regional scale.

Keywords*—ecosystem services, green infrastructure, Zemgale Planning Region.

Introduction

Ecosystem services (ES) are benefits that human obtain directly or indirectly from ecosystems [1]. In the Millennium Ecosystem Assessment all of the ES are classified into four categories: (1) supporting ES that are essential to provide other ecosystem services e.g., maintenance of biodiversity or habitat for species, biomass production, nutrient cycling and soil formation, (2) provisioning ES that provide people with direct benefits and can be identified as market value, e.g., hay for animal feeding, biomass for energy production, herbs for medical treatment, genetic resources, (3) regulating ES that are of paramount importance for the well-being of humanity, e.g., climate regulation, pollution reduction, erosion protection, (4) cultural EC that contribute to personal growth, raise knowledge, provide aesthetic enjoyment and recreational facilities, e.g., landscape and its aesthetic qualities and cultural heritage, providing the basis for recreation and tourism, as well as quality of life for living in that area [1], [2]. The concept of ES was introduced in 1980, but only during the last years the inclusion of ES in policy and decision-making processes has been advocated for promoting sustainable development [3].

The idea of ES is closely linked to other definitions of natural components and their multiple functions. In the course of development ideas of ES have been followed by concepts of green infrastructure (GI) as well as nature-based solutions [4]. The European Commission defines GI as "a strategically planned network of natural and semi-natural areas with other environmental features designed and managed to deliver a wide range of ecosystem services such as water purification, air quality, space for recreation and climate mitigation and adaptation" [5]. GI also plays a vital role in the conservation and enhancement of biodiversity and in tackling habitat fragmentation [6]. In this research we use quantitative assessment of ES to

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4085

define areas at the regional level where GI (e.g. value of biodiversity, watershed protection etc.) is insufficient of lacking in order to support policy decisions about further planning process of GI. Thus, the aim of this paper is to discuss the assessment of ES supply potential and analyse its spatial distribution to reveal cold/hot spots of ecosystem capacity to provide wide range services and functions for GI.

MATERIALS AND METHODS

A. Study area

The study area is an administrative territory – Zemgale Planning Region (ZPR) that covers 10 742 km² and is situated in the central part of Latvia. It is comprised by diverse landscape regions: large tracts of intensive agricultural fields, mosaic type landscapes, as well as areas with large forest or wetland areas. The distribution of landscape types is related mainly to geo-ecological potential of the area, such as soil fertility, topography, drainage conditions. However, socio-economic processes, such as land abandonment and depopulation, have also affected landscape functions in the last decades, especially in the territories of marginal locations and of low agricultural potential. There are several natural features of historical value, such as, the River Daugava and the River Lielupe, which determine the largest settlement areas (towns of Jelgava, Bauska, Jēkabpils and others), while the nature protection areas are related to the distribution of natural wetlands (mires and bogs), but also – river valleys.

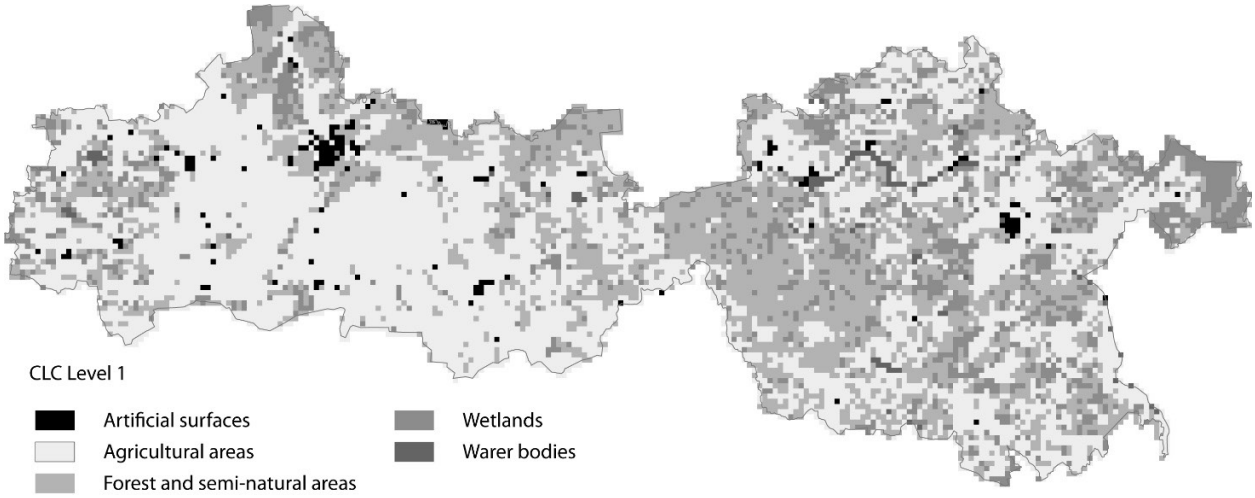

Fig. 1. Land use in ZPR according to (CLC2018)

According to the level 1 of Corine land use classes (CLC2018), the territory of ZPR is composed by 1.75% of artificial surface, 49.31% agricultural area, 45.11% forest and semi-natural area, 2.63% wetlands and 1.21% of water bodies (Fig. 1).

B. Methods

This study used the CICES v.4.3, the most widely used classification of ecosystem services, where support services are not considered separately, as they are assumed to be a prerequisite for other service categories. The ES matrix method, developed by Burkhad et al. [8] – [10], was used to assess the ES. It is a semi-quantitative, adaptive and efficient GIS technique to assess the potential of ecosystems to provide certain services based on the type of Land Cover / Land Use (LCLU). This method uses the CORINE LCLU type class as a basis for expert judgment on the potential of this class to provide a separate service. A list of ES that included regulatory ES and supply ES (Table 1) was adapted from previous studies [1], [11] – [13] and adjusted to the specifics of the ZPR. The expert assessment was based on the ES assessment study [14] in the territory of Lithuania. The ES potential was mapped using a 1x1 km grid to provide further data analysis capabilities, especially hot and cold spots, ES clusters, and ES interactions. The grid used is fully in line with the grid of data collection of the Central Statistical Bureau of Latvia, thus it contains the potential to link the analysis of the spatial distribution of ES supply potential to the socio-economic indicators.

The results of the identification of the ES supply potential were used to identify ES clusters - ES bundles within which the ES interacts. The analysis was performed in SPSS software using the Principal Component (PCA) statistical procedure, which is able to divide the dataset into components, thus highlighting potential ES bundles. Sums of ES supply potentials of the ES Group (Regulatory, Production, Cultural) were used as a basis for spatial-statistical analysis in ArcGIS software using the Hot Spot Analysis (Getisi-Ord Gi *) procedure, thus separating statistically significant cold and hot spots of the ES group's supply potential.

TABLE I. Ecosystem services used in the study and indicators describing them (CICES)

Ecosystem services	Potential indicators
Regulating EC	
Global climate regulation (GCR)	Emitted-associated CO^2, methane, water vapours, etc..
Local climate regulation (LCR)	Temperature (amplitudes), albedo, precipitation, evaporation.
Air quality regulation (AQR)	Leaf area index, amplitude of pollution indicators.
Water flow regulation (WFR)	Amount of water on hold
Water purification (WP)	Water quality and quantity
Nutrient regulation (NR)	Balance of N, P and other substances
Erosion regulation (ER)	Quantity of particles on hold, ground coverage
Natural hazard regulation (NHR)	Quantity of floods, fires, frequency pf them
Pollination (POL)	Number of pollinators
Pest and disease control (PDC)	Diversity of landscape and species, spreading of diseases and pest sites
Provisioning EC	
Crops (CRO)	Harvest, t/ha
Biomass for energy (BFE)	Biomass t/ha, kJ/ha
Fodder (FOD)	Fodder t/ha
Livestock (LST)	Animal units /ha
Fibber (FBR)	Fibber t/ha
Timber (TBR)	Timber m^3/ha
Wood fuel (WDF)	Wood m^3/ha
Fish (FSH)	t/ha
Aqua culture (AQC)	t/ha
Wild foods and resources (WDR)	t/ha
Biochemicals and medicine (BCM)	t/ha
Fresh water (FRW)	m^3/ha
Cultural EC	
Recreation and tourism (RCT)	Relative fitness of the ecosystem for recreation and tourism
Landscape aesthetics and inspiration (LAI)	Relative suitability of the ecosystem for enjoyment and inspiration
Knowledge systems (KNS)	Relative relevance of the ecosystem to the maintenance of knowledge systems
Religious and spiritual experience (RSE)	The relative capacity of the ecosystem to provide religious and mental experience
Cultural heritage and cultural diversity (CHD)	Relative relevance of the ecosystem to the maintenance of cultural heritage and diversity
Natural heritage and natural diversity (NHD)	Relative relevance of the ecosystem to the maintenance of cultural heritage and diversity

RESULTS AND DISCUSSION

Assessment of ecosystem services was based on CORINE CLC type classes. The assessment was carried out on a relative scale of 1-5, indicating the potential of the given ES collateral (1-very low, 2-low, 3-average, 4-high, 5-very high). 0 is given in a situation where the service is not provided (Table 2).

TABLE II. Expert assessment by categories of EC

CLC type (Corine)	The sum of regulating ES	The sum of provision ES	The sum of culture ES	Total EP POTENCIĀLS
Discontinuous urban fabric	3	2	17	22
Industrial or commercial units	0	1	4	5
Road and rail networks	0	0	10	10
Airports	0	0	0	0
Mineral extraction sites	0	8	5	13
Dump sites	0	3	1	4
Sport and leisure facilities	14	0	9	23
Non-irrigated arable land	11	24	13	48
Fruit trees and berries	22	16	17	55
Pastures	20	19	16	55
Complex cultivation patterns	15	18	11	44
Agriculture & natural vegetation	25	21	19	65
Broad-leaved forest	49	22	20	91
Coniferous forest	46	22	22	90
Mixed forest	47	22	21	90
Natural grassland	28	14	19	61
Transitional woodland shrub	19	9	11	39
Inland marshes	29	9	13	51
Peatbogs	35	7	22	64
Water courses	21	17	22	60
Water bodies	24	20	22	66

The results obtained were analysed in the SPSS software, using the statistical procedure of the principle components analysis (PCA) and potential ES bundles were highlighted. Using the Hot Spot Analysis (Getisi-Ord Gi *) procedure in the ArcGIS software 1 x 1 km network grid, the cold and hot spots of statistically significant ES bundles potential were distributed. As the main trade-offs of ES in the context of green infrastructure are linked to benefits obtained from regulation of ecosystems, further in the research we will probe into one class of ES – regulating services. The map of regulating ES reveals the spatial distribution of hot and cold spots of the services (Fig. 2). The hotter the spot (red), the amount of service is higher, the colder the spot (blue), more statistically significant the lack of specific ES in the territory. Regional scale analysis of areas covered by forests (Fig. 1) reveal to be the hotspots of regulating ES (Fig. 2), while the areas intensively used for agriculture purposes as well as the territories with higher density of inhabitants reveal to be cold spots, i.e., spatial clustering of specific ES depends on the dominating land use.

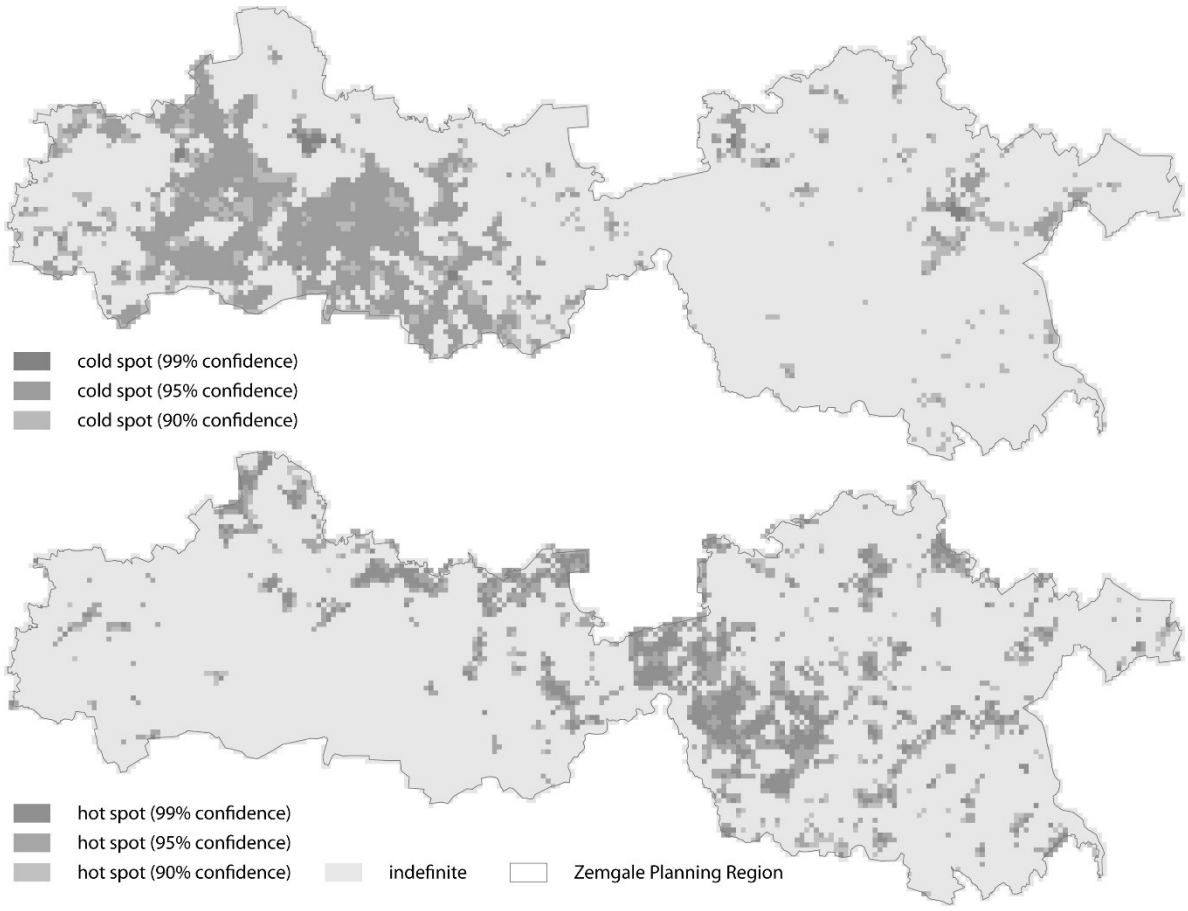

Fig. 2. The hot/cold spots of regulating ecosystem services supply potential in ZPR

The map of regulating ES reveals the spatial distribution of hot and cold spots of the services (Fig. 2). The hotter the spot (red), the amount of service is higher, the colder the spot (blue), more statistically significant the lack of specific ES in the territory. Regional scale analysis of areas covered by forests (Fig. 1) reveal to be the hotspots of regulating ES (Fig. 2), while the areas intensively used for agriculture purposes as well as the territories with higher density of inhabitants reveal to be cold spots, i.e., spatial clustering of specific ES depends on the dominating land use.

The central part of ZPR, where the landscape of agricultural lands with a dense network of rivers prevail, plays a crucial role in the warranty of provisional ES, but it lacks regulating ones. Thus, intensive farming practices result in contamination of surrounding water bodies and decline of biodiversity. It means that various components of green infrastructure dealing with the reduction of agricultural runoffs and pollution, e.g. buffer-zones between agricultural lands and water bodies that would minimize the negative impacts of agricultural pollution, should be planned and implemented in the agricultural landscape. At the same time trade-offs between provision ES and regulating ES should be analysed when planning green infrastructure.

More densely populated territories (towns and villages), disclose the lack of ES potential in both (regulating and provisioning) classes. In these areas cold spots of regulating as well as provisional ES prevail (Fig. 2). This is related to the continuous urban fabric, which significantly reduces the capacity of regulating and provisioning ES [14]. Therefore, when referring to green infrastructure, these territories should be taken into account primarily. Components of green infrastructure, e.g., buffer zones, green corridors and pathways, should be planned and implemented there.

In the context of the evaluation of the planning of GI, the main role is played by existing deployment and availability of regulatory ES. Previous researches have shown that management that attempts to maximize a particular ES often results in substantial declines in the provision of other ES [15]. Therefore, when assessing potential development areas of GI, deployment of provisioning and cultural ES should also be taken into account. This makes it possible to assess the relationship between all groups of ES and to find the best trade-offs between them.

CONCLUSIONS

The approach used in the research shows a capability to cover geographic areas at a regional scale in order to map ES. The results disclose the potential of ES assessment and mutual matching of them in order to find trade-offs between classes of ES in order to prioritize territories for GI development as well as to support and substantiate GI planning at the regional and national level. The method can support the decision-making processes in the field of regional planning, nature protection and GI development as a whole. Mapping of ES, as well as assessing the interactions among various ES and analysing their supply

potential's cold/hot spots, considerably enhances and substantiates the planning process of GI, particularly at the regional scale and for the territories with diverse landscape potential.

This research is the first attempt to use the assessment of ES in GI planning at regional level in Latvia. The results reveal uneven distribution of ES thus showing the necessity to estimate trade-offs between regulatory and provisioning ES as well as landscape dependent spatial clustering of these trade-offs. Thus, the study is laying s a foundation for further planning of GI at the regional scale.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 320-324

The Number of Medical Imaging Services in Latvia and Lithuania

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***Abstract*—The increase in medical imaging services has a significant impact on healthcare costs. The study analyses the dynamics of a number of medical imaging services in Latvia, Lithuania, and in England for comparison (2012-2016), which shows that the number of medical imaging examinations increases in all the countries covered by the study. Moreover, there are significant differences in the application of those services in Latvia and Lithuania if compared to England, which may indicate to inefficient resource management and differences (or absence) of diagnostic guidelines. The following research methods have been used for the research: monographic or descriptive method and graphical method for visualisation, and analysis of visual information.**

Keywords—*examinations, health, radiations.*

I INTRODUCTION

In recent years, the high and ever-growing costs of healthcare systems due to technological innovation and an ageing population are a significant and pressing issue in almost all economies [1], [2]. Diagnostics is an integral part of healthcare and provides a more accurate diagnosis of the type, cause, and severity of a disease. Diagnosis allows for a more precise treatment plan [3]. The advances in medical technology in both diagnostics and treatment have contributed to a rapid increase in healthcare spending [4]. Expanding medical imaging services has a significant impact on healthcare costs, healthcare quality, and healthcare risks. As the number of

radiological examinations increases, the risk of radioactive exposure increases as well, which is not always beneficial to patient care [5]. One of the strategic objectives of the World Health Organisation (WHO) is to ensure the availability, quality, and correct use of medical devices (instruments). In May 2007, the WHO Assembly expressed concerns about the inadequate investment in healthcare technologies related to medical devices (instruments) that do not meet national priorities and are used irrationally or misused, thus wasting money [6]. The WHO states that the increase in the availability of medical devices would increase the number of imaging procedures significantly [7]. Efficient use of resources (medical imaging instruments in this case) is discussed not only in terms of a number of examinations performed with one device but also in terms of a number of completed examinations per population in comparative economies (Latvia, Lithuania). The authors of the study assume that the higher performance corresponds with the worse efficiency because it increases the overall cost of healthcare. The study uses data from public databases (such as NHS England, OECD), as well as the data received on demand from Latvia and Lithuania.

The study was aimed at showing the differences between the number of medical imaging services in Latvia and Lithuania and the number of examinations performed with them compared to England that can indicate the efficiency of the instrument use. To achieve the overall goal, the following tasks were set:

1. Compare the number of medical imaging devices and the number of examinations in the OECD countries.
2. Compare the number of examinations performed with medical imaging devices in Latvia and Lithuania in comparison to England.

The study is based on the data from the Organisation for Economic Co-operation and Development (OECD) between 2012 and 2016 (or last published) [8]. In OECD statistics, data is available on a number of Computed Tomography, Positron Emission Tomography (PET), Magnetic Resonance, whereas the data on most commonly used devices such as X-ray and ultrasound instruments have not been aggregated. The authors obtained data from Latvia (Center for Disease Prevention and Control), Lithuania (Hygiene Institute), and England [9]. There is a decentralised healthcare system in the United Kingdom, so only national data for England were used in the research. The following research methods have been used for the study: monographic or descriptive method and graphical method for visualisation, and analysis of visual information.

II RESULTS AND DISCUSSION

Modern medical imaging has direct benefits, which include more efficient surgical treatment, shorter stay in the hospital, elimination of diagnostic surgery, better cancer diagnosis and treatment, more efficient post-trauma treatment, better stroke treatment, better heart disease treatment, and rapid diagnostics of life-threatening vascular conditions such as mesenteric ischemia [10]. These benefits require new imaging instruments and expand their use in diagnostic and treatment. Over the past decade,

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4136

imaging services and their costs have risen about twice as much as other healthcare technologies [10]. The most significant number of Computed Tomography (CT) devices per million population (Table 1) is in Australia (62.95), while the smallest number is detected in Mexico (6.12). Hence, the number of imaging devices differs tenfold in OECD countries. In five countries (Luxembourg, Lithuania, Austria, Iceland, and the United States of America), the number of CT instruments has decreased. In its turn, an increase of 117% was observed in Chile reaching 24.27 units per million population; an increase of 25% was noticed in France reaching 16.92 units per million population, an increase of 25% in Australia leading to 62.95 units per million population.

TABLE 1
Computed tomography unit per million population [8]

Country	The 2012 year	The 2016 year or last available	2016/2012 (%)
Mexico	5.11	6.12	120%
Hungary	7.66	8.86	116%
United Kingdom	9.09	9.46	104%
Israel	9.1	9.71	107%
Netherlands	10.92	13.04	119%
Slovenia	12.64	14.04	111%
Turkey	13.53	14.53	107%
Canada	14.68	15.28	104%
Czech Republic	15.03	15.52	103%
France	13.49	16.92	125%
Luxembourg	24.48	17.14	70%
Ireland	16.74	17.24	103%
Slovak Republic	15.53	17.31	111%
Poland	15.4	17.33	113%
Estonia	17.39	17.48	101%
New Zealand	15.43	17.9	116%
Spain	17.19	18.26	106%
Lithuania	23.76	23.01	97%
Finland	21.8	24.2	111%
Chile	11.18	24.27	217%
Austria	29.77	29.07	98%
Italy	33.29	34.29	103%
Germany	34.01	35.17	103%
Latvia	32.44	36.23	112%
Greece	33.41	36.66	110%
Korea	36.93	37.8	102%
Iceland	40.53	38.76	96%
Switzerland	34.64	38.93	112%
Denmark	33.09	39.11	118%
United States	43.87	41.82	95%
Australia	50.48	62.95	125%

The largest number of Magnetic Resonance (MR) devices per million population (Table 2) is found in the United States of America (36.69), while the smallest number is found in Mexico (2.57). The number of MR devices differs 14 times in OECD countries. Only in two countries, the number of MR devices is declining, that is, Luxembourg and Iceland. The most substantial increase in the number of MR instruments was stated in Australia (160%), Chile (114%), France (56%), Poland, and the Slovak Republic (43%).

TABLE 2
Magnetic resonance units per million population [8].

Country	The 2012 year	The 2016 year or last available	2016/2012 (%)
Mexico	2.16	2.57	119%
Hungary	2.82	3.97	141%
Israel	3.29	4.91	149%
United Kingdom	7.16	7.23	101%
Poland	5.49	7.87	143%
Czech Republic	6.95	8.52	123%
Slovak Republic	6.29	9.02	143%
Chile	4.41	9.43	214%
Canada	8.86	9.49	107%
Turkey	9.58	10.55	110%
Slovenia	8.75	11.14	127%
Luxembourg	13.18	12	91%
Lithuania	10.04	12.2	122%
Netherlands	11.82	12.8	108%
France	8.65	13.52	156%
Estonia	9.83	13.68	139%
Latvia	9.83	13.78	140%
New Zealand	11.12	13.85	125%
Australia	5.5	14.29	260%
Ireland	12.39	14.72	119%
Spain	14.77	15.92	108%
Iceland	21.83	20.87	96%
Austria	19.1	22.43	117%
Finland	21.61	25.48	118%
Greece	21.91	26.63	122%
Korea	23.37	27.81	119%
Italy	24.62	28.4	115%
Germany	28.66	34.49	120%
United States	34.44	36.69	107%

When comparing the loading of medical imaging devices in Latvia (data Center for Disease Prevention and Control Latvia) and Lithuania (data Hygiene Institute Lithuania) in 2016 (Table 3), we can see that X-rays instruments are used 1.66 times more efficiently in Latvia than in Lithuania, CT instruments are used 1.14 times more efficiently, while MR devices are used 1.07 times more efficiently in Lithuania than in Latvia. USG

equipment is applied equally in both countries.

TABLE 3
Number of examinations per medical imaging unit in 2016

Equipment	Latvia	Lithuania	highest value/ lowest value
X-rays	10.375	6.235	1.66
CT	4.923	4.337	1.14
MR	3.460	3.692	1.07
USG	1.766	1.759	1.00

The number of medical imaging devices cannot be the only comparator. One does not know the age of medical devices, whether end-of-life equipment is written off when new imaging devices are bought, which are safer for patients (reduced radiation time, reduced examination time [11]), or the use of those devices continues. It is quite important because the latest generation imaging instruments are more advanced and have better image quality, as well as less exposure for a human. Is equipping with medical technology based on a number of examinations and are the devices loaded maximally? In all three countries compared (Fig. 1, 2, 3), the total number of medical imaging services is growing, as well as the number of methods considered separately, id est., Magnetic Resonance (MR), Computed Tomography (CT), radiography (X-rays), and ultrasonography (USG), is increasing.

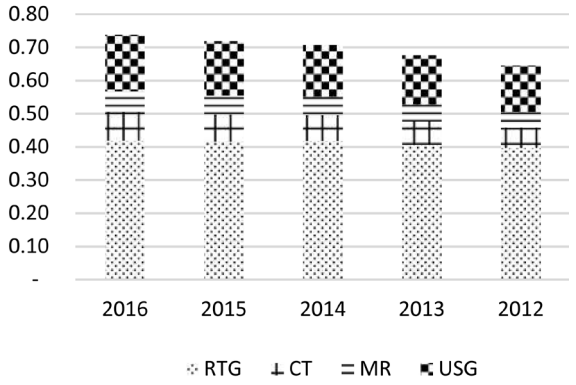

Fig. 1. The number of examinations per capita in England (2012-2016 year) [9]

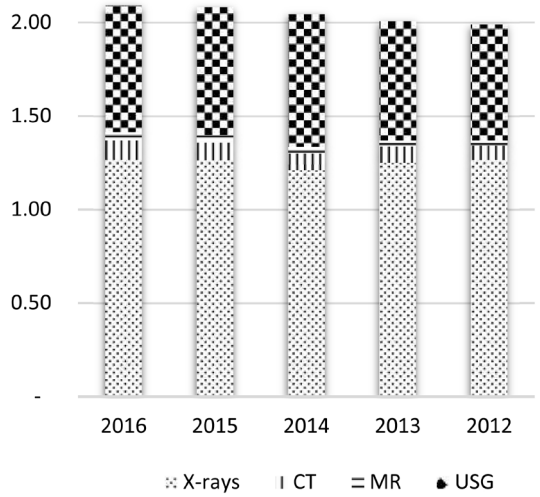

Fig. 2. The number of examinations per capita in Lithuania (2012-2016 year), (data Hygiene Institute Lithuania)

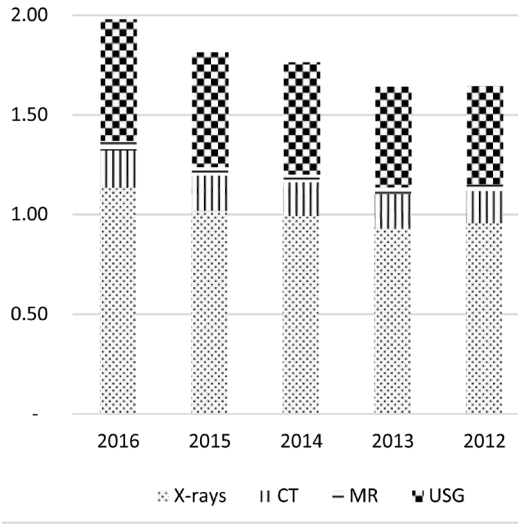

Fig. 3. The number of examinations per capita in Latvia (2012-2016 year), (data Center for Disease Prevention and Control Latvia)

The total number of examinations is the largest, namely, 2.09, in Lithuania; the total number of examinations is 1.98 in Latvia and 0.74 in England per capita per year, Which is almost 3 times less than in Lithuania. Figure 4 illustrates the vast difference between England and Latvia, Lithuania in each type of medical imaging examination in 2016.

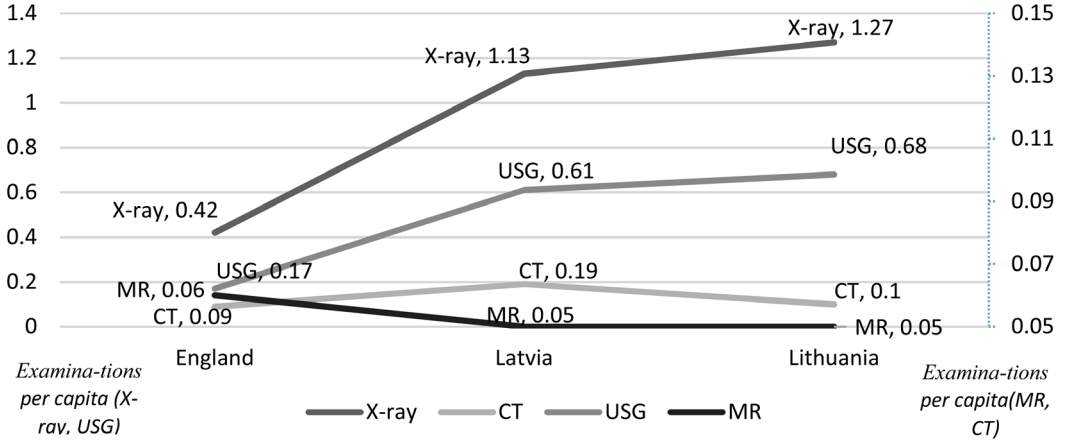

Fig. 4. The number of examinations per capita in 2016 year

The increase in the number of examinations per capita over the five years (2012-2016) is observed in all the countries studied (Table 4-6). The fastest percentage growth is MR examinations in Latvia (+ 68%), Lithuania (+ 63%), and England (+ 40%), while the growth rate of CT examinations is the fastest in England (+ 40%), Lithuania (+ 29%), and Latvia (+ 15%). The number of X-ray examinations per capita in Latvia (+ 19%), England (+ 6%), Lithuania (+ 0.4%) as well as USG examinations are also increasing.

TABLE 4
Number of examinations per capita Latvia

	2016. y	2015.y	2014. y	2013.y	2012. y	2016.y/ 2012.y (%)
X-rays	1.13	1.02	0.99	0.93	0.95	119%
CT	0.19	0.18	0.17	0.17	0.16	115%
MR	0.05	0.04	0.04	0.03	0.03	168%
USG	0.61	0.58	0.56	0.51	0.50	123%

TABLE 5
Number of examinations per capita Lithuania

	2016. y	2015.y	2014. y	2013.y	2012. y	2016.y/ 2012.y (%)
X-rays	1.27	1.26	1.21	1.25	1.26	100.4%
CT	0.10	0.09	0.09	0.09	0.08	129%
MR	0.05	0.04	0.04	0.03	0.03	163%
USG	0.68	0.68	0.71	0.64	0.62	109%

TABLE 6
Number of examinations per capita England

	2016. y	2015.y	2014. y	2013.y	2012. y	2016.y/ 2012.y (%)
X-rays	0.42	0.42	0.42	0.41	0.40	106%
CT	0.09	0.08	0.08	0.07	0.06	140%
MR	0.06	0.06	0.05	0.05	0.04	140%
USG	0.17	0.16	0.16	0.15	0.14	119%

III CONCLUSIONS

In most countries, the number of medical imaging devices is growing significantly, but there is a huge difference in access to common healthcare services among the OECD countries. A large number of examinations does not always indicate that the population has access to these examinations, as shown by the example of Latvia, where are long queues for state-funded imaging services. For instance, an individual must wait between 50 and 180 days for an MR examination in Latvia [12]. To identify the productivity of imaging instruments precisely, one should study a number of examinations performed by each individual imaging device, as specific productivity will depend on a number of population at a particular location, where the device is installed. In a sparsely neighboured area, the productivity of imaging device can be lower than in a densely populated area. There are significant differences in the number of medical imaging services in Latvia and Lithuania if compared to England, so additional research is needed to compare this indicator in as many countries as possible so that correct conclusions can be drawn on the reasons why the differences in the number of examinations are so significant. The authors consider that the lack of precise medical guidelines in Latvia and Lithuania is the primary reason resulting in unjustified examinations being performed and medical imaging services being overused. The study [10] identifies the ways to tackle causes to reduce the overuse of imaging devices. The authors agree that the countries with a high number of medical examinations (such as Latvia and Lithuania) should develop evidence-based eligibility criteria, draft comprehensive guidelines, educate attending physicians, patients, and the public because patients demand imaging examinations (they have read about them or have seen advertising). It is also essential to introduce a payment reform for imaging services so that no payment is made for individual examinations, thus creating economic incentives. Providing maximum control over double examinations is crucial by ensuring a single database of all the examinations. All the countries are recommended to publish open data as well as to grant access to medical data for further scientific advancement to improve the efficiency of national medical services.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 325-329

Rational Power Supply of Energy-Deficient Regions

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***Abstract*—The questions of supplying power to the region with remote consumers are considered. The model of integrated power supply is proposed. Mathematical dependences that allow accounting volumes of certain types energy resources consumption and forming rational energy balance of the region are formulated.**

***Keywords*—energy balance of the region, centralized power supply, electricity consumers, decentralized power supply.**

I. Introduction

Efficient power supply of energy-deficient regions (remote consumers of electricity) determines the conditions for safe, efficient and sustainable functioning of the energy sector, as well as the system of relations between the subjects of the fuel and energy complex, consumers and the state, ensuring the achievement of the goals set in energy policy for the real conditions of the country's energy sector [1].

The strategic goals of supplying power to the energy-deficient regions are:

1) Reduction of consumption of non-renewable fuel and energy resources (fuel and energy resources);
2) Reducing the environmental impact from the fuel and energy infrastructure;
3) Improving economic efficiency of supplying energy to a region;
4) Ensuring reliable power supply for geographically distant consumers.

From these goals we can suggest following ways to achieve them:

a) Integrated use of centralized and decentralized energy supply for large enterprises and remote energy-deficient regions;
b) Quick creation of autonomous (decentralized) facilities (systems) based on unconventional and renewable energy sources;
c) Introduction of elements of intelligent energy systems (IES) for monitoring and control, transmission and distribution of electricity, as well as the effective management of electrical equipment at enterprises and utilities [2].

II. Model of Integrated Power Supply

Generalized scheme of the energy balance of the region (Pskov region) is shown in "Fig. 1".

Assuming that in the region there are no other consumers rather than enterprises, designated as "K", it is possible to write the following formula:

$$\sum_{i=1}^{I} W_i^c + \sum_{\kappa=1}^{K} W_\kappa^{\ d} = \sum_{\kappa=1}^{K} W_\kappa (1+\alpha_\kappa) \quad (1)$$

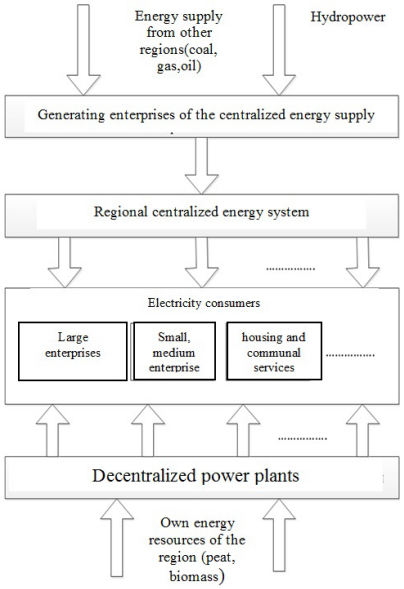

Fig. 1. Generalized scheme of the energy balance of some region, the Pskov region, for example.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4139

Let's introduce following notation:

where: W_i^c - is electrical energy generated by the i-th enterprise (i=1….I), that provides the operation of a centralized power supply system

$W_{\hat{e}}^{\ d}$ - is electrical energy generated by an autonomous (decentralized) source;

W_κ - is energy consumed at the K-th enterprise (K=1.....(K); coefficient $\alpha_{\hat{e}} = \frac{W_{k(losses)}}{W_k}$, that takes into account losses W_κ during transportation of electricity from the source to the consumer [3];

$W_\kappa = W_{k(original)} - W_{k(losses)}$, where $W_{k(losses)}$ - is energy losses during transportation.

W_{lr} - is the electrical energy consumed at the lth enterprise (l = 1 ...) in the rth area (r = 1 ... .R), where R is the number of areas in the subject of the Russian Federation (for the Pskov region, R = 26);

W_{nr} - is electric energy consumed by housing and utilities enterprises and individual users from the population in the r-th area (n=1…. N_r); M – is a total number of autonomous (decentralized) sources of electrical energy in the region($M \le K + \sum_{r=1}^{R}(L_r + N_r)$,autonomous (decentralized) sources that consumers can have, but in practice they do not. For the case when there is a transfer to a centralized network of excess electricity generated by an Autonomous source, the ratio will take form:

$$\sum_{i=1}^{I} W_i^c + (\sum_{\kappa=1}^{K} W_\kappa^{\ d} - W_{excess}^{\ d}) = \sum_{\kappa=1}^{K} W_\kappa(1+\alpha_\kappa) \quad (2)$$

The energy balance of the region can be written in the following form:

$$\sum_{i=1}^{I} W_i^c + \sum_{m=1}^{M} W_m^{\ d} = \sum_{\kappa=1}^{K} W_\kappa(1+\alpha_\kappa) + \sum_{r=1}^{R}[\sum_{i=1}^{L_r} W_{lr}(1+\alpha_{lr}) + \sum_{n=1}^{N_r} W_{nr}(1+\alpha_{nr})] \quad (3)$$

The model of the energy system of the region can be represented by a directed graph, the vertices of which correspond to the sources and consumers, and the edges reflect the direction of electricity transmission ("Fig. 2").

Energy losses during transportation are shown here as the corresponding vertices of the graph ( ). Other notation:

$W_{\alpha(L1,1)}$ - losses associated with the transmission of energy to the L-th consumer (medium and small enterprises) in the first area;

$W_{(L1,1)}$ - is the energy consumed by L-consumer in the first area;

$W_{(L1,1)}$ - is the energy consumed by L-consumer in the first area;

$W^d_{(L1,1)}$ - is electrical energy generated by an autonomous (decentralized) L-th source in the first area [4];

$W^S_{\alpha(N1,1)}$ - losses associated with the transmission of energy to the N-th consumer (utilities and individual users in the first area;

$W^S_{(N1,1)}$ - is the energy consumed by the N-consumer (housing and individual users) in the first area;

$W^{dS}_{(N1,1)}$ - is electric energy generated by an autonomous (decentralized) source N-th source (housing and utilities and individual users of the population) in the first area [5].

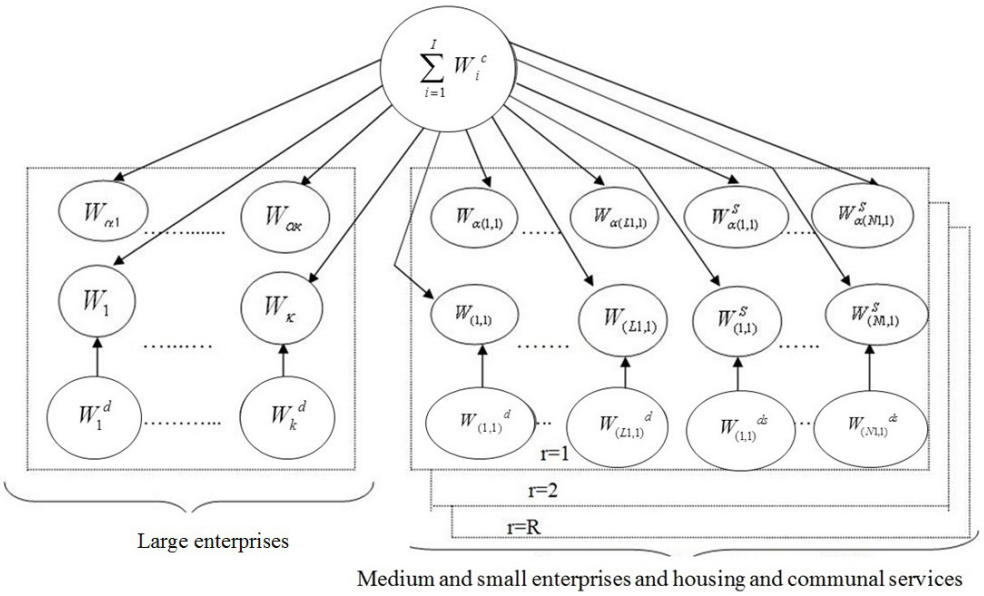

Fig. 2. Model of energy supply to consumers of the regional energy system

III. METHOD OF EVALUATING ECONOMIC EFFECTIVENESS OF THE SYSTEM PROVIDING SUSTAINABLE ENERGY SUPPLY FOR ENERGY DEFICIENT REGION

Let's introduce following notation:

z^{res} - is the unit costs associated with the use of fuel and energy resources (coal, gas, etc.), i.e. the cost of fuel and energy resources needed to generate a unit of electricity;

$z^{res} = b_c \cdot P_T$, where b_c - specific consumption of fuel and energy resources,

P_T - is price of fuel and energy resources; In this case, the absolute costs are equal to:

$z^{res} \cdot W$, where W - is generated electrical energy;

$z^{\exp}$ - is unit operating costs for the generating plant or a combination of plants of the generating company, required to generate a unit of electrical energy. Absolute costs are: $z^{\exp} \cdot W$, where W - is generated electrical energy.

$z^{c.tr}$ - is specific costs for the transportation of energy from the generating source to the consumer, including losses during transportation per unit of transmitted electrical energy [6].

In this case, the absolute costs are: $z^{c.tr} \cdot W$, where W is the consumed electric energy (in this case, we assume that it is equal to the generated electricity).

Costs of centralized power supply:

$$Z^c = (z^{c.res} + z^{c.\exp} + z^{c.tr}) \cdot W \quad (4)$$

Costs of integrated use of centralized power supply and energy of Autonomous (decentralized) sources based on non-traditional and renewable energy sources:

$$Z^{com} = (z^{d.res} + z^{d.\exp} + z^{d.tr}) \cdot W^{"} + (z^{c.res} + z^{c.\exp} + z^{c.tr}) \cdot W^{'} \quad (5)$$

where: $W^{"}$ и $W^{'}$ account for electrical energy consumed from a centralized network and from an Autonomous source respectively, $W = W^{"} + W^{'}$ - is total electrical energy.

Autonomous (decentralized) energy source is usually located directly on consumer's territory. In this regard it can be assumed that the costs of transporting electricity from such a source are negligible: $z^{d.tr} \approx 0$

When using renewable energy sources, the costs for fuel and energy resources can also be considered zero: $z^{d.res} \approx 0$

In this case, formula (5) takes the form:

$$Z^{com} = (z^{d.res} + z^{d.\exp} + z^{d.tr}) \cdot W^{'} + z^{d.\exp} \cdot W^{"} \quad (6)$$

The economic efficiency of using of integrated energy supply is determined by the expression:

$$\Delta Z = Z^c - Z^{com} \quad (7)$$

Taking into account formulas (4) and (6) we get:

$$\Delta Z = (z^{c.res} + z^{c.\exp} + z^{c.tr}) \cdot W - (z_{\text{or}}^{d.res} + z^{d.\exp} + z^{d.tr}) \cdot W^{'} + z^{d.\exp} \cdot W^{"},$$

$$\Delta Z = (z^{c.res} + z^{c.\exp} + z^{c.tr})(W - W^{'}) - z^{d.\exp} \cdot W^{"} \quad (8)$$

A positive economic effect from the integrated energy supply is obtained if:

$$(Z^{c.res} + Z^{c.\exp} + Z^{c.tr}) - Z^{d.\exp} > 0 \quad (9)$$

If the tariff for electricity from the centralized network is overstated comparing to the real costs, this can be taken into account using coefficient T >1. In this case, for the consumer the positive economic effect of the integrated energy supply will significantly increase and will be expressed as follows:

$$\Delta Z = T \cdot (z^{c.res} + z^{c.\exp} + z^{c.tr})(W - W^{'}) - z^{d.\exp} \cdot W^{"} \quad (10)$$

Mathematical model reflecting the total cost of integrated energy supply in the region Z^{reg} and economic efficiency of integrated power supply ΔZ^{reg} is defined by following formulas:

$$Z^{reg} = \sum_{\hat{e}=1}^{\hat{E}} (z_{\hat{e}}^c \cdot W_k^{'} + z_k^{c.tr} \cdot W_k^{'} + z_k^d \cdot W_{\hat{e}}^{"}) + \sum_{r=1}^{R} [\sum_{l=1}^{L_r} (z_{lr}^c \cdot W_{lr}^{'} + z_{lr}^{c.tr} \cdot W_{lr}^{'} + z_{lr}^d \cdot W_{lr}^{"}) + \sum_{n=1}^{N_r} (z_{nr}^c \cdot W_{nr}^{'} + z_{nr}^{c.tr} \cdot W_{nr}^{'} + z_{nr}^d \cdot W_{nr}^{"})] \quad (11)$$

$$\Delta Z^{reg} = \sum_{\hat{e}=1}^{\hat{E}} \Delta Z_{\hat{e}} + \sum_{r=1}^{R} [\sum_{l=1}^{L_r} \Delta Z_{l,r} + \sum_{n=1}^{N_r} \Delta Z_{n,r}] \quad (12)$$

where: z^c, z^d are the unit costs of centralized power supply and costs of energy supply from an autonomous and decentralized sources;

$z^{c.tr}$ - is the unit costs of transportation of energy from the generating source to the consumer, including losses during transportation per unit of the transmitted electric energy. Thus, absolute cost is: $z^{c.tr} \cdot W$.

The total cost depends on many variables: the cost of fuel and energy resources (Z^{res}), costs of transportation of electric power taking into account losses (Z^{tr}), number and location of large, small and medium-sized consumers (K,L,N, R), etc..[3]

As a criterion for the optimality of the proposed model, the total cost of integrated energy supply in the region can be taken. In this case, the optimality condition takes the form:

$$Z^{reg}(Z^{res}, Z^{tr}, K, L, N, R) \to \min. \quad (13)$$

Other optimality criteria can be used, for example, the

economic efficiency of integrated energy supply in the region:

$$\Delta Z^{reg}(Z^{res}, Z^{tr}, K, L, N, R) \to \max. \quad (14)$$

A detailed analysis of the formulas (3), (11) and (12), reflecting the energy balance of the region and the total cost and economic efficiency of integrated energy supply in the region requires taking into account all the parameters characterizing the needs of consumers and the peculiarities of their territorial location in individual areas within their region. For a generalized interpretation of the energy system model of the region, the expression (11) can be presented in the following formulas [7]:

$$Z^{reg} = Z^{c} + Z^{c.tr} + Z^{d} \quad (15)$$

$$Z^{c} = \sum_{\hat{e}=1}^{\hat{E}} (z_{\hat{e}}^{c} \cdot P_{k}^{'}) + \sum_{r=1}^{R} (\sum_{l=1}^{L_r} z_{lr}^{c} \cdot P_{lr}^{'}) + \sum_{n=1}^{N_r} (z_{nr}^{c} \cdot P_{nr}^{'}) \quad (16)$$

$$Z^{c.tr} = \sum_{\hat{e}=1}^{\hat{E}} (z_{\hat{e}}^{c.tr} \cdot P_{k}^{'}) + \sum_{r=1}^{R} (\sum_{l=1}^{L_r} z_{lr}^{c.tr} \cdot P_{lr}^{'}) + \sum_{n=1}^{N_r} (z_{nr}^{c.tr} \cdot P_{nr}^{'}) \quad (17)$$

$$Z^{d} = \sum_{\hat{e}=1}^{\hat{E}} (z_{\hat{e}}^{d} \cdot P_{k}^{''}) + \sum_{r=1}^{R} (\sum_{l=1}^{L_r} z_{lr}^{d} \cdot P_{lr}^{''}) + \sum_{n=1}^{N_r} (z_{nr}^{d} \cdot P_{nr}^{''}) \quad (18)$$

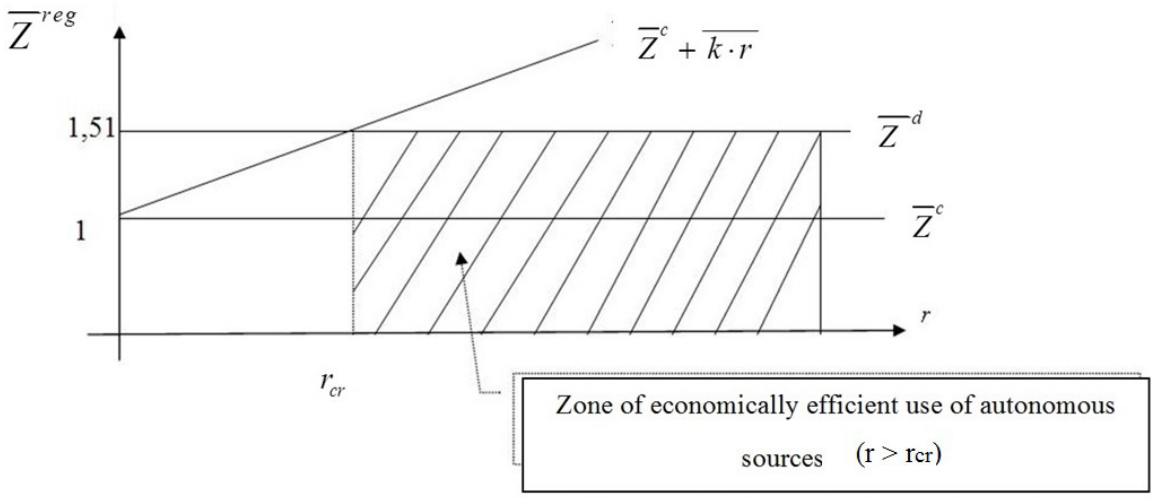

Fig. 3. Dependence of costs vs length of electrical networks for centralized sources and for autonomous energy sources.

If centralized and autonomous sources of electrical energy operate on the same type of fuel and energy resources, the costs of generating electrical energy with an autonomous source are higher. For example, for state district power plant (centralized source) and microturbines operating on natural gas, this ratio is approximately equal to 1.51. Taking into account the above, we will depict in "Fig. 3" components of the formula (20). At length of electric networks in region to $r > r_{cr}$ the use of autonomous energy sources is economically justified (this area is shown in "Fig. 3". indicated by hatching).

For the Pskov region $r_{cr} = \frac{0,51}{0,0005} \approx 1000 км$, the total length of electrical networks in the region $r = 4608 км.$

Assuming that the value of $Z^{c.tr}$ includes the cost of transmission of electricity, loss of electricity, the cost of maintaining networks and substations, in proportion to the length of the electric networks of the region [8]:

$$Z^{c.tr} = k \cdot r \quad (19)$$

where r – is the length electrical networks; κ – is the coefficient of proportionality.

Based on the established tariffs for energy transmission networks for the region, it is possible to determine the coefficient of proportionality k= 0,005 RUB/ KWh•km.

Let's move on to the relative variables, taking as a base Z^{c}. Denote the relative variables with the upper line formula (15) write in the following form [9]:

$$\overline{Z}^{reg} = \overline{Z}^{c} + \overline{k \cdot r} + \overline{Z}^{d} \quad (20)$$

where $\overline{Z}^{reg} = \frac{Z^{reg}}{Z^{c}}, \overline{k \cdot r} = \frac{k \cdot r}{Z^{c}}, \overline{Z}^{d} = \frac{Z^{d}}{Z^{c}}$

If electricity tariffs are too high, and autonomous energy sources use local fuel and energy resources, then the feasibility of using autonomous sources from an economic point of view becomes even more obvious [10].

IV. CONCLUSION

1. The model of integrated power supply is proposed. Formulated mathematical dependences that allow considering volumes of energy resources consumption of each type and forming rational energy balance of the region.
2. The method of assessing the economic efficiency of the system of sustainable energy supply for the energy deficient region and on its basis determined the effectiveness and socio-economic efficiency of the proposed model of energy supply of the Pskov region.
3. Sustainable energy supply for energy-deficient regions is proposed to be formed based on the integrated systems that provide the joint use of centralized and distributed energy supply, including ones, based on non-traditional and renewable energy sources.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 330-335

Behaviour's Analysis of Load-Carrying Members for Timber Framework Building

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***Atract*—The problem of limited raw material and energy resources can be solved by the replacement of non-renewable structural materials by renewable ones. Using of timber structures enables to decrease impact on the planet. It will also help to reverse some of the effects of industrialization. Structural members from solid and glued laminated timber, cross-laminated timber and other timber-based materials are widely used for one-storey and multi-storey buildings.**

Three-storey timber framework building was considered as an object of investigations. The considered three-storey building has length and width equal to 28 and 13 m, correspondingly. The using of software Autodesk Robot Structural developed FEM model of three-storey platform framed framework building. Load-carrying structures of considered framework building consist from the load-carrying walls, floors and roofs structures, which develop horizontal and vertical diaphragms providing strength and rigidity of the framework. The rational bay of the light framework structures changes within the limits from 300 to 600 mm. The rational span of beams and purlins does not exceed 4 m. Solid timber with the strength class C24 was assumed as a structural material for timber frameworks members. The OSB sheets were considered as a material of the cladding for external structures.

Behaviour of the load-carrying shear walls were analysed by the using of FEM models developed by the software Autodesk Robot Structural and ANSYS 15 so as methods explained in EN 1995-1-1. The software ANSYS 15 was used for the development of separate model of load-carrying shear walls. Initial unit of shear wall – a panel with the dimensions 1.2X2.7 m was considered for the purpose. The bar sub-members of the panel were modelled by the BEAM 188 finite element type. The SHELL 181 and COMBIN 14 finite element types modelled the cladding sub-members and mechanical fasteners. The dependence between the horizontal displacements of the load-carrying wall, intensity of the applied load, area of the openings so as thickness of the wall was obtained as a second power polynomial equation. It was stated, that the obtained FEM models enables to describe the behaviours of the load-carrying shear walls with enough precision.

***Keywords*—FEM model, horizontal displacements, load-carrying shear walls, platform framing.**

I. Introduction

Environmental protection is actual problem nowadays. It is important to reduce the quantity of carbon emissions. Timber use in construction can reduce the use of other construction materials, such as concrete, steel and brick, which require a lot of energy for their production and entail higher emissions. So, timber is environmentally friendly, renewable and recyclable natural resource, which can decrease impact on the planet. Structural members from glued laminated timber and other timber-based materials are widely used for multi-storey buildings and constructions [1] – [2]. Construction of multi-storey timber buildings represent the most practical, effective and environmentally responsible solution to the global housing shortage which is caused by the increased urbanization and the densification of cities. Not so far timber use for the multi-storey buildings was mentioned as the most significant limitation of it use as a structural material. But at the present moment this limitation was deleted due to the development of new timber based structural materials which provide development of mass structural members. The mass timber structural members are characterized by the increased fire resistance in comparison with the light timber members with the small cross-sections [3] – [5]. The frame of the world's tallest 18-storeys timber building, the Mjosa Tower, has completed at the present moment in Norway. This multi-storey building is being built using glulam, cross-laminated timber and laminated veneer lumber [6]. But possibility to create more than 30-storey timber building was stated [3].

The spatial stability of the multi-storey frameworks in case of horizontal actions usually is provided by the development of bracing system and shear walls. So spatial stability of the 18-storey frame of the Mjosa Tower is provided by the system of the external bracings (Fig. 1. (a)) [6]. NMIT Arts and Media Building is a first of multi-storey timber framework buildings, which employs an advanced damage avoidance earthquake design (Fig. 1. (b)) [7]. It is provided by the special joints between the panels of shear walls. Development of the shear wall model, which can be used for the behaviour's investigations of multi-storey timber building, is a target of the current investigation. Dependence between the horizontal displacements of the shear wall, intensity of the applied load, area of the openings so as thickness of the shear wall should be obtained for the purpose. Three-storey building is considered as an object of investigation taking in to account tendency in realisation of the similar objects in Latvia during the last years.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4068

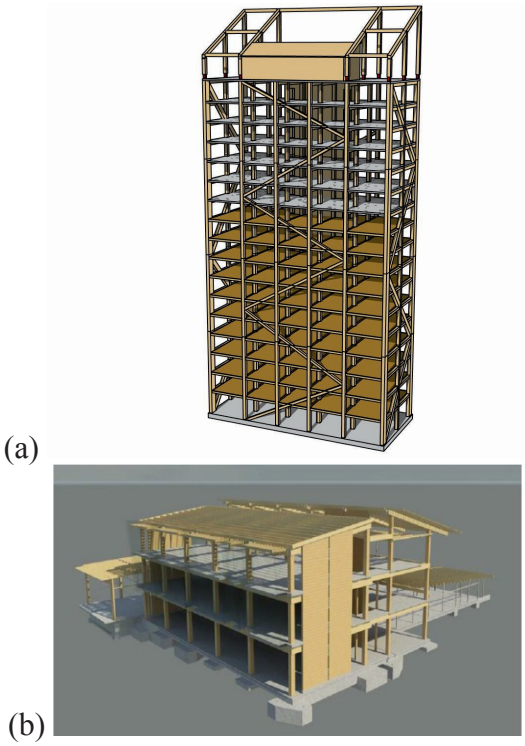

Fig. 1. Multi-storey framework timber buildings: (a) the world's tallest timber building, Mjosa Tower, which has 18 floors [6]; (b) NMIT Arts and Media Building [7].

II. Approach to the Solution of the Problem

A. Choice of structural solution for the multi-storey timber building

Structural solutions of multi-storey timber buildings can be divided in to the following groups:

- heavy framework's structures;
- light framework's structures;
- post-tensioned timber framework's structures [8].

Heavy framework's structures are widely used for modern multi-storey buildings. Heavy framework's structures are characterized by the mass columns and beams cross-sections and pinned or moment joints which are provided by the steel, hardwood or plywood mechanical fasteners. The Mjosa Tower can be considered as an example of the multi-storey building with the heavy framework's structures [6]. Another example of the heavy framework's structure is shown on Fig. 2 (a).

Light framework's structures (Fig. 2. (b)) are widely used for multi-storey timber buildings. This group of structures is characterized by the decreased materials consumption. The major load-carrying members are made from the solid timber and dimensions of cross-sections are within the limits from 70x45 to 245x95 mm. Structures of floors and external walls usually are covered by OSB and plywood sheets. Structures of internal walls are covered by the gypsum boards [8] – [9]. Light framework's structural solutions are divisible on the balloon framing and platform framing dependently from the joining methods of the major structural members (Fig. 3.).

Fig. 2. Structural solutions of multistorey timber buildings: (a) heavy framework's structure; (b) light framework structure [8] – [9].

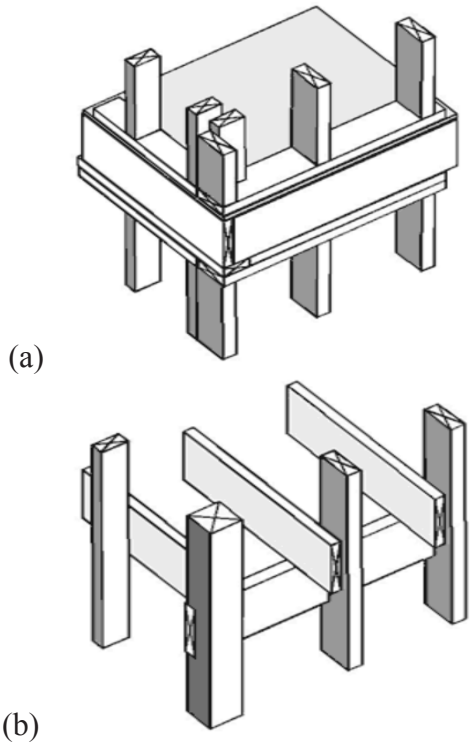

Fig. 3. Light framework's structural solutions: (a) platform framing; (b) balloon framing [8] – [9].

The platform framing joining method enables to obtain timber frameworks which are characterized by the increased fire resistance and spatial stability of the framework in comparison with the frameworks obtained by the balloon framing joining method. Decreased length and dead weight of the walls enables to reduce time and cost of the building's erection. The platform framing joining method is considered as a preferable one for the buildings with amounts of the storeys bigger than three [8] – [9].

Post-tensioned timber framework's structures are

characterized by the increased resistance to horizontal actions caused by the wind and seismic loads. Post-tensioning is provided by the steel tendons, which usually go through beams and columns and increase the load-carrying member's bending moment's resistance. Increased compliance enables to delete the eccentricities, which can occur in the case of big horizontal actions. Post-tensioned timber framework's structures are characterized by the fast and easy assembling due to the simplicity of the structural joints [8].

So, light framework's structures and platform framing joining method are chosen for the three-storey building which was considered as an object of investigations. Plan and cross-section of considered three-storey building with the structural dimensions are shown on Fig. 4.

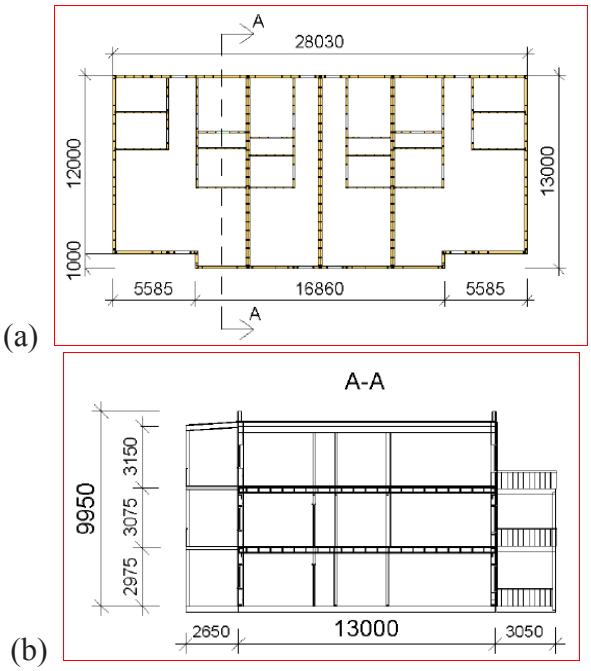

Fig. 4. Plan (a) and cross-section (b) of considered three-storey building [8].

B. Method of analysis

Light framework's structures of considered three-storey building are presented by the floor and roof's structures so as external and internal shear walls. The floors and roofs structures are presented by the members subjected to flexure due to the action of snow load on the roof and imposed load on the floor. Dimensioning and check of ultimate limit state for the load-carrying members of the roof and floors should be carried out by the formulas (6.11), (6.12) and (2.2) of EN 1995-1-1. The determinant condition for the dimensioning of the floors and roofs members are strength conditions in flexure, which can be checked by the formulas (1) and (2) [10].

$$\frac{\sigma_{m,y,d}}{f_{m,y,d}} + k_m \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \qquad (1)$$

$$k_m \frac{\sigma_{m,y,d}}{f_{m,y,d}} + \frac{\sigma_{m,z,d}}{f_{m,z,d}} \leq 1 \qquad (2)$$

Where: $\sigma_{m,y,d}$ and $\sigma_{m,z,d}$ are maximum normal stresses acting in the cross-section of the members due to the bending moments acting relatively y and z axis, correspondingly; $f_{m,y,d}$ and $f_{m,z,d}$ are the design resistances of timber in bending; km is a factor, equal to 0.7 for rectangular sections.

The main functions of the load-carrying shear walls are taking up of vertical and horizontal loads and actions and transferring it to foundations so as providing of spatial stability of the building's structure. The load-carrying shear wall structure usually is formed by the system of struts placed with the regular spacings joined together by the system of cross-bars and struts. Typical structural solution of load-carrying shear walls for the buildings with the light framework is shown on Fig. 5 [11] – [13].

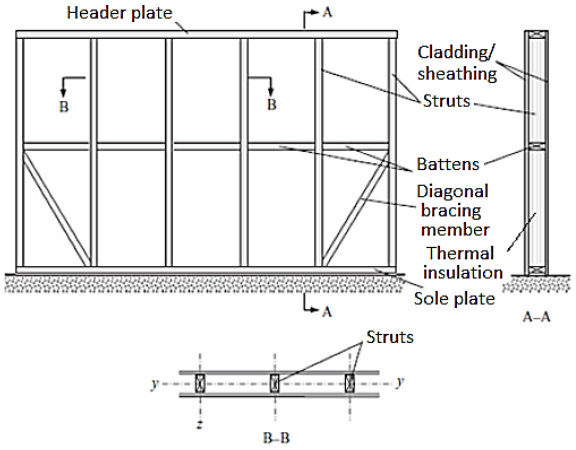

Fig. 5. Typical structural solution of load-carrying shear walls for the buildings with the light framework [12].

External load-carrying shear walls are subjected to the action both of vertical and horizontal loads, but internal ones to the vertical loads only. The determinant condition for the dimensioning of the struts, cross-bars and bracings are stability conditions, which can be checked by the equations (3), (4) and (5). The equations (3) and (4) are used in the case, if relative slenderness of the members is less or equal to 0.75 [12], [10].

$$\frac{\sigma_{c,0,d}}{k_{c,z} f_{c,0,d}} + k_m \frac{\sigma_{m,d}}{f_{m,d}} \leq 1 \qquad (3)$$

$$\frac{\sigma_{c,0,d}}{k_{c,y} f_{c,0,d}} + \frac{\sigma_{m,d}}{f_{m,d}} \leq 1 \qquad (4)$$

Where: $\sigma_{m,d}$ and $\sigma_{c,0,d}$ are maximum normal stresses acting in the cross-section of the arch due to the bending moment and compressive force, correspondingly; $f_{m,d}$ and $f_{c,0,d}$ are the design resistances of timber in bending and compression, correspondingly; $k_{c,y}$, $k_{c,z}$ are factors, which should be determined by the equations (6.25) and (6.26) [10]; other designations as for equations (1) and (2).

The formula (5) is used in the case, if relative slenderness of the members is bigger than 0.75, respectively [10]:

$$\left(\frac{\sigma_{m,d}}{k_{crit}\, f_{m,d}}\right)^2 + \frac{\sigma_{c,0,d}}{k_{c,z}\, f_{c,0,d}} \leq 1 \qquad (5)$$

Where: k_{crit} is a factor which takes into account the reduced bending strength due to lateral buckling; other designations as for formulas (1) – (4).

Light framework's structures of multi-storey timber buildings can effectively withstand to horizontal and vertical loads in the case, if shear wall and floors structures are correspondingly joined by the mechanical fasteners. So, shear walls of the considered building with light framework's structures consists from the framework and plywood sheets joined together by the mechanical fasteners [8], [13]. Software Autodesk Revit was used for development of 3D model of timber framework (Fig. 6.).

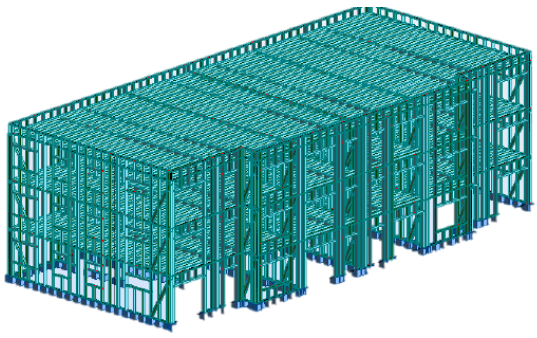

Fig. 6. 3D model of three-storey light framework's structures developed by software Autodesk Revit [8].

Vertical and horizontal members were modelled by the "bar" and "beam" finite element's types, correspondingly. "Cladding" type finite element was used for the modelling of the plywood sheets joined with the framework's members of load-carrying shear walls. Software Autodesk Robot Structural was used to analyse the obtained 3D model of timber framework on the action of permanent, imposed, wind and snow loads [14]. Separate model of load-carrying shear wall was developed by the software ANSYS 15.0. Finite elements types Beam 188, Shell 181 and Combin 14 were used for modelling of timber bars, plywood sheets and nails joined timber bars and plywood sheets [15].

III. Behaviour's analysis of load-carrying members for timber framework building

Behaviour's analyse of load-carrying members of framework structure of three-storey timber building was joined with analyse of the maximum internal forces and stresses, acting in the members of timber framework. Maximum vertical and horizontal displacements of shear walls, roof and floors are taken into account also.

3D model of light framework structure of three-storey timber building (Fig. 6) was analysed by the software Autodesk Robot Structural on the action of permanent load, imposed load, determined as for the residential building, and snow and wind loads determined for Riga climatic conditions. Intensity of design permanent loads acting on the roof and floors are equal to 1.30 and 1.80 kPa, correspondingly. Intensity of characteristic value of imposed load was taken as 2.0 kPa. Design snow load acting on the roof was equal to 2.04 kPa. The maximum values of positive and negative wind pressure are equal to 1.14 and 0.77 kPa, correspondingly [14].

Solid timber with strength class C24 was considered as a structural material of solid timber members [16]. Birch plywood with mean values of density, flexural modulus of elasticity parallel to the fibres of outer veneers equal to 680 kg/m^3 and 10719 MPa, was considered as a material of outer sheets of load-carrying shear walls [12].

It was shown, that maximum compression axial force in 48.18 kN acting in the strut of the first floor. Corresponding values of bending moment and shear force are equal to 1.31 kNm and 2.26 kN, correspondingly.

According to the calculations obtained by the software Autodesk Robot Structural The maximum values of the bending moment and shear forces acting in the beams of the floors are equal to 4.32 kNm and 4.78 kN, correspondingly. Maximum value of instantaneous vertical displacements of the beams is equal to 11 mm.

Design schemes of the struts in plane and perpendicular to the plane of shear wall so as scheme of the frameworks load-carrying members' placement in shear wall are shown on the Fig. 7. Height of the shear wall structure is equal to 2.7 m. One row of the cross-bars is placed in the height's middle of the shear wall structure.

This crossing bars provide support of the struts in the middle of its height in plane of the shear wall. Two head binders provide joining of the struts. The struts are placed with the spacings equal to 600 mm [8]. The depth and width of the struts are equal to 195 and 45 mm, correspondingly. The beams of the roof and floors have solid timber cross-sections with depth and width equal to 220 and 45 mm, correspondingly.

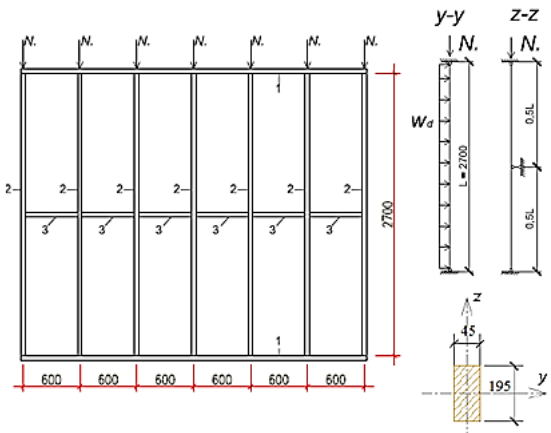

Fig. 7. Design scheme of the struts in shear walls in planes y-y and z-z.1 – head binders; 2 – struts; 3 – cross-bars [8].

The obtained parameters of the struts and beams were used for the development of the 3D models for shear wall by the using of software ANSYS 15.0. Shear wall's panels were considered as the initial members for investigation of shear wall stiffness at the action of horizontal loads. Three variants of shear wall panels were considered: variant without openings, variant with window opening

and variant with door opening (Fig. 8).

The maximum horizontal displacements as a function from the thickness of the plywood sheets, areas of the openings so as intensities of the horizontal load was found as a second power polynomial equation [17] – [18]. Thickness of the plywood sheets, areas of the openings so as intensities of the horizontal load changes within the limits from 6 to 9 mm, from 0 to 1.22 m2 and from 0.5 to 2.5 kN, correspondingly.

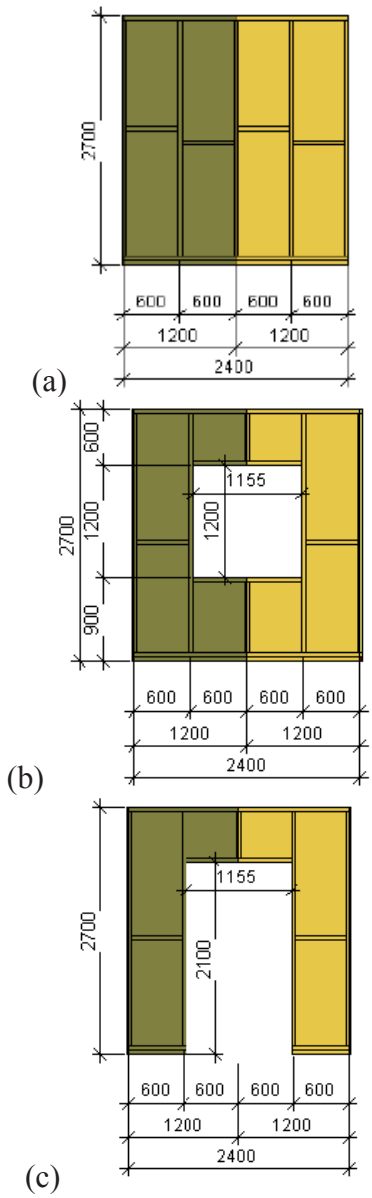

Fig. 8. Three variants of considered shear wall panels: a) – variant without openings; b) – variant with window opening; c) – variant with door opening [8].

Distribution of stresses by the considered shear wall panel surface, which was obtained by the software ANSYS 15.0, is shown on the Fig. 9. It was shown, that the maximum stresses in 0.84 MPa, acting in the plywood sheets, were obtained for the panels with the door openings. The maximum stresses are equal to 0.25 MPa for the panel without openings. The stresses and horizontal displacements were determined using recommendations for simplified analysis of wall diaphragms reflected in the clause 9.2.4.2. of EN 1995-1-1. The dependences of maximum horizontal displacements from the thickness of the plywood sheets, areas of the openings so as intensities of the horizontal load are shown on the Fig. 10.

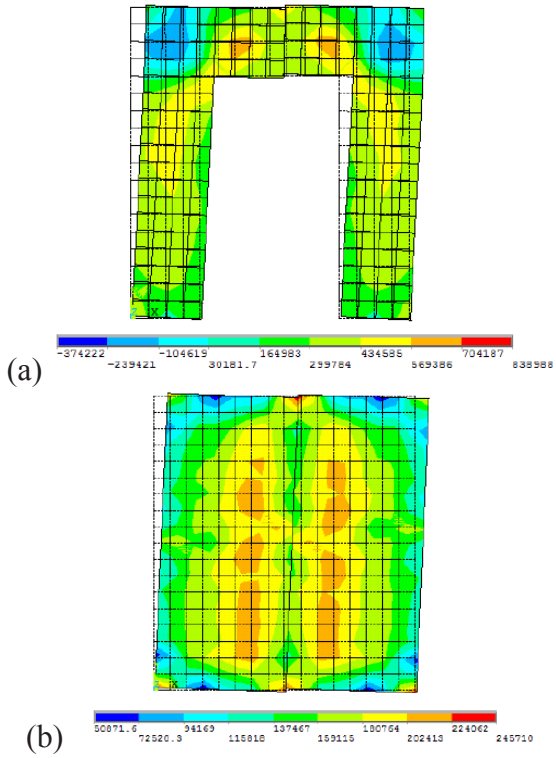

Fig. 9. Distribution of stresses (N/m^2) by the considered shear wall panel surface obtained by the software ANSYS 15.0: (a) – variant with door opening; (b) – variant without openings [8].

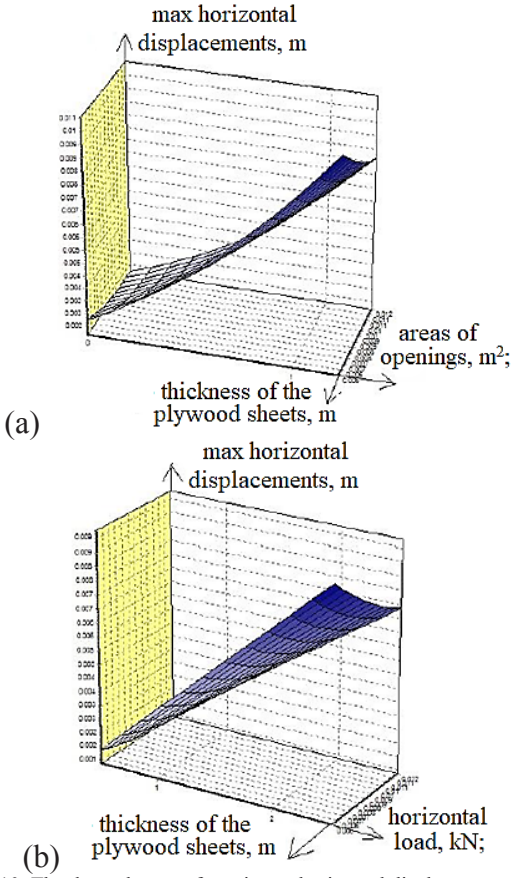

Fig. 10. The dependences of maximum horizontal displacements from the thickness of the plywood sheets, areas of the openings so as intensities of the horizontal load [8], [19].

The obtained dependence enables to conclude, that thickness of the plywood sheets has the most significant influence on the horizontal displacements of the shear walls. It was shown that the values of the maximum horizontal displacement changes within the limits from 0.67 to 16.36 mm. The maximum shear force acting at the mechanical fastener joined together plywood sheets and elements of framework was equal to 128 N.

IV. Conclusions

Behaviour's analyse of load-carrying members of framework structure of three-storey timber building was carried out. 3D model of light framework structure of three-storey timber building was developed and analysed by the software Autodesk Robot Structural on the action of permanent, imposed, snow and wind loads determined for Riga climatic conditions, for this purpose. 3D model was developed by the software ANSYS 15.0 to analyse behaviour of separate shear walls with and without openings in the case of horizontal force action.

The dependences of maximum horizontal displacements from the thickness of the plywood sheets, areas of the openings so as intensities of the horizontal load was obtained for shear walls of considered three-storey timber building. It was shown, that the values of the maximum horizontal displacement changes within the limits from 0.67 to 16.36 mm when thicknesses of the plywood sheets, areas of the openings so as intensities of the horizontal load changes within the limits from 6 to 9 mm, from 0 to 1.22 m2 and from 0.5 to 2.5 kN, correspondingly.

Acknowledgments

The research leading to these results has received the funding from Riga Technical University, Faculty of Building and Civil Engineering Grant "DOK.BIF/18".

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 336-338

The Device of the Shallow Frame (Half-Frame) With Quick Fitting of a Beeswax Foundation and Its Advantage

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***Abstract*—Transformation of the world food market, caused by the change of China from the world's largest exporter into importer, and the expansion of the world food crisis, actualizes the need to solve the main problem of beekeeping – technical and technological backwardness.**

Automation and mechanization of beekeeping has a long history, however the high rates of the industry are achieved mainly due to the huge costs of manual labor, time and means. The amount of time, spent by beekeepers on the service of beehives, grows in direct proportion to the expansion of the apiary, and it can be seen as an obstacle to the development of the entire industry. Fitting of a beeswax foundation in the frame is one of the most labor-intensive technological operations [1].

Description of the device of the shallow frame (half-frame), which allows to abandon the traditional technology of fitting of a beeswax foundation in favor of the new – accelerated one, is presented. The device is a frame, divided longitudinally in two parts, connected together by loops. On the edges of the separated bars there are protrusions, which allow, while closing, to cut off the sheet of a beeswax foundation. The technical result of using the proposed device is simplification of the assembly process and reduction of labor costs while servicing beehive frames.

The proposed device changes the traditional technology of fitting of a beeswax foundation, reducing the number of operations of the beekeeper to: opening the frame, positioning the standard sized sheet of a beeswax foundation in the frame, cutting the sheet to the required size while closing the frame. The usage of this device will allow the beekeeper to save a significant amount of time for performing other technological operations.

***Keywords*—beeswax foundation, fitting of beeswax foundation, half-frames, loops, shallow frame, technology.**

Introduction

Beekeeping is one of the most important branches of agricultural industry in the world. It delivers honey, flower pollen, beeswax, bee bread, propolis, apitoxin, royal jelly and other products. In addition, beekeeping plays a huge role in crop pollination.

In per capita production of honey, Russia is 1.5 times ahead of China, the US and Germany - more than 2 times, India - 8 times, and Japan - 18 times. In per capita consumption of honey, Russia also occupies a rightful place in the world ranking.

World indicators of honey production and consumption are presented in Table I.

TABLE I.
World indicators of honey production and consumption [2].

Country	***Production of honey, thousand tons***	***Import of honey, thousand tons***	***Export of honey, thousand tons***	***Consumption of honey, thousand tons***	***Per capita consumption, grams***	***Per capita production, grams***
Russia	68,4	1,2	0,5	69,1	481	476
China	450	15	125	325	238	329
Turkey	90	1	3	88	1147	1173
India	80		25	55	45	65
Mexico	60		33	27	219	498
Argentina	75		64,4	13,6	319	1760
Brazil	38		18,6	19,4	92	189
USA	65	135	3,5	201,5	634	206
EU 27	217,7	147,3	11,8	352,8	703	433
Germany	18	85	21	82	1016	223
Japan	3,3	40		43,3	340	26

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4104

According to the approximate calculations of the employees of the FSBSI "Scientific and Research Institute of beekeeping," the volume of a melliferous base allows Russia to increase honey production up to 300 thousand tons and more [2].

About 7496 thousand bee colonies are required for full pollination of the entomophilic crops, available in the Russian Federation. The fodder resources of entomophilic cultivated plants of Russia are capable to provide the maintenance of 9023 thousand bee colonies. The determined melliferous resources allow to increase the number of bee colonies and the volume of marketable honey production in Russia by 8-9 times, compared to current corresponding indicators [3].

According to the forecast of the Russian National Union of beekeepers, the volume of gross honey yield may increase up to 180 thousand tons by the end of 2019 [4]. Such an optimistic scenario for the development of the industry is supported not only by the calculations of the volume of melliferous resources, but also by Russia's accession to the World Trade Organization:

1. World honey production is growing at a fairly high rate – about 2% per year.
2. Environmental issues of one of the world's major honey exporters – China can lead to an almost complete disappearance of beekeeping in its territory.
3. The need for beeswax, which no one has yet managed to synthesize chemically and which is used in more than 50 branches, is still growing.
4. Scales of the usage of biologically active honey products (honey, beeswax, propolis, pollen, royal jelly and apitoxin) in medicine, cosmetics, dietetic nutrition are rapidly growing.
5. Beekeeping is the least capital-intensive production in comparison with any other branch of animal husbandry, so it is a very suitable object for organization of a large business, and for activities that provide an additional revenue sources.

Thus, the transformation of the world food market, caused by the change of China from the world's largest exporter into importer, and the expansion of the world food crisis, actualizes the need to solve the main problem of beekeeping – technical and technological backwardness.

Automation and mechanization of beekeeping has a long history, however the high rates of the industry are achieved mainly due to the huge costs of manual labor, time and means. The amount of time, spent by beekeepers on the service of beehives, grows in direct proportion to the expansion of the apiary, and it can be seen as an obstacle to the development of the entire industry.

Materials and methods

Fitting of a beeswax foundation in the frames is one of the most labor-intensive technological operations. A beekeeper must have a special tool for this operation: a template board, a special knife, a spur roller or an electrical apparatus for embedding a beeswax foundation, which replace all these tools, but require a source of electricity.

The use of a plastic beeswax foundation significantly facilitates the work of a beekeeper on fitting of a beeswax foundation in frames. Despite the absolute functional readiness of the plastic beeswax foundation, this alternative solution has a number of disadvantages, including the need to cover the plastic beeswax foundation with a layer of beeswax.

Mel'nik V. I., Romanchenko N.. and Romanchenko, V. N., the inventors of RU 2065266 dated August, 20, 1996, are trying to solve the problem of significant labor costs [5]. A beehive frame, proposed by them, contains two mirror-like half-frames, joined by a lintel with a hinge, located along two similar bars. The lintel allows for a movement of the first half-frame against the second half-frame with one degree of freedom. A sheet of a beeswax foundation, inserted between the half-frames, glues to the device by beeswax while compressing this half-frames with a certain force.

The disadvantage of this device is that the use of a beehive half-frame requires preliminary preparation of a beeswax foundation – cutting off under the size. In addition, the use of the device in a beehive together with frames of traditional size is difficult due to a difference in contours (forms). The presence of the lintel makes it possible for bees to patch up by beeswax a junction of the half-frames. The need to ensure the elastic deformation of the device limits the use of hard food grade plastic, which gives rigidity to the frame, in its production.

Results and discussion

The staff members of the FSBEI of Higher Education "Pskov State University" have developed a

device, that can change the technology of fitting of a beeswax foundation. When using this device, a beekeeper has no need in such operations as cutting with a knife the sheet of a beeswax foundation to the required size, bending the edges of the beeswax foundation under a spur roller, installation of the beeswax foundation with a curved edge to the frame, ironing with the pre-heated roller with a few movements along the edge and along the wire. Also, there is no need to purchase and use electrical appliances for fitting of a beeswax foundation and kindling of beeswax.

The technical problem, solved by the proposed device, is not only a refusal of the necessity of cutting the sheet of a beeswax foundation into the frame size, but also ensuring the possibility of using this device in conjunction with traditional beekeeping frames, ensuring a mobility of the parts of the device without a lintel, giving rigidity to the frame and reliability of its binding with a beeswax foundation.

The proposed device is made of hard food grade plastic (for example, polyvinyl chloride), has loops and has sizes similar to the parameters of traditional

beehive frames. One of the half-frames is provided with a protrusion along the closed edge, which allows cutting the sheet of a beeswax foundation into the frame size, and a longitudinal locking mechanism that securely holds the frame from opening [6].

Appearance and structure of the shallow frame (half-frame) with quick fitting of a beeswax foundation are presented on Fig. 1.

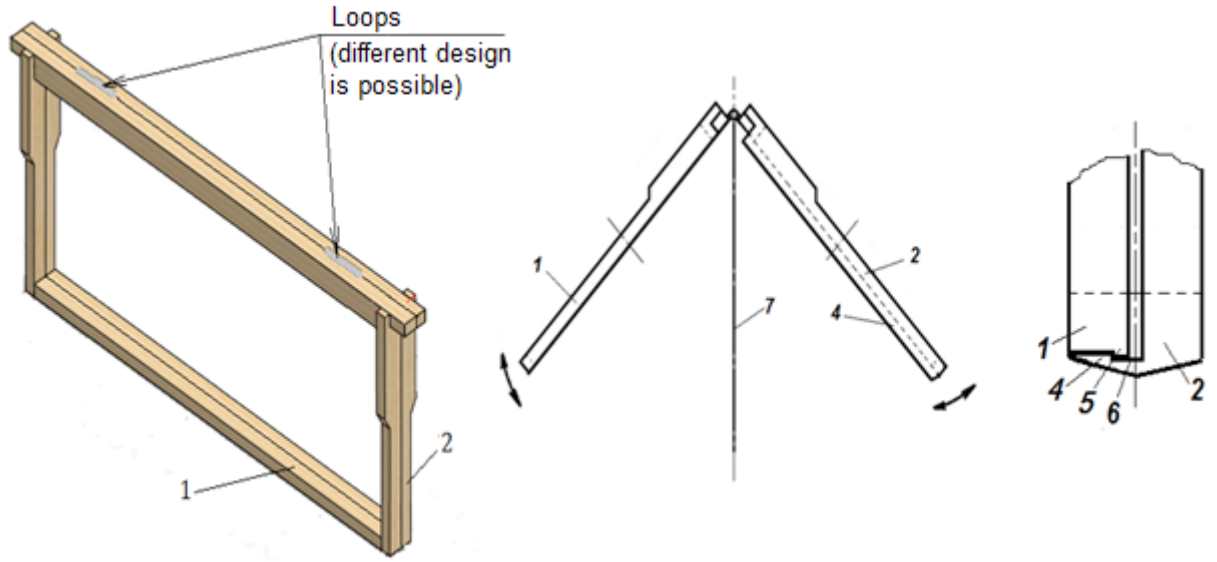

Fig. 1. Appearance and structure of the shallow frame (half-frame) with quick fitting of a beeswax foundation

The proposed device consists of two mirror-like half-frames, marked on the Fig. 1 as 1 and 2. Each of half-frames 1 and 2 has a rectangular design, conjugated together by outside loops 3, which are positioned over the two top bars of half-frames 1 and 2. The loops allow for the movement of half-frame 1 against half-frame 2 with one degree of freedom. Half-frame 2 has a cutting protrusion 4. There is protrusion 5 on half-frame 1, and there is recess 6 on half-frame 2, together they are forming a locking mechanism. Overall dimensions of the frame are taken according to existing standards for such structures.

The principle of operation of the proposed device is: half-frames 1 and 2 open to the required clearance between bottom bars, while top bars are held by loops 3. Sheet of a beeswax foundation 7 is positioned on half-frame 1 and is cutting to the required size by pressing half-frame 2. Half-frames glue together with beeswax from the deformed part of the sheet of a beeswax foundation, which is on a rough surface of interlocked half-frames 1 and 2.

Conclusions

The proposed device changes the traditional technology of fitting of a beeswax foundation, reducing the number of operations of the beekeeper to: opening the frame, positioning the standard sized sheet of a beeswax foundation in the frame, closing the frame and cutting the sheet to the required size simultaneously. The usage of this device will allow the beekeeper to save a significant amount of time for performing other technological operations.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 339-343

The Technology of Co-Culturing of Potatoes with Honey Plants and Prospects of Its Technical Support

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***Abstract*—The right way out of the crisis of the agro-based industries is the maximum use of the opportunities of scientific and technological progress and the orientation of the real economy to innovative development.**

One of the promising technologies of crop production is an innovative technology in potato growing, which provides for the co-culturing of potatoes with honey crops.

Phacelia tanacetifolia (PhaceliatanacetifoliaBenth) is selected as honey crop, which is a valuable green manure. It allows to reduce the need for organic and mineral fertilizers, increases the ecological cleanness of products, favors the growth of potato yield, provides the additional honey yield.

Phacelia significantly improves the soil structure, displacing a significant part of weeds, providing natural loosening of the soil, protection from drying out, from pests and parasites. The co-culturing of potatoes with phacelia protects the environment from the use of dangerous plant protection products.

If the economic effect is defined as the difference between the profits of innovative and traditional technologies, then, according to preliminary calculations, the level of profitability of innovative technology in potato growing is 1.9 times higher, and the profit from 1 ha is 1.6 times higher compared with the traditional technology.

Large-scale development of the proposed technology is hampered by the lack of potato planters and seed planters, which provide planting of potatoes and sowing seeds of honey crops simultaneously, in the Russian market and the markets of the European Union.

An innovative technology - mounted seeder for potato planters was developed by the staff members of the Pskov State University. The article describes the main agro-technological requirements to this device. A general model and a kinematic scheme were developed to visualize the combination of the working elements of the potato planter and the mounted seeder.

The developed model falls into the type of seed planters, which is designed to sowing in drills the seeds of honey crops (phacelia) in the furrow between potatoes at the time of the forthcoming closing of this furrow by soil, and can be used in agricultural engineering.

Potential consumers of the proposed innovative technology in potato growing and the developed mounted seeder are farm enterprises and agricultural production cooperatives, which have small plots of land, use crop rotation systems in potato growing, and work for reducing costs and increasing the yield of potato cultivation.

***Keywords*—device, effect, green manure, phacelia, potato growing, potato planter, seed planter, technology.**

Introduction

Russia is the main potato producer in the world, occupying the first place in acreage, the second – in gross yield and one of the last places – in crop yield. The main reason for the low crop yield of this domestic culture is a significant lag behind the world agro-technological progress [1].

In order to increase competitiveness, the potato growing of Russia is trying to enter an innovation-based development: new varieties are established, high-production equipment is mastered, technology is improved, new types of fertilizers and plant protection products are used.

Review and analysis of traditional technologies of potato growing shows that they differ in the level of mechanization of work and a fairly wide range of technical equipments, and they are intended for farms with different production volumes. Analysis of potato production allows us to distinguish three systems of its cultivation: crop rotation, mixed sowing (planting) and monocultural [2]. The potato crop rotation system is used in large and medium–sized enterprises in field potato production, monocultural and mixed sowing (planting) – in small farms [3]. Technologies of co-culturing of potatoes with other crops: root vegetables, legumes, etc. are in use for a long time. However, the economic reserves of co-culturing of potatoes with honey crops have not yet been realized.

Materials and methods

In the course of the research, the object of which is the technology and technical support of potato cultivation, technological cards of traditional and proposed potato cultivation and harvesting have been developed to assess the effectiveness of innovative technologies. The costs of the previous year for future harvest are included in technological cards. According to the traditional technology, the forecrop is vetch and oat mixture. According to the new technology, the forecrop is phacelia [4].

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4108

Phacelia tanacetifolia (PhaceliatanacetifoliaBenth) is selected as honey crop, which is a valuable green manure. It allows to reduce the need for organic and mineral fertilizers, increases the ecological cleanness of products, favors the growth of potato yield, provides the additional honey yield [5].

Results and discussion

Innovations, which allow to increase the soil fertility and yield of potatoes and to get the maximum profit at minimum cost, are much-needed in potato growing. We offer an innovative technology of co-culturing of potatoes with valuable honey plant – phacelia. Phacelia is a very valuable green manure. Plowed in, green mass (approximately 200 hundred kilograms per hectare) is equivalent to an application of 20 tons/ha of humus. Biomass accumulation is 343 hundred kilograms per hectare, including green mass - 317 hundred kilograms per hectare, root residues - 26 hundred kilograms per hectare. Phacelia does very well on almost any type of soil, enriches them with nitrogen and potassium compounds [6].

The list of technological operations of potato production according to the traditional technology is: loading and application of organic fertilizers; autumn plowing; sorting of potatoes; closing of moistness; application of mineral fertilizers; cultivating with harrowing; potato planting with pretreatment; spraying of potato plantings against annual, dicotyledonous and cereal weeds; loosening with harrowing; hilling; mowing of the tops with its mandatory removal from the field; mechanized harvesting of potatoes; transportation of potatoes to the place of storage.

The technological operations for spraying against weeds, Phytophthora and Colorado potato beetle are excluded, if potatoes are co-culturing with honey plants. But an additional work like sowing phacelia, hand weeding of potatoes and collecting Colorado beetles is requires.

Following scheme of sowing of potatoes with phacelia in agricultural enterprises is suggested: 2 or 4 rows (ridges) of potatoes, 2 or 4 ridges of phacelia. In such cases, phacelia can be sown in June after hilling or the last loosening of potatoes, and it can be plowed in like green fertilizer after harvesting of potatoes.

In households and small peasant (farm) enterprises with limited land resources phacelia can be sown in the spacing. It is also possible to use phacelia as a universal organic fertilizer three times during one season. Sowing of phacelia is possible: in the early spring period (before planting of potatoes); together with potatoes in a hole; additional autumn sowing of phacelia, which will form the third fresh yield on green manure until the autumn cold.

Considering the weak supply of organic fertilizers to agricultural enterprises, green-manure pairs are provided in crop rotation system. For these purposes, an area is scattered with vetch-oat mixture, white mustard with spring vetch or hairy vetch, green masses of which are plowed in. The use of phacelia as a green manure is more promising, as it allows quickly and cheaply to enrich the soil with organic matter and biological nitrogen. It significantly increases the yield of crops, reduces deseases of potatoes and vegetables, reduces a content of nitrates and heavy metals in products [7]. In general, this green manure crop increases crop productivity by 15-20% while improving product quality.

Phacelia is a reliable defender of a soil from drying out, erosion, deep freezing [8].

When mixed sowing, phacelia significantly reduces a damage to the main crop by various species of fir seed moth, caterpillars and other pests, repels wireworms and locusts. In addition, phacelia prevents viral and fungal diseases on neighboring plants and subsequent crops in the crop rotation [9].

Fertilizer costs are 19-21% in the cost structure per 1 ha of potato-growing enterprises. The introduction of the proposed innovative technology will allow enterprises to significantly reduce costs on this item.

In addition, up to 20-30 kg of pollen and 200 to 500 kg of honey can be obtained from 1 ha of phacelia. This is beneficial to enterprises engaged not only in crop production, but also beekeeping [6].

Calculation of the economic efficiency of implementation of the proposed technology is determined by the example of a conventional agricultural producer engaged in or planning to be engaged in beekeeping. Acreage, yield, productivity, gross output, level of marketability and others are used as basic indicators (Table I).

TABLE I.
Calculation of the economic efficiency of the innovative potato production technology.

Indicators	*Technology*	
	traditional	***innovative***
Acreage in total, ha:	10	10
including Potatoes	10	5
Phacelia	0	5
Yield of potatoes, hundred kilograms per hectare	200	200
Bees productivity, kg/ha	0	200
Gross output:		
Potatoes, tons	200	100
Honey, kg	0	3000
Level of marketability, %		
Potatoes	82	82
Honey	0	95
Cost of commercial products, in total, RUB, in thousands:	1640	1675
including Potatoes	1640	820
Honey	0	855
Costs in total, RUB, in thousands:	**1170**	**946**
including Potatoes	1170	917
Honey	0	29
Profit, in total, RUB, in thousands	**470**	**729**
Level of profitability, %	40	77
Economic effect, RUB, in thousands		**259**

The economic effect is defined as the difference between the profits of innovative and traditional technologies. According to our calculations, the level of profitability of the innovative technology is 1.9 times higher, the profit from 1 ha is 1.6 times higher and the total economic effect amounts to 259 thousand rubles compared with the traditional technology.

The proposed allocation of a part of the cultivated area under potatoes for phacelia is very conditional. The use of the innovative technology of potato cultivation can significantly "condense" the crop rotation, increasing the area under potatoes and reducing it under complete fallow.

The spread of this technology and its widespread use by potato-growing agricultural enterprises require the development of mechanization in sowing of phacelia while planting of potatoes.

The research of the functional purpose and technical characteristics of some popular models of potato planters and seed planters allows us to draw the following conclusion: in the domestic and foreign markets there are no potato planters, providing simultaneous planting of potatoes and sowing of seeds of honey crops (Table II).

TABLE II.
FUNCTIONAL PURPOSE OF POTATO PLANTERS AND SEED PLANTERS.

Name	*Country of manufacture*	*Performed functions*			
		Planting potatoes	*Fertilization*	*Application of insecticides/ Pretreatment*	*Planting seeds (including combined culture)*
Potato planters					
Harrison	USA	+	+	+	-
Grimme(GL)	Germany	+	-	+	-
Hassia/Structural	Holland	+	+	-	-
RBS/Multiplant	France	+	+	-	-
Bomet	Poland	+	+	-	-
SKN-2a	Russia	+	+	-	-
SKN-4, L-201, L-207	Belarus	+	+	-	-
Seed planters					
SZMP-4	Russia	-	+	-	+
SPCH-6L	Russia	-	+	-	+
STV	Belarus	-	+	-	+

The seed planters, used by enterprises, combine no more than two functions: sowing seeds and fertilizing [10]. Therefore, development of a principally new device is essential for realization of the economic reserves of co-culturing of potatoes with honey crops [11].

The model, developed by the staff members of the Pskov state University, is a mounted assembly unit, including: a hopper for phacelia seeds, with two rigid conical hoses that contain gates. A state of the gate is regulated by the mechanism connected with the photocells, which are fixed on the lower end of the planting device of the potato planter [12].

The developed model falls into the type of seed planters, which is designed to sowing in drills the seeds of honey crops (phacelia) in the furrow between potatoes at the time of the forthcoming closing of this furrow by soil (Fig. 1), and can be used in agricultural engineering.

The conical transfer devices, driven by a belt drive from the additional pulley, which is located on an axle of the potato planter, are fixed on rigid hoses. The disk, which contains the holes in a certain order for sowing the phacelia seeds and is connected with a rigid hose, is driven by the transfer device.

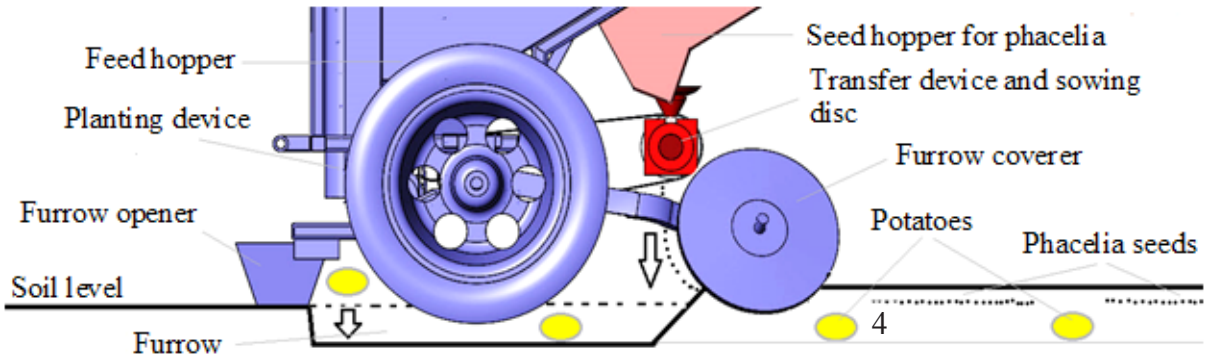

Fig. 1. Technological scheme of the combined model (potato planter and seed planter).

The main agro-technological requirements to the developed model are:

- uniform flow of seeds in dispersing disc;
- ensuring sustainable seeding through time;
- no damage to seeds;
- closing of seeds by a moist layer of soil;
- possibility of long-term usage.

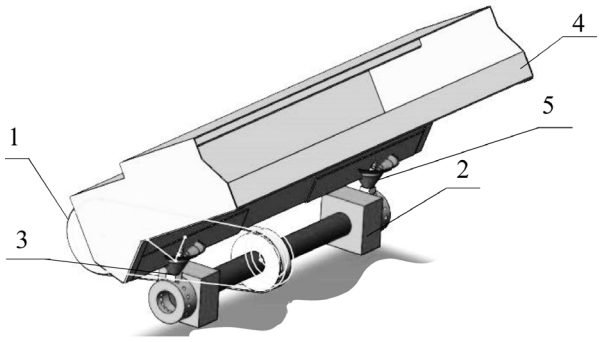

Fig. 2. General view of the mounted seeder.

Conventional symbols of the belt drive (1), the conical transfer device (2) and the feed disc (3) are used to explain the principle of the mounted seeder in the kinematic scheme (Fig. 2).

The mounted seeder for potato planter operates in the following manner. After loading the potatoes and seeds in the appropriate hoppers a tractor operator is starting from rest, a turning torque from driving wheels of the potato planter is transmitted to the shaft of the seeder through a belt drive (1).

Conical transfer devices with sowing discs are situated on the shaft of the seeder (2). The conical transfer device transmits the rotation to the disc,

reducing the rotation speed. When a signal is received from a photocell, a hopper gate (3) opens and the seeds from a honey crop hopper (4) get in a rigid conical hose (5) and then into the center of the sowing disc. The disc has holes, through which the seeds fall into the soil.

The general model (Fig. 3a) and the kinematic scheme (Fig. 3b) are developed to visualize the combination of the working elements of the potato planter and the mounted seeder. Figure 3a shows: the components of the potato planter in blue color, mounted seeder in red color.

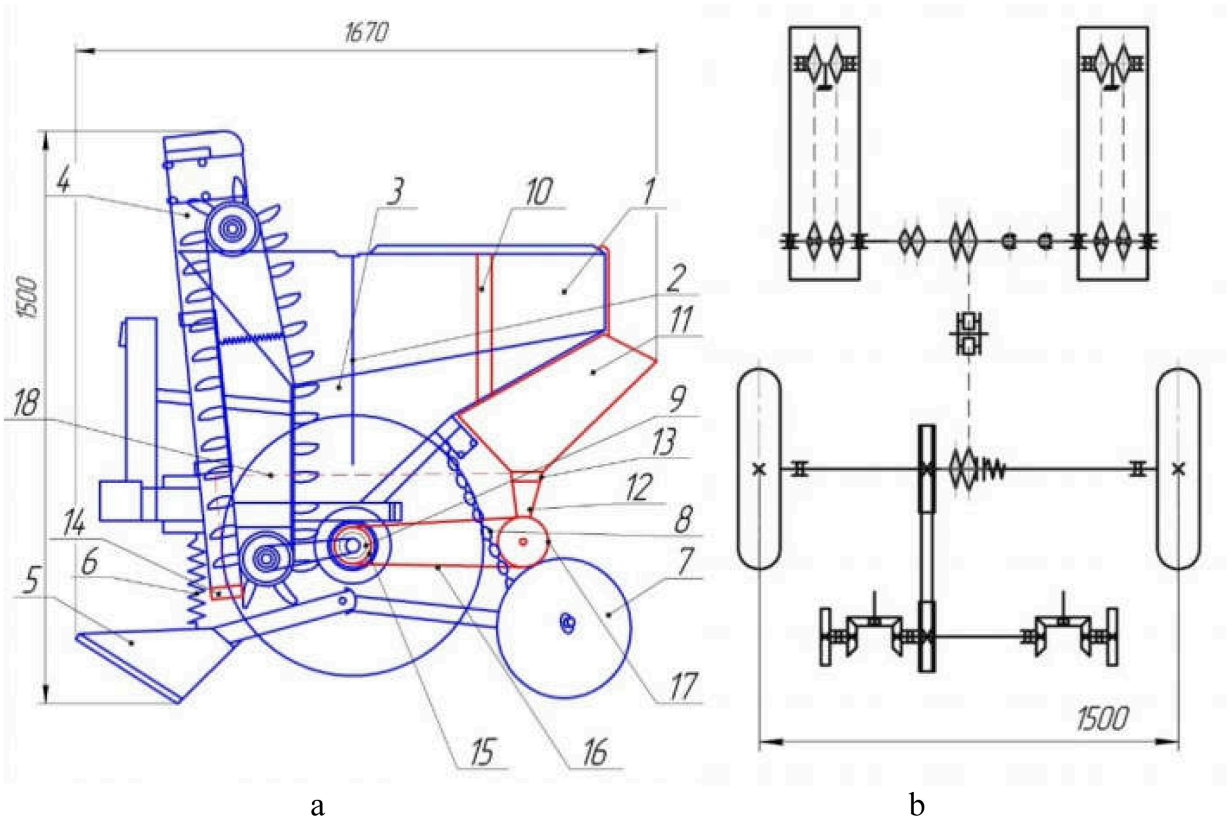

Fig. 3. The model (a) and the kinematic scheme (b) of combination of the potato planter and the seeder.

Symbol names of the model elements are presented in Table III.

TABLE III.

SPECIFICATION OF THE COMBINED MODEL.

Position	*Assembly unit*	*Number*	*Position*	*Assembly unit*	*Number*
1	Hopper	1	10	Rigid attachment of mounted seeder	2
2	Hopper gate	1	11	Seed hopper for phacelia	1
3	Feed hopper	1	12	Rigid conical hose	2
4	Planting device	2	13	Hopper gate	2
5	Furrow opener	2	14	Photocell	2
6	Tine of furrow opener	2	15	Additional pulley	2
7	Furrow coverer	2	16	Belt	1
8	Round-link chain	2	17	Conical transfer device	2
9	Drive with supporting wheels	1	18	Cable	2

The kinematic scheme is a graphical scheme of working units and blocks of a construction's mechanism [13]. The schematic kinematic scheme shows the sequence of transmission of motion from an engine through an intermediate mechanism to working elements of the device and their relation.

CONCLUSIONS

Thus, the right way out of the crisis of the agro-based industries is the maximum use of the opportunities of scientific and technological progress and the orientation of the real economy toward an innovative development.

One of the promising technologies of crop production is the innovative technology in potato growing, which provides for the co-culturing of potatoes with honey crops. It is developed by the staff members of the Pskov State University.

Phacelia tanacetifolia (PhaceliatanacetifoliaBenth) is selected as a honey crop, which is a valuable green manure. It allows to reduce the need for organic and mineral fertilizers, increases the ecological cleanness of products, favors the growth of potato yield, provides the additional honey yield.

The substantiation of necessity and expediency of introduction of the innovative technology in potato growing of the region is given; the execution sequence of technological operations of the proposed technology is presented; the advantages of co-culturing of potatoes and the most valuable honey plant – phacelia are described; the economic effect from introduction of the innovative technology is calculated.

Large-scale development of the proposed technology is hampered by the lack of potato planters and seed planters, which provide planting of potatoes and sowing seeds of honey crops simultaneously, in the Russian market and the markets of the European Union.

The innovative technology – the mounted seeder for potato planters is developed by the staff members of the Pskov State University. The article describes the main agro-technological requirements to this device. The general model and the kinematic scheme are developed to visualize the combination of the working elements of the potato planter and the mounted seeder.

The developed model falls into the type of seed planters, which is designed to sowing in drills the seeds of honey crops (phacelia) in the furrow between potatoes at the time of the forthcoming closing of this furrow by soil, and can be used in agricultural engineering. The scientific novelty of this model is the combination of work of two working devices simultaneously (potato planter and planter for sowing seeds of honey crops), which had never been combined before.

Potential consumers of the proposed innovative technology in potato growing and the developed mounted seeder are farm enterprises and agricultural production cooperatives, which have small plots of land, use crop rotation systems in potato growing, and work for reducing costs and increasing the yield of potato cultivation.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 344-348

The Factors Determining Profitability of Grain Production in a Region

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***Abstract*—The research was conducted in order to determine influence of structural factors on profitability of grain production in the Altai Region, which is one of the main producers of grain in Russia. The influence of specialization and placement on the economic efficiency of grain production in the Altai Region was determined, factors for the formation of financial results and the financial condition of grain-type organizations were revealed. Comparison of agricultural organizations for which grain farming was the main production sector indicates that in case of increase in the cultivation area, the economic efficiency of resource use will be increased, despite higher costs per hectare of grain crops. The variation of organizations in the profitability of production is explained by the imperfection of the management system of the main branches in separate agricultural organizations, including non-optimal production volumes and placement in natural and economic zones. In the largest highly tailored organizations the economic efficiency of the resources used increased in the short-term perspective rose, but risks of its decline are created in the long-term period.**

Keywords – Specialization, grain crops, economies of scale, financial results, Altai Region.

Introduction.

Specialization, production location, production scale, combination of industries, the structure of cultivation areas, the system of crop rotation and other elements of the organization of the production process are interrelated and determine the reserves for improving the economic efficiency of grain production, since they directly determine the productivity of grain crops, laboriousness and production prime cost per unit of output.

Grain field husbandry for the Altai Region is one of the main branches of agricultural production. In the area of grain and leguminous crops the region from 1990 to 2017 always took 1st place in Russia (3393.6-3998.0 thousand hectares for all categories of agricultural producers or 6.34-8.33% of the total cultivation area in a whole of the Russian Federation). The Altai Region is represented by eight natural and economic zones, which differ significantly in climatic conditions, soil quality, agricultural land structure, provision with material and technical resources and labour. Wheat is sown mainly in the western and central parts of the Altai Region, barley – in southern part, buckwheat – in southeast.

The purpose of the study was to determine the influence of the structure of grain production, the specialization of enterprises and their territorial location on the economic efficiency of cultivating of grain crops in the Altai Region. For this purpose an assessment of the efficiency of grain production in agricultural enterprises was made, taking into account their location in the natural and economic zones. A comparison was made between the efficiency of grain-type enterprises with different degrees of specialization.

There is no consensus among economists about the essence of economic efficiency. So, according to Campbell R. McConnell, Stanley L. Brue, economic efficiency affects the problem of "input-output": "… economic efficiency means obtaining a particular output of product with the least input of scarce resources, when both output and resource inputs are measured in dollars and cents" [1]. V.A. Dobrynin defines economic efficiency as "... the ultimate beneficial effect from the use of means of production and live labor, the return of aggregate investments", K.P. Obolensky – as "... acquisition of the maximum amount of agricultural production required by society from every hectare of land, with the least expenditure of social labor – live and materialized – for the production of a unit of production" [2], [3]. However, from our point of view, this method of determining of economic efficiency can be used at the level of the country, region, but at the micro level it is inapplicable. A. Shafronov considers efficiency as "... the ratio of the actual gross income (profit) of the enterprise to the unit of reduced costs (or simply incurred costs) to their planned level", as well as "the degree of utilization of the production potential of the enterprise" [4]. The disadvantage of this approach is difficulty in determining of the production potential of an enterprise in conditions of market situation instability and uncertainty, of assessing the economic efficiency of enterprises characterized by different in terms of

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4036

production and bioclimatic potential, and the level of resource endowment. In addition, in conditions when the planned indicators at the enterprise level have weak economic justification, it is hardly possible to express the efficiency of production by comparing actual and planned results. However, in conditions of the improvement of economic services' organization and the increase of the validity of plans, the use of this approach at practice is quite acceptable. Thus, the general indicator of economic efficiency in agriculture is the level of profitability of production. A number of scientists propose to determine it as a ratio of profits from the sale of products and its full cost price.

When assessing the influence of the size of a grain-type farm in various countries on the productivity of labor, Sheng Yu., Wang X., Chen Yu., Sui P., Yan P., Yang X., Gao W., Key N., Osaki M., Batalha M.O. revealed that, on the one hand, the profitability of sales of medium and large farms in agriculture is lower than in small farms, but growing production increases the income of agricultural producers [5] – [8]. On the other hand, it is noted that in larger farms there are reserves of increasing both the economic and ecological efficiency of grain production, while in organizations with small production volumes these reserves are exhausted. In addition, when comparing enterprises of different production types, it is noted that grain specialization farms are characterized by lower profitability than farms whose activities are related to the production of livestock products [9].

Materials and methods.

The theoretical and methodological basis of the research was the scientific research of Russian and foreign scientists in the field of identifying factors and assessing their impact on the economic efficiency of agricultural production. In the process of research general scientific (scientific abstraction, inductive, deductive, comparative analysis) and special sub-approaches were used. Special methods: comparison, monographic, balance, normative, economic-statistical (statistical sampling, economic grouping, calculation of statistical indicators, including average, absolute and relative values). To analyze the statistical data, the Microsoft Office software package was used.

Rosstat and its territorial bodies, data of the Ministry of Agriculture of the Altai Region were the sources of statistical information. Data from the online edition "System of Professional Analysis of the Market and Companies (SPARK)", the global reference system for Russian legal entities and entrepreneurs "Rusprofile.ru", the network edition "Center for Disclosure of Corporate Information" were sources of statistical information about the financial and economic activities of agricultural enterprises.

When constructing of analytical (factorial) statistical groupings, in account was taken the typicality in the creation of groups, the sufficiency of units in individual groups, the need to distribute units into groups in accordance with the law of normal distribution.

The grouping of enterprises on the basis of influence of the productivity of grain crops on the financial and economic indicators of enterprises of the grain type was carried out according to the hydrothermal coefficient of the Altai Region territories, which was settled by the climatologist G.T. Selyaninov and shows the level of moisture supply or moisture insufficiency of the territory. As a basis for determining the hydrothermal coefficient, the ratio of the amount of precipitation during the growing season to the sum of temperatures above 10 ° C, reduced in 10 times, is taken.

The direction of activity of organizations was determined by the structure of commodity output of agricultural enterprises of the Altai Region. There were identified 30 production types of enterprises, the grain type is the most numerous among them. The following division of organizations into three groups was taken for classification: *highly specialized* with a specific weight of one type of production of not less than 50.0% of revenue; *specialized* enterprises, in which each of the two industries occupies 33.3-50.0%, or each of the three industries occupies 25.1-33.3%; *non-specialized* (multisectoral) farms with four or more branches with a specific weight of incomes less than 25.1%.

Results and discussion.

Altai Region according to the hydrothermal coefficient (hereinafter – HTC), which reflects the ratio of the sum of active temperatures to the sum of precipitation for a certain period, is represented by eight natural and economic zones with an HTC of 0.6 (insufficient humidification) to 1.2 (optimum hydration) and 1.6 (excessive moistening). The production of grain of various crops is represented in all natural and climatic zones with varying degrees of concentration. More than 84.5% of wheat is sown in the western and central parts of the Altai Region, buckwheat prevails in the southern and southwestern part of the region, barley is grown almost evenly.

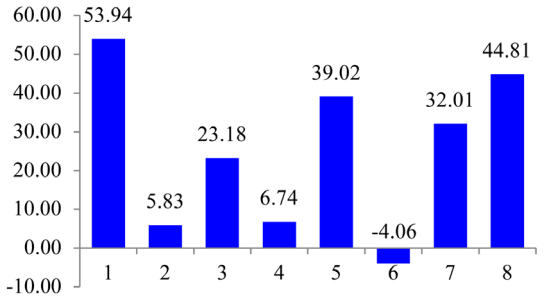
According to the planting acreage of grain and leguminous crops, the region in 1990-2017 has always occupied the first place in Russia (3393.6-3998.0 thousand hectares or 6.34-8.33% of the total planting acreage in Russia as a whole). The main grain producers in the region in 2016-2017. were agricultural enterprises receiving 2.88-3.00 million tons of grain or 60.3-61.4% of the total gross harvest, as well as peasant (farm) enterprises – 1.86-1.90 million tons or 38.6-39.7%, respectively (for the majority of farms grain specialization is decisive, especially in the steppe and forest-steppe parts of the region).

In the structure of sales of grain and leguminous crops in 2016-2017 wheat grain prevailed (63.5-65.9%), buckwheat was 10.3-11.9%, oats was 8.2-8.9%, which indicates a lack of diversification of grain production, a significant effect on the profitability of products of price volatility of wheat and oats. The share of production of highly profitable crops – millet, maize, peas – is insignificant and in total does not exceed 4.0-6.1% (Table 1).

TABLE 1.
THE STRUCTURE OF SALES AND PROFITABILITY OF GRAIN PRODUCTION IN AGRICULTURAL ENTERPRISES OF THE ALTAI REGION, %

Grain and leguminous crops	Share in the structure of the volume of sold grain, %				Level of profitability of grain production, %			
	2010	*2015*	*2016*	*2017*	*2010*	*2015*	*2016*	*2017*
Wheat	70,5	61,3	65,9	63,5	19,9	37,6	32,2	15,3
Rye	3,9	2,5	2,2	1,7	-20,5	35,6	29,6	6,7
Millet	0,6	0,7	0,6	1,0	56,0	67,2	44,4	7,7
Buckwheat	4,9	8,9	10,3	11,9	169,1	91,6	130,3	35,9
Corn	0,0	0,1	0,2	0,4	-6,4	45,3	78,4	46,9
Barley	6,7	9,9	7,9	7,9	31,7	30,0	25,2	2,2
Peas	3,7	3,0	3,2	4,7	47,0	57,3	66,4	32,6
Oats	8,4	12,1	8,2	8,9	11,1	2,0	31,8	18,1
Other grain and leguminous crops	1,3	1,6	1,7	-	8,5	67,5	125,3	x
Average	x	x	x	x	33,2	42,4	49,4	15,3

The financial results for the whole agricultural sector of the region depend significantly on the situation in the grain market, since in the structure of agricultural enterprises of the Altai Region in 2013-2017 grain-type organizations prevailed (up to 58.9% of the total number of enterprises) with a share of revenues from grain sales exceeding 50.0%. The level of profitability of production in the group was from 20.9% to 53.9% (Figure 1), however 17.9-21.8% of grain specialized organizations were unprofitable.



1 – grain field crop cultivation; 2 – grain field crop cultivation, dairy cattle breeding; 3 – dairy cattle breeding, grain field crop cultivation; 4 – grain field crop cultivation, growing and fattening of cattle; 5 – growing and fatteningof cattle, grain field crop cultivation; 6 – grain field crop cultivation, cultivation of sunflower for oilseeds; 7 – cultivation of sunflower for oilseeds, grain field crop cultivation; 8 – grain field crop cultivation, dairy cattle breeding, cultivation of sunflower for oilseeds

Fig. 1. The level of profitability of production in agricultural enterprises, depending on the combination of grain field crop cultivation with other industries (Altai Region, 2016), %

The profitability of the production of grain as a whole is determined by the total volume, structure, specific prime cost of grain and selling price, which in turn depend on the system of regulated (the system of farming and industry, management functions, etc.) and unregulated (price conjuncture, state regulation of agro-industrial production, etc.) factors. For the period of 2010-2016 the level of profitability of grain production increased from 33.2% to 49.4% or 16.2 percentage points due to the positive impact of sales prices and the total amount of production that, in terms of aggregate influence, exceeded somewhat the negative influence of the grain sales structure (if in 2016 only the structure of sold grain had changed, and its total quantity, prices and prime cost had remained at the level of 2010, the profitability would have decreased by 6.4 percentage points) and its unit cost. In 2017, the profitability of grain production decreased from 49.4% to 15.3%, or by 34.1 percentage points, mainly due to a decrease in prices (if in 2017 only the prices of sold grain had changed but the total quantity, structure and the cost price remained at the level of 2016, then the profitability would have decreased by 40.1 percentage points), as the change in structure and unit cost positively influenced on the change in profitability. The decrease in prices was observed on average for all grain crops: for wheat, rye, barley, peas, oats – in 1.12-1.19 times, for mais and buckwheat – in 1.73 and 2.09 times respectively.

At the same time, agricultural producers are not materially motivated to improve the quality of grain. The profitability of wheat production of grades 1 and 2 at the level of 19.7% was significantly lower than the profitability of food and feed grain (31.9-32.9% in 2016), as a result, the share of strong wheat in the structure of sales in 2016 did not exceed 1.5%. In 2017, the price of wheat below grade 3 significantly decreased compared to 2016, as a result, for the first time in many years, the profitability of high-quality grain was higher than the profitability of lower-quality grain (Table 2).

TABLE 2. THE LEVEL OF PROFITABILITY OF WHEAT PRODUCTION IN AGRICULTURAL ENTERPRISES OF THE ALTAI REGION BY ITS QUALITY GRADES, %

Quality grades of wheat	Price per 1 t., Rub.			Structure of sale, %			Level of production profitability, %		
	2010	*2016*	*2017*	*2010*	*2016*	*2017*	*2010*	*2016*	*2017*
1st and 2nd grades	4021	7847	7915	2,3	1,5	1,7	29,9	19,7	22,6
3rd grade	4393	9037	6775	35,1	43,7	70,7	37,5	31,9	9,7
4th grade	3585	8527		62,6	54,9		9,9	32,9	
Lower than 4th grade	-	-	6963	-	-	27,5	-	-	9,9
Average	3878	8733	6846	x	x	x	19,9	32,2	10,0

Similar trends are observed in Russia as a whole. As A.I. Altukhov notes "the share of 1st and 2nd grades in the total volume of grain sales ... does not exceed 2%, and the 3rdclass varies between 19-22% [10]. Quality is also changing due to the "inconsistency" of the economic interests of individual ... participants in the grain market, the absence of a clear policy of pricing for high-quality wheat." In these conditions many scientists suggest improving the price measures of state regulation for wheat of the 1st and 2nd grades by establishing minimum guaranteed prices with a profitability of at least 25.0% and compensatory payment when the market prices fall below the normative ones, providing a break-even management [11], [12].

Our economic evaluation of the location of grain field crop cultivation testifies to its profitability in all the natural and economic zones of the Altai Region: in 2016 the level of profitability of grain production varied on average from 27.5% to 78.1% (in 2017 from 9.5% to 26.5%), including wheat from 21.2% to 42.0% (in 2017 from 7.6% to 13.3%), buckwheat from 101, 2% to 159.1% (in 2017 from 18.1% to 62.4%) (Table 3). The economic evaluation of the effectiveness of the location of grain field crop cultivation on the level of profitability indicates the presence of competitive advantages in the development of grain production in natural economic zones with a higher hydrothermal coefficient (the acreage of buckwheat is concentrated there).

TABLE 3. THE LEVEL OF PROFITABILITY OF GRAIN PRODUCTION ACCORDING TO THE NATURAL AND ECONOMIC ZONES OF THE ALTAI REGION, %

Grain crops	**Year**	**Hydrothermal Coefficient***						
		0,6	***0,7***	***0,8***	***0,9***	***1,0***	***1,1***	***1,2 and more***
Wheat	2016	28,5	37,0	34,8	21,2	27,3	32,6	42,0
	2017	10,1	7,6	9,8	13,3	11,8	11,3	9,3
Buckwheat	2016	130,5	100,3	124,1	101,2	138,2	113,8	159,1
	2017	62,4	31,5	32,1	19,2	18,1	27,7	50,9
On average for all cereals and legumes	2015	23,9	41,6	35	31,5	42,3	53,8	60,4
	2016	34,5	41,1	45,8	27,5	50,6	61,1	78,1
	2017	17,2	9,5	12,7	12,5	15,0	15,8	26,5

* at HTC less than 0.5 humidification is weak, less than 1.0 – insufficient, from 1.0 to 1.5 – optimal, over 1.6 – excessive.

At the same time, the change in the productivity of grain crops is the determining factor in the cost-effective cultivation of these crops. So, in 2017, with a productivity of more than 25 c/ha (32 organizations), the average profitability of grain production was 38.3%, with a productivity of 12-25 c/ha (344 organizations), ranging from 8.0% up to 19.6%, with productivity below 10 centners per hectare (195 organizations) was negative (returns on investment did not exceed 91.1-97.1% (Table 3.) The change in the productivity of grain crops also determines laboriousness of grain production (the dependence is inversely proportional).

TABLE 4. CORRELATION OF PRODUCTIVITY OF GRAIN CROPS AND PROFITABILITY OF GRAIN PRODUCTION IN THE ALTAI REGION

Productivity, c/ha	**Number of organizations in the group, pcs.**		**Production expenditures, Rub./ha**			**Level of production profitability, %**		
	2015	***2017***	***2015***	***2016***	***2017***	***2015***	***2016***	***2017***
Less than 5	62	16	3513	4271	3981	-7,9	31,0	-8,9
From 5 до 10	297	179	5114	5445	5079	31,2	28,6	-2,9
From 10 to 12	139	124	7202	6974	6900	39,2	39,5	9,4
From 12 to 15	137	160	8505	8264	7852	45,3	46,5	8,0
From 15 to 20	90	135	10466	10396	11094	43,7	52,2	19,6
From 20 to 25	20	49	13637	14643	15465	61,8	54,2	11,5
More than 25	11	32	16349	17431	16453	88,6	89,7	38,3

The economic efficiency of specialization in grain field cultivation is influenced not only by the location of grain production, but also by the level of concentration of production. The conducted research testifies the achievement in specialized enterprises the optimal structure for the use of arable land with significantly higher productivity than on the average in the region or in non-specialized enterprises [13]. Increase in the size of production in grain field crop cultivation in 2013-2017 allowed to reduce laboriousness of the goods produced, and to raise the level of its profitability (Table 5).

TABLE 5. THE INFLUENCE OF THE SPECIALIZATION LEVEL ON THE ECONOMIC EFFICIENCY OF THE USE OF RESOURCES IN GRAIN FIELDING, 2017

Groups of farms with share of grain in the structure of commercial output, %	**Production laboriousness, man hours**		**The level of profitability of grain production, %**
	for 1 ha of crops	***for 1 c of grain***	
Up to 25,1**	7,0	0,49	11,0
Up to 33,3**	5,6	0,38	2,6
Up to 50,0**	5,5	0,38	15,3
including 10 of the smallest	8,6	0,68	26,9
the rest	6,0	0,44	16,3
10 of the biggest	4,1	0,27	12,2
More than 50,0**	6,6	0,46	19,7
including 10 of the smallest	11,0	1,25	4,3
the rest	6,8	0,49	15,2
10 of the biggest	4,8	0,27	50,4
Average	6,4	0,45	15,4

The use of scientifically grounded and regionally adapted systems for the cultivation of grain crops facilitated the production of higher productivity. In 2016-2017 in the Altai Region, taking into account the conditions of each of the natural and economic zones, the introduction of resource-saving technologies continued, the main elements of which were technical and technological modernization in the organization of production processes, the use of high-productive varieties and hybrids, and a plant protection system. The organization of innovative processes in the production of crops was carried out on an area of more than 3.8 million hectares, including strip-till technology – 15.0 thousand hectares, no-till technology – 350.0 thousand hectares. The application of these technologies allowed OOO KH "Partner" of the Mikhailovskiy District (HTC is at the level of 0.6, which indicates a lack of humidification of the territory) to obtain productivity of spring crops of 18.3 centners per hectare, and for OOO "AF Goodwill" of the Sovietskiy District to reach the productivity of winter wheat on the level of 64-80 c/ha in 2016.

Conclusions.

The conducted research allowed to identify the main patterns of changes in the profitability of grain production in the Altai Region under the influence of structural factors, mainly related to price volatility in the market. Grain crops of various types were unevenly distributed across the natural and economic zones of the region: wheat prevailed in steppe and forest-steppe territories, buckwheat – in more wetted areas. This fact directly affected the change in the yield of grain crops and indirectly on the profitability of their cultivation: when the grain yield was higher 25 hwt/ha, the profitability of grain production was 38.3%, with a yield of 12–25 hwt/ha –8.0–19.6%, with a yield below 10 hwt/ha was negative. The deepening of specialization with an increase in the size of production raised the efficiency of the used resources, despite the higher material and cash costs per hectare of grain crops. These farms had the maximum profitability of the products produced (50.4%). It allowed them to continue carrying out expanded reproduction on an innovative basis. A further increase in the size of production in such organizations is inexpedient, since it creates the risks of breaking the systems of crop rotation and reducing the yield of grain crops. In non-specialized enterprises labor costs per hectare of sowing were significantly higher than the average costs – it was determined by the use of labor-intensive technologies.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 349-352

Cereal Species Effect on Protein Content in Pea Grains in Legume Cereal Mixtures Depending Cropping System

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Abstract – Within the European Union's Seventh Framework Programme project "Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed" (EUROLEGUME) producing of the knowledge required for the implementation of legume supported cropping system in sustainable agriculture was done. The main objective of this study was to investigate spring cereal species effect on protein content in pea grains depending cropping system (organic and conventional). The research involved two field pea (*Pisum sativum* var.*arvense* L.) cultivars – 'Kirke' and 'Bruno', and two spring cereal species: spring wheat (*Triticum aestivum* L.) and oat (*Avena sativa* L.) grown in mixtures.

The results demonstrated that in pea-cereal mixtures cereal species can affect the protein content of grains of pea. Depending cultivar the effect was different. In grains of cv 'Bruno' crude protein content was highest; the higher the protein of grains fixed in yield from organic field.

Keywords – field pea, spring cereals, legume supported cropping system, organic and conventional farming

I. Introduction

Field peas are one of the oldest domesticated crops [21] and are now grown in all world for both human consumption and animal feeding. Peas are high in protein, starch, fiber, and micronutrients [4] and are well adapted to wide range of agroecological conditions, explaining the fact that they are second largest grain legume crop in the world [14]. Not least is the fact that its vines also could be useful as a nitrogen source [22]. Like all legumes, peas are an excellent plant for cropping systems because of its unique ability to fix atmospheric nitrogen [6], [13].

Legumes generally have lower gross margins than cereals, but their rotational effects increase the gross margins of subsequent crops [5]. In addition, legume production can protect and enhance public goods, including through reduced greenhouse gas [11] and nutrient emissions, increased crop and associated biodiversity, and reduced resource requirements of cropping and animal feeding systems [20]. Field pea is invariably grown as a component of a cropping system, and its interaction with other crops is an important consideration in a farmer's decision to grow it [9], [10], [23].

Growing peas in mixtures with cereals is commonly done for forage production because growing of them as sole crops is a challenge since its steam is prone to lodging thereby resulting in harvesting difficulties, reduced yield and decreased profits [2],[15]. However, in Latvia mostly it is thought that growing peas in mixtures with cereals help reduce lodging and weed pressure therefore are grown them in mixtures also for grain [1].

Taking into account that the intercropped legume-cereal systems reduce inter-specific competition by enhancing complementary processes thereby improving the exploitation of resources [8], pea-cereal mixtures generally reflecting in the increase of yield of both pea and cereal mixture components. However, previous studies have demonstrated too large effects of climate conditions, so harvests over the years are fluctuating [12], [16], and [24]. Studies have shown that year-on-year fluctuations in pea grain yields in mixtures with cereals are less, particularly in case of organic field [24].

In a temperate climate zone, summer barley, summer wheat and oats are traditionally used for growing peas in mixtures [12], [15], and [16]. In the literature, information is available on the positive effects of peas on the harvest of the supporting plant [7] and, conversely, the impact of the supporting plant on the quality of pea yields is very limited in the results of the studies [17].

On the basis of fact that one of the essential factors determining the quality of yield is genotype [19], as well as the fact that quality, i.e., chemical composition, is also affected by farming systems [3], the main objective of this study was to investigate spring cereal species effect on protein content in two maturity classes pea cultivars grains depending cropping system (organic and conventional).

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4179

II. Materials and methods

Site and soil description. Three years experiments were performed in organically and conventionally managed sod podzolic loamy sandy soil fields at the Priekuli Researc Centre of the Institute of Agricultural Resources and Economics during 2014-2016. A measurement of basic soil agrochemical characteristics (pH, organic matter, available phosphorus and potassium) was performed every year accordingly corresponding methodology traditionally adopted for agricultural experimental fields: pHKCL– LVSISO10390: 2006, organic matter content (according to Tyurin method) – LVSTZM80–91), phosphorus and potassium content (by Egner-Rhym method) – LVSTZM82–97, and are presented in Table 1.

TABLE 1.

Soil characteristic:	2014	2015	2016
Organic fields			
pH_{KCl}	5.9	5.7	5.6
humus, g kg^{-1}	19	24	19
P_2O_5, mg kg^{-1}	142	139	139
K_2O, mg kg^{-1}	148	171	135
Conventional fields			
pH_{KCl}	5.1	5.7	6.0
humus, g kg^{-1}	21	19	16
P_2O_5, mg kg^{-1}	192	159	146
K_2O, mg kg^{-1}	153	172	156

SOIL CHARACTERISTICS OF EXPERIMENTAL FIELDS

Field and crop management

In organic farming system field the field crops have been cultivated according to the principles of organic farming since 2003. Pea – cereal mixtures were grown in six-field crop rotation: spring barley with red clover as undersown – red clover – spring cereals – winter rye – potatoes – pulses. In conventional farming system field the sequence of crops was as follows: spring cereals with white clover as undersown – white clover for seed production (three years using) – winter cereals – potatoes – pulses.

Soil tillage technology in crop rotation was based on the traditional manners–the mouldboard ploughing to a depth of 20 cm in autumn and cultivations (twice) before sowing in spring. Straw and crop residues were crushed in pieces of 5 – 7 cm pieces and dispersed. In organic field weeds were controlled in the spring cereals and pulses after sowing and in the rye field at the end of April or in the beginning of May by spring-tine harrowing. In the potato field inter-rows (70 cm spacing) were harrowed and cultivated three to four times, respectively. In conventional field pesticides were used: insecticide– *deltametrin,* herbicide– *bentason* and *pendimetalin*).

As the basic soil fertility management measure for organic field was green manure (crucifers or buckwheat), for conventional field—mineral fertilizers using doses according to soil analyses. Additionally the enriching of soil was achieved by cultivating of clover as the improvement through the nitrogen fixation, as well as by turning the plants residues into the soil.

Sowing of mixtures (with *Hege*) was performed in last decade of April, using sowing rate 60 seeds m^2 of pea kernels for mixtures and 120 seeds m^2 for pure stand of pea. Grain yield of the plots was harvested at complete maturity stage with combine *Sampo* till the middle of August, dried and the yield data (determined moisture content of 14%) recorded for each plot and finally calculated for t ha^{-1}.

Weather conditions

The data about air temperature and rainfall were obtained from the Priekuli observation station which shows that weather conditions during research period were different, and are presented in table 2 and 3.

TABLE 2.

Mean air temperature, ^0C	2014	2015	2016	Long term average
April	7.1	5.4	6.1	4.8
May	11.9	10.2	14.5	11.1
June	13.5	14.3	16.4	14.8
July	19.5	15.9	17.9	16.9
August	16.7	17.8	16.3	15.9
September	12.2	12.9	12.9	12.1

TEMPERATURE DURING GROWING PERIOD

TABLE 3.

Precipitation per month, mm	2014	2015	2016	Long term average
April	32.1	75.8	82.2	39.6
May	96.7	53.3	9.8	55.9
June	108.3	39.4	144.5	78.5
July	76.5	91.5	109.5	93.3
August	158.2	24.1	175.8	87.9
September	30	42.1	23.2	65.3

MOISTURE DURING GROWING PERIOD*Genotypes,*

Measuring and sampling

The varieties of field pea were: 'Bruno'- pink flowered, semi- leafless, medium early maturity variety, bred in Latvia and Estonian variety 'Kirke'- pink flowered, early maturity and with good résistance to diseases. Varieties of other mixture components were: 'Laima' (oat) – characterized by high and stable grain yield under different climatic conditions, have high resistence to diseases. 'Uffo' (spring wheat) – mid-early, having high yield potential, characterized by moderate lodging resistance. The grain quality is suitable for food and feed.

Evaluation of phenology of crops by recording of dates of the beginning of emergence (when at least 50% of cotydelons were opened) and beginning of flowering (when at least 50% of flowers were opened) was carried out. For measurements 10 plants per plot were selected. Plant high was measured at the beginning of flowering (BBCH 61–64) and at the beginning of forming pods (BBCH 71–75) and at the beginning of maturity (BBCH 81– 85). Amount of pods per plant also were counted.

Pea seed samples were analysed on protein content in the four replications (n=4) by near infrared spectroscopy by using an *XDS Rapid Analyzer* (Foss) where the average sample of all

applications was analysed for each variant.

Statistical analysis

Data were subjected to analyses of variance (ANOVA) using STATISTICA. The level of significance was set at $p<0.05$.

III. Results and discussion

Plant development and the yield

The plants in the organic field were taller, more podded, that ultimately led to higher yields (Table 4). Similar Kadžiuliene *et all*, 2010 [12], we found that number of the productive steams was lower in the mixture crops than in sole peas. Number of pods also was lower.

TABLE 4.

Variety	Plant hight in the beginning of flowering, cm	Amount of pods per plant	Yield of pea, tha^{-1}
Conventional field			
Kirke+oat	51c	2c	0,36c
Kirke+wheat	54c	3b	0,35c
Kirke, sole	51c	4a	1,14ab
Bruno+oat	64b	2c	0,58bc
Bruno+wheat	68ab	2c	0,62b
Bruno, sole	73a	4a	1,61a
ANOVA , p-value	3,2	0,9	0,88
Organic field			
Kirke+oat	68c	6b	1,19b
Kirke+wheat	68c	6b	1,11b
Kirke, sole	85a	8a	3,91a
Bruno+oat	81b	5c	0,85c
Bruno+wheat	86a	6b	1,50b
Bruno, sole	87a	8a	3,27a
ANOVA , p-value	2,4	1,2	0,86

PLANT DEVELOPMENT AND THE YIED OF PEA IN MIXTURES

Compared to years in 2014 a slight increase in the plant length was fixed that can be explained by the abundance of precipitation at the beginning of vegetation. There were no differences found between the plant length, amount of pods and yield level of pea 'Kirke' from plots with mixtures in organic field. Significantly higher yield was obtained from both mid-early maturity 'Kirke' and mid-late maturity 'Bruno' sole plots. This fact leads to the conclusion that the tested varieties in mixtures form lower yields than pure ones, irrespective of the farming system.

Within experimental period the higher yield was obtained in 2015 when July was characterized by moderate monthly temperature (15.9^{0}C) and rainfall (91.5 mm), followed by relatively dry and warm August [25]. The results showed that the productivity of pea in mixtures not depended on the species of cereals but there was high dependence on cultivation conditions. Differences seem to be related to the better organic performance– an organically managed field provides necessary conditions for yield formatting also in adverse climate conditions. However, this is only an assumption, because the trials were carried out in fields with different plant sequences.

Protein content

Data (Fig. 1 and Fig.2) indicate the effect of genotype on protein content in grains, regardless of the farming system. The highest yield was obtained in 'Bruno'- from 23.5 to 24.7% in conventional field and from 23.9 to 27.8% in organic field, which is more than 2.9 and 2.8% than the other variety, accordingly. Variety 'Bruno' also has shown high protein content in other studies [19].

In the case of cultivations of pea in mixtures, less impact was fixed on the organic field. In the conventionally managed field, the protein content of pea grain from sole plots was higher in all experimental years than in mixtures, while in organically managed field these differences were not significant.

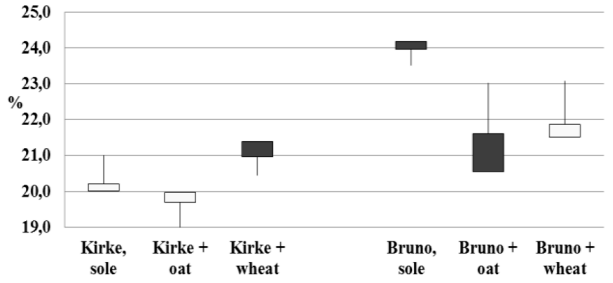

Fig. 1. Protein content in pea grains from conventional field

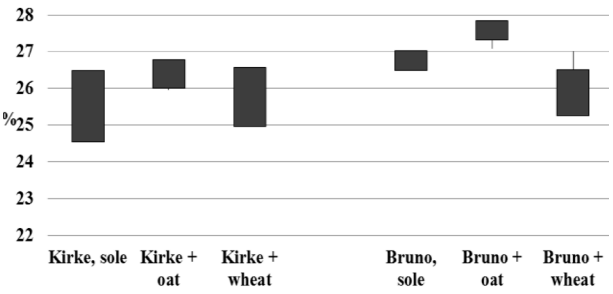

Fig. 2. Protein content in pea grains from organic field

The yield of crude protein in the mixtures varied between experimental years, suggesting the sensitivity of peas to agroecological factors which are already known from other [16] research results. However, the results of our studies show that choice of cereal species (spring wheat or oat) for mixture does not affect or affect insignificant the protein content in pea grains. Taking into account that through growing of legume–cereal mixtures enriched feed, it was important to clear also other relationships between mixture crops.

IV. Conclusion

The choice of spring cereal species for pea-cereal mixtures does not affect the protein content of pea cultivar's 'Kirke' and 'Bruno' grains.

The maximum protein yield per area unit was obtained from plots of pure crops. In a mix with cereals pea yield decreased.

The effect of the farming system on the protein content of pea grains was fixed: in the conventional field, compared to organic, the difference between the

protein content of sole sown plots and mixtures was more pronounced.

Acknowledgments

This work was supported by the European Commission within the FP7 research project 'EUROLEGUME – Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed (grant agreement no 613781)'.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 353-358

Development of Inclusive Society with the Instruments of "green" Economy and Education

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***Abstract*—The article substantiates that in order to ensure the effective development of economic systems, the issues of rational use of natural resources and environmental safety are significant. Environmental problems for modern economies of the world are systematized. The aim of the research is to study the theoretical and practical experience in the formation of an inclusive society and the "green" economy of the regions in the Republic of Belarus based on the analysis of the mechanism for introducing circular technologies at the micro level, schemes for engaging vulnerable groups of the population, creating "green" jobs, creating courses on the principles of inclusion economy in the workplaces. The following tasks were set and resolved: the mechanism for the formation of the inclusive society and the "green" economy in the Republic of Belarus was identified through the introduction of circular technologies at the micro level; considered the features of involvement in employment of vulnerable groups of the population; identified and systematized features of creating "green" workplaces; specificity of courses for on-the-job training on the principles of inclusion and "green" economy is grounded. The research methodology is based on the principles of systems analysis, formal logic and an interdisciplinary scientific approach. Monographic and descriptive method was used in the formation of theoretical and practical basis for development an inclusive society with elements of the "green" economy; method of analysis and synthesis, method of statistical data analysis in the short-term analysis. The novelty of this research lies in the fact that the theoretical and practical foundations for building the inclusive society through the tools of the "green" economy and education have been studied and scientifically grounded. The conclusions are that the creation of "green" jobs, learning the principles of a "green" economy, as well as the implementation of other measures to ensure the sustainable development are necessary. And development of inclusive society and "green" economy depend on ability of government and firms to teach their basic principles and create inclusive and "green" workplaces and jobs. As recommendations it is proposed to involve older labor resources in employment, taking into account coordination of the vocational qualification structure of labor supply and technical and technological parameters of workplaces; to assess development of the international labor market and sustainable development of the labor market with created by authors list of indicators; to develop an electronic web resource with information about the skills of the workforce, indicating the geography of workplaces and schemes for building up the necessary skills contributes to the advance preparation of the workforce; and to organize and conduct courses for employers and employees in the field of inclusive development and "green" jobs.**

***Keywords*—Effective employment, "green" economy, inclusive society, inclusive education.**

I. Introduction

An inclusive society is seen as a society in which conditions are created for people with special needs and disabilities to lead an independent lifestyle and actively participate in all aspects of life and development of such a society.

The labor market is developing in the formation of a circular economy. Such an economy involves the rational use of labor resources. Global risks are discussed at the Davos Economic Forum (The Risk-Trends Interconnections). Such risks are associated with unemployment and underemployment. The reason is seen in the not fully use of the potential of the employed population. The situation is complicated by the aging of society, social instability, age polarization of society.

Studies in the field of forecasting the labor potential of various countries and regions are conducted by leading international organizations. Research results are reflected in economic models and projects, for example, The Labor Market Development Project, The Staff Studies for the World Economic Outlook, The Cohort-Based Model of Labor Force Participation. People of older working age are actively involved in the process of creating value added and for a long time remain the economically active part of the population. The article highlights the difficulties of the older generation in the labor market. They are:

-low awareness of available vacancies and job requirements;

- difficulties in acquiring new competencies.

The article substantiates the involvement of older labor resources in employment, taking into account:

- features of the circular economy and global risks of the world community;

- coordination of the vocational qualification structure of labor supply and technical and technological parameters of workplaces;

- features of gender and age characteristics of the types of aging society.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4057

Published by Rezekne Academy of Technologies.

Consideration of these factors will allow:

-support the creation of jobs with high added value;

- rational distribution of labor resources of the necessary qualifications and gender characteristics;

- rationally distribute labor resources by traditional and / or innovative sectors of the economy.

The novelty of this research lies in the fact that the theoretical and practical foundations for building the inclusive society through the tools of the "green" economy and education have been studied and scientifically grounded.

II. Materials and methods

Studying of documents of global importance on productive and full employment (Global Jobs Pact, ILO) showed that indicators "... increasing employment, production and investment and aggregate demand and ensuring decent work for all …" are important for inclusive economic growth.

The approach is valuable by highlighting young women and men in the labor supply structure. According to the ILO, "... every year about 45 million young women and men enter the global labor market, mainly in developing countries ..." [1].

Analysis of the documents revealed the tools to achieve full and productive employment. They are:

-stimulating labor demand;

-supporting of labor resources actively looking for work;

-supporting for the unemployed;

-consultation with employers and employees [1].

Examination of global documents (Resolution adopted by the General Assembly on September 25, 2015 of the United Nations) also shows that youth employment issues are being updated on the global labor market.

In the article's noted the importance of the employment of young people of different levels of education, the aspects of self-employment of young people in entrepreneurial activities [2].

The study of the global document (Work Program 2018-2020, Horizont 2020) showed that the labor market is developing in the conditions of the formation of a circular economy [3].

For the development of the international labor market, it is highlighted the following indicators: decent quality work, employment indicator, involvement in the economy, labor market efficiency [4].

The authors offer as indicators of the sustainable development of the labor market: elasticity between employment and output growth by sectors of the economy, an index of dependents in the country [5].

The research methodology is based on the principles of systems analysis, formal logic and an interdisciplinary scientific approach. Monographic and descriptive method was used in the formation of theoretical and practical basis for development an inclusive society with elements of the "green" economy; method of analysis and synthesis, method of statistical data analysis in the short-term analysis.

III. Results and discussion

The authors distinguish a pattern: with hard labor laws, staff turnover decreases, and the devaluation of skills during a cyclical recession also decreases. Noted the conclusion that the high level of unemployment benefits is an additional incentive for workers to accept the risk of preserving human capital. The presence of sectoral skills in workers contributes to high skill at workplaces and intensive production, productive work. Authors point out the following category - internal flexibility of the labor market. It manifests itself as follows: the employee takes overtime during the peak of the economic cycle. The employer is responsible for maintaining the number of the employed labor force and raising professional qualifications during the economic downturns.

It is concluded that the factors of external inflexibility of the labor market are:

1) the reactivity of monetary and fiscal policies to adapt to fluctuations in the economic cycle;

2) the amount of government spendings and their impact on the value of aggregate demand.

Identified factors of labor supply in the labor market. They are:

- changes in income distribution;

- regulation in the credit market;

-quality of social protection;

-the ratio of private and public funding in the education system;

- employee qualification (ratio of specific skills to general skills),

-reaction ability of monetary, fiscal policy in cyclical unemployment.

Methodological principles for achieving productive employment for inclusive economic growth are substantiated. They are the following:

1) if the growth rate of the real interest rate is lower than the growth rate of labor productivity, then it contributes to the formation of real financial wealth (rentier);

2) reduction of overhead costs for firms contributes to the shift in income distribution in favor of labor with a stimulating effect on aggregate demand;

3) financial policy contributes to achieving full employment and even distribution of disposable income.

The formation of the institutional framework of the labor market to combat the devaluation of labor skills has been proposed. It is electronic web resource with

information about the skills of the workforce, indicating the geography of workplaces and schemes for building up the necessary skills contributes to the advance preparation of the workforce.

It is concluded that for sustainable and balanced global economic growth, it is necessary to create high-quality jobs. Therefore, the authors point out the following economic indicators:

-crisis jobs;

-strengthening the ability of workers to adapt to the future needs of the labor market;

-development of employment as the basis of economic growth;

-training of workers to benefit from new investments. It is about investments to clean energy production, healthcare and infrastructure;

-increasing the share of salary in the cost structure,

-labor productivity growth;

-reducing income inequality;

-creating "green" workplaces (in frames of "green" economy) [1].

Among the problems faced by humanity at this stage of development, a special group stood out the issues of environmental management and environmental protection, i.e. "environmental problems". One of the options for achieving the necessary balance of "human-ecology-society" is outlined in the idea of creating a fundamentally new approach to managing human activities of the so-called "green" economy.

The importance of studying of "green" economy formation in regions and organizations of Belarus is connected with the need for sustainable development.

According to L. Kuzina [6], "an analysis of the final documents adopted at the United Nations Conference on Sustainable Development "RIO + 20" allows to come to the conclusion that the world community accepts inevitability of replacement of market model of progress on new, or "green" economy. Most often, the "greening" of the economy is understood as ensuring economic growth and improving the well-being of people while preserving the environment.

Many developed countries have already begun to develop concrete strategies for the transition to a "green" economy. The National Strategy for the Sustainable Socio-Economic Development of Belarus until 2030 aims to implement the principles of "green economy" in practice [7]. At the same time, the circular component of the "green" economy does not receive enough attention from both the government and business. Creating conditions for "green" growth is considered by the Ministry of Economy to be an essential tool for attracting foreign investment.

Currently, the country is implementing a number of projects, for example:

− "Development of the forest sector of Belarus" − implemented through a World Bank loan ($ 40.7 million) and a related grant from the Global Environment Facility ($ 2.7 million).

− "Promoting Belarus's transition to a "green" economy" is funded by the European Union and implemented by the United Nations Development Program. The total project budget is 5 million euros. The project started in 2015.

Belarus is a participant of the program (project) "Greening the Economy in the Eastern Partnership Countries of the European Union" (national coordinators are the Ministry of Economy and the Ministry of Natural Resources and Environmental Protection), jointly implemented by United Nations Economic Commission for Europe, the Organization for Economic Cooperation and Development, United Nations Environment Programme and United Nations Industrial Development Organization.

Belarus has developed a National Action Plan for the development of the "green" economy in the Republic of Belarus until 2020 [8]. One of the publications from the series of works on the circular economy in Belarus, carried out in the framework of the Development Project of the Center for Economic Research BEROC prepared by N. Batova, P. Sachek and I. Tochitskaya [9]. The authors revealed that the "green" economy is one of the instruments for achieving sustainable development, and the circular economy is the practical basis for its implementation.

Next, it is considered the features of the introduction of the circular technologies mechanism at the level of regions and organizations. The authors will base on the fact that, in the opinion of N. Batova, P. Sachek and I. Tochitskaya, the important features of the "green" economy are a steady decline in all types of negative impacts, including pollution; preventing the loss of ecosystem services and biodiversity; the innovative nature of economic dynamics, income growth and employment; a drastic reduction in poverty, and in a circular economy, priority is given to the lower consumption of resources from the environment, as well as their lesser return to the environment as waste.

The research object chosen by the authors corresponds to one of the sectors covered at the UN conference on sustainable development "RIO + 20" "Sustainable cities and the environment". Next, it is considered how the principles of a "green" and circular economy are implemented in one of the largest industrial centres of Belarus – Novopolotsk city.

The authors analyses the indicators characterizing the features of the formation of a "green" and circular economy, using data from the National Statistical Committee of Belarus [10] It is reflected in table I.

Table I. Indicators characterizing the features of "green" and circular economy formation in Novopolotsk in comparison with indicators of the Vitebsk region and Belarus

Name of the indicator	Value of the indicator in 2017		
	in Novopolotsk	*in Vitebsk region*	*in the Republic of Belarus*
1. The unemployment rate registered (end of year), as a percentage of the labor force	0,8	0,7	0,5
2. Real wages, as a percentage of the previous year	105,8	105,7	107,5
3. Emissions of pollutants into the air from stationary sources, tons per organization tons per person	70,92 0,48	7,93 0,09	3,20 0,01
4. Production waste generation tons per organization tons per person	58,71 0,40	59,57 0,65	392,50 5,85
5. Volume of water used thousand cubic meters per organization thousand cubic meters per person	78,33 0,53	12,24 0,13	8,94 0,13

Source: made and calculated by authors based on data of National Statistical Committee of the Republic of Belarus

The features of the formation of a "green" and circular economy in Novopolotsk are due to the functioning on its territory of the largest industrial organization Open Joint-Stock Company Naftan, which produces various types of fuels, lubricating oils and bitumens, aromatic hydrocarbons and petrochemical products.

So, Novopolotsk is characterized by significant amounts of pollutant emissions into the air from stationary sources both per organization and per inhabitant. At the same time, the unemployment rate exceeds the average for the Vitebsk region and for Belarus as a whole. The growth rates of real wages in Novopolotsk as a whole correspond to its growth rates in the Vitebsk region and are significantly lower than the average for Belarus. Thus, for Novopolotsk, the formation of a "green" economy is undoubtedly an important and urgent task, since it causes significant harm to the environment. This negatively affects the standard of the population living of the region, despite the fact that the growth rates of real incomes are insignificant here, and unemployment exceeds the average level in the state and the region.

Referring to the features of the circular economy, it should be noted that the volume of water use in Novopolotsk in 2017 significantly exceeds similar figures for the Vitebsk region and Belarus, that is, there is significant water consumption. At the same time, the volume of waste generation on average corresponds to the average regional level and is significantly lower than the average national level. That is a problem for the city is significant water consumption.

In general, it should be noted that the formation of both a "green" and a circular economy is relevant for Novopolotsk, since there is a threat to the sustainable development of the region, caused by significant consumption of certain types of resources, the negative impact of industry on the environment unemployment and insufficiently high growth rates of real wages.

Creation of inclusive society and "green" economy is closely connectedto the education sphere.

Education as a social institution plays an exceptional role in the development of the individual and its socialization. Today, the features of each are considered as an undeniable value, as a potential for socio-economic development as a whole. The construction of modern society is based on an understanding of the developing potential of diversity, the significance of the contribution of each to a single process of improvement.

Inclusive education is a chance to create a tolerant, open and personal-oriented society, with equal conditions of development for all its members, regardless of abilities and opportunities. The disadvantages of inclusive education are the psychological unreadiness of society to accept a person with disabilities, the imperfection of the system of social support and the provision of such persons and persons with disabilities.

In this regard, it is necessary to organize and conduct courses for employers and workers in the field of inclusive development.

Inclusive education is based on the following principles:

- systemic - inclusive education is a systemic phenomenon in education, covers the entire education system, applicable at all levels and in all types of education;
- complexity - inclusive education causes changes in the whole complex of relationships in the educational institution, implies coordinated activities of specialists;
- accessibility - inclusive education requires adaptation of the educational environment for any category of students;
- variability and consideration of the specific educational needs of each student;
- tolerance - inclusive education involves the formation of relationships based on understanding, accepting and respecting existing differences, recognizing equal rights.

Combining a labor resource with a social combination of production factors is limited by the reluctance of employers to hire people with disabilities, the lack of regular and accessible information about available vacancies, and segregation. The society, having incurred the cost of forming the labor resource of a disabled person, is waiting for its return, which requires jobs and other opportunities for the realization of the labor resource. The lack of interest of an entrepreneur to use a non-competitive labor resource of a disabled person should be compensated by creating conditions in which the entrepreneur agrees to present jobs to people with disabilities.

Ways of inclusion of persons with disabilities in the socio-economic relations of employment and the use of their labor resources are unique and depend not only on the conditions of the region, but also on the inherent limitations of labor opportunities.

Education plays a key role in effectively using the tools and mechanisms of the "green" economy in practice. Education as a social institution is the most important of the basic conditions for the transition to a "green" economy, since it contributes to the support and dissemination of innovations, both technological, economic and socio-cultural. It is the ability of society to generate new ideas and approaches to solving problems and having the opportunity to demonstrate the effectiveness of these innovations and their widespread introduction becomes the key to the competitiveness of national economies.

In the same way, education in the interests of a "green" economy can play the role of a supplier to the labor market of new personnel or retraining of some of the former. In the course of the development of "green" industries in the labor market, the demand for specialists of new professions - the so-called "green collars" - is increasing [11].

At the moment, staff shortages in specialists in "green" industries are already felt, for example, there is a shortage of personnel in the biofuels sector in Brazil, in renewable energy and the production of environmental goods and technologies in Germany, the USA and Bangladesh, in the construction sector in Australia, China, Europe and South Africa [12].

In addition to specific qualifications and competencies related to employment in the sector of environmental goods and services, the task of "greening" all labor capital in all sectors and at all levels is no less important. In general, in terms of content, approaches and methods, education for a "green" economy is first of all education for change, since the transition to sustainable development and a "green" economy requires abandoning outdated forms of management, changing not only formal rules (government policies, legislation), but also informal (business ethics, social norms and values). Under new conditions, education requires efficiency in the preparation of creative initiative individuals who are able to solve complex problems in innovative and flexible ways. And for this, first of all, the transition from the reproductive to the creative approach in the organization of the educational system and the educational process, as well as in the content and methods of teaching, is required.

It is highly necessary to improve cooperation between universities and sectoral departments in order to match training programs (both students and civil servants) with government priorities.

IV. Conclusions

It was concluded that it is important to increase the so-called "green skills" in time for the emerging "green" jobs.

It is substantiated that production itself is fragmentary and is built in different economic systems. This entails the distribution of labor skills across countries.

It has been substantiated that the scope of the services market allows developing self-employment for people of different skill levels.

The conclusion was made and substantiated that in order to ensure inclusive economic growth, taking into account the fragmentation of production, the creation of production chains for the production of different added value, it is necessary to take into account a number of indicators. They are the following:

- analysis of the national economy on the current and possible rates of savings and the mentality of nations, as well as their desire to invest in self-employment and the creation of GDP;
- structure of the total population by age and gender;
- the proportion of the working population in the total population;
- share of exports in the production of each of the national economies;
- the proportion of labor costs in the structure of the gross domestic product;
- on the ability of national economies to create jobs through the coefficient of capital growth (the size of gross investment to change in real GDP);
- size of infrastructure investments (size of investments in tangible infrastructure networks: transport, energy, and intangible infrastructure networks: education, research costs);
- productivity of services in production and in the service sector;
- the share of GDP by sectors of the economy to assess the contribution of changes in sectoral employment to the growth of total employment;
- elasticity between employment and output growth by sector to assess changes in sectoral employment depending on an increase in sectoral output by 1 percentage point.

Authors offer to develop an electronic web resource with information about the skills of the workforce, indicating the geography of workplaces and schemes for building up the necessary skills contributes to the advance preparation of the workforce.

Taking into account the importance of education in modern economic development it is necessary to organize and conduct courses for employers and employees in the field of inclusive development and "green" jobs.

Creation of "green" jobs, learning the principles of a "green" economy, as well as the implementation of other measures to ensure the sustainable development are necessary. Development of inclusive society and "green" economy depend on ability of government and firms to teach their basic principles and create inclusive and "green" workplaces and jobs.

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 359-363

Mentoring as one of the Prerequisites for the Development of the Entrepreneurial Environment

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***Abstract*—The quality of the entrepreneurial environment is one of the preconditions for the competitiveness of the national economy of Latvia. Mentoring in entrepreneurship is mainly used to foster the expansion of new and less-experienced enterprises. Cooperation between a mentor and a mentee gives opportunities for the mentee to grow and develop. The paper is based on the implementation results for the research grant "Mentoring Opportunities for Entrepreneurship Development in Rezekne Municipality". The research aim is to examine mentoring as one of the preconditions for the development of the entrepreneurial environment. The research results revealed that mentoring could be one of the most effective ways how to promote an increase in the number of entrepreneurs and economic growth. Potential mentors rated a mentor's knowledge of relevant business legislation and how to enter a new market and attract a new cooperation partner as "important" and "very important". Mentees, in contrast, wished to make new contacts, acquire new cooperation partners and attract investments and funds with the help of their mentors as well as expected that their mentors would help them to reveal their personal potential and how to effectively use it in entrepreneurship. The key traits needed by mentees, the potential mentors referred to, confirmed the theoretical principles of mentoring – mentors have to hear and listen and to help their mentees to find answers to problems themselves.**

In Rezekne municipality, mentoring in entrepreneurship could contribute to the development of less-experienced enterprises. Accordingly, it is necessary to continue the research begun by the authors, identifying and creating a database of potential mentors and mentees in the other municipalities of Latgale region who can and are ready to engage in the business mentor network.

Research methods used: monographic and descriptive, analysis, synthesis, statistical analysis and a sociological method – surveying. The research was done based on relevant research studies by foreign and national scientists as well as industry experts, data of the Central Statistical Bureau and other information sources.

***Keywords*—entrepreneurship, mentee, mentor, mentoring.**

I. Introduction

The quality of the entrepreneurial environment is one of the preconditions for the competitiveness of the national economy of Latvia – the better conditions the government can create for entrepreneurs, the more investment could be made in the national economy, which, in turn, contributes to the creation of new jobs and the standard of living (Ekonomikas ministrija, 2018). A draft of the Plan of Measures for Enhancing the Entrepreneurial Environment announced at a meeting of state secretaries set the following goal: an entrepreneurial environment has to be attractive to entrepreneurs: available and understandable services and a lower administrative burden. The plan is comprised of 12 sections focusing on the entrepreneurial environment or action priorities that involve 47 measures with deadlines of up to three years.

Today, competitiveness and skill to respond to changes fast are the most important factors for entrepreneurship in the regions. In the period 2013-2017, according to the Central Statistical Bureau (CSB) of Latvia, the number of market sector economically active statistical units per 1000 capita in Rezekne municipality was larger than that in Latvia as a whole. In 2017, there were 68 enterprises per 1000 capita in Rezekne municipality, while in Latvia this figure was on average 90 [1].

In 2017, the number of enterprises registered in Rezekne municipality, measured per 1000 capita, totalled 60.69, which could be viewed as a low indicator compared with Durbe municipality with 146.00 and a relatively high indicator compared with Zilupe municipality with 33.96 [2].

Promoting entrepreneurial activity in rural areas requires a comprehensive approach, which includes retraining of rural residents, providing opportunities for acquiring basic knowledge of entrepreneurship, general economic knowledge and advice [3], and applying experience-sharing methods to develop the entrepreneurial environment [4] - [6]. As indicated by European practices, entrepreneurial experience transfer or mentoring in business is one of the most effective ways how to contribute to the number of new businesses and economic growth [7]. In many countries, mentoring is recognised as a progressive business growth instrument.

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4088

Transferring successful experience among enterprises, actively sharing knowledge, experience and contacts as well as forming business cooperation culture are the unique values of it. Mentoring is mainly used to contribute to the development of new and less-experienced enterprises [5]. However, it has to be admitted that "mentoring is not a key to success or a solution to all problems – only an opportunity to learn the opinion of experienced entrepreneurs and get advice" [8].

The authors believe that despite the expansion of mentoring in Latvia, in Rezekne municipality mentoring in entrepreneurship is practised insufficiently, and it could be one of the ways how to increase the number of new businesses in the municipality.

The research aim is to examine mentoring as one of the preconditions for the development of the entrepreneurial environment.

Specific research tasks:

1. To examine the conjunctive theoretical aspects of mentoring and entrepreneurial environment development;
2. To assess the results of a survey of mentors and mentees in Rezekne municipality.

Research methods used: monographic and descriptive, analysis, synthesis, statistical analysis and a sociological method – surveying.

The research was done based on relevant research studies by foreign and national scientists as well as industry experts, data of the Central Statistical Bureau (CSB) and other information sources.

To process the data, the research employed SPSS (Statistical Package for the Social Sciences) and Microsoft Excel analysis tools.

II. Materials and methods

The research conducted a survey of entrepreneurs – mentors – and mentees with the aim of collecting information and data on the entrepreneurs who wished to participate in the activities of the business mentor network in Rezekne municipality. The questionnaires were distributed electronically, Rezekne municipality enterprise managers were spoken to in person and interviewed via phone as well as the questionnaires were published on the Facebook page of the Rezekne municipality local government. Two kinds of questionnaire were disseminated, appealing to both current entrepreneurs being ready to become mentors as well as future entrepreneurs wishing to learn and get inspired by experienced entrepreneurs. The quantitative survey of entrepreneurs was conducted from November 2018 to January 2019. Among the respondents, women represented 18.2% and men 81.8%; the highest percentage (36.4%) was found for the group aged 41-45 who had a Bachelor's degree or second-level professional higher education (36.4%) in natural sciences (36.5%). Among the mentees, 52.6% were women and 47.4% were men; the highest percentage (31.6%) was observed for the group aged 26-30 who had a Bachelor's degree or second-level professional higher education in social sciences (36.5%).

The surveyed enterprises engaged in mentoring were divided into three categories:

- microenterprises (0-5 employees) – 72.7% of the total respondents;
- small enterprises (6-10 employees) – 18.2% of the total respondents;
- medium enterprises(31-40 employees) – 9.1% of the total respondents.

The participation activity of entrepreneurs (mentors) in the survey was low in Rezekne municipality. Only 11 questionnaires were received back from entrepreneurs (mentors) and 19 from future or new entrepreneurs (mentees).

Based on the information available in public databases and on the Internet, 98 enterprises registered in Rezekne municipality (Table 1) were selected; the enterprises were sent an invitation to participate in the online survey conducted by use of the indirect surveying method (information on the survey was sent to the potential respondents via email, requesting them to fill in a questionnaire electronically on the portal google.com). The invitation was sent twice – in the beginning of November 2018 and in December (the second one was a reminder about the participation in the survey). In view of the low activity of entrepreneurs, the authors made a decision to do interviews by phone, speaking to every potential respondent in person and filing in questionnaires themselves.

TABLE 1. CHARACTERISTICS OF THE SAMPLE REACHED

Kind of study	Number
Number of email addresses that were sent an invitation to participate in the survey	98
Number of completed web questionnaires	12
Telephone – the number of interviews	25
Size of the sample	37
Number of valid and processed questionnaires	30

Source: authors' study

To reach a larger number of potential mentees, which could be also represented by entrepreneurs who are establishing their own enterprise or only plan to do it and their contact information is not available publicly, the authors used an opportunity to publish the questionnaires on the Facebook page of the Rezekne municipality local government.

A questionnaire was filled in for every entrepreneur individually (or it was done by the entrepreneur him/herself). The research group tested the questionnaires received for validity. The questionnaires meeting the quality standards were prepared for data processing and summarisation.

Among the respondents – Rezekne municipality entrepreneurs (mentors) –, the highest percentage was found for those representing enterprises engaged in agriculture, forestry and fisheries, wholesale and retail trade and repair of motor vehicles and motor cycles (27.3%). Of the respondents, 36.4% indicated that earlier they worked in another enterprise engaged in the same field of economic activity; 90.9% noted that besides entrepreneurship they had experience in other fields, the duration of their enterprises was 6-10 years (45.5%) and the average number of employees was 0-5 (72.7%).

As regards the mentees, the highest percentage was

found for those representing enterprises engaged in agriculture, forestry and fisheries as well as accommodation and food service activities (21.1%). Of the respondents, 42.1% indicated their enterprises were in the process of establishment.

III. Results and discussion

Mentoring in entrepreneurship represents a systematically shaped relationship based on long-term and voluntary support between a successful entrepreneur sharing his/her knowledge, experience and views and another entrepreneur who is ready and wish to learn it and improve his/her professionalism [9]. Mentoring is generally a one-to-one interrelation that normally occurs between a senior, more experienced person (the mentor), and a junior less skilled one (the mentee) to help the mentee to effectively and rapidly adapt to the business environment through advice and guidance so that mentees acquire organizational socialization, career advancement and professional and personal growth [10].

Mentoring is the relationship between a person with advanced experience and knowledge and a more junior person who seeks assistance, guidance and support for their career, personal and professional development [11].

Mentoring is a long-term relationship between a mentor and a mentee that meets the need for development, helps to unlock the mentee's full potential and benefits all the parties involved. A mentor individually works with an enterprise to assess its business performance and problems or opportunities for developing its potential, give advice and recommendations on business expansion and particular action [12].

Scientists have researched various factors affecting the quality of mentoring. The researchers [13] believe that trust is an essential component of effective mentoring relationships, and mentoring programmes have to include activities helping to build up and promote trust between a mentor and a mentee. Researching the prototypes of an ideal mentor, the researchers [14] pointed out that when asked about their ideal mentor, the respondents stressed the guidance given by the mentor, interpersonal "warmth" and his/her ethical integrity. The prototypes of an ideal mentor varied, depending on ethnicity and gender, and also on how the question was asked. The researchers [15] identified 29 mentor characteristics (age, gender, work experience, motivation to be a mentor etc.). The practice showed [16] that there was no statistically significant difference in clients' satisfaction according to whether an entrepreneur worked with a mentor of the same gender. In the case of small enterprises, mentees, first of all, wanted a mentor who listened to them, and who accurately assessed their particular business situation. They wanted a mentor who was helpful and who provided relevant advice in a respectful manner.

The authors conclude that mentoring is a knowledge transfer process implemented by experienced mentors and mentees. Mentoring in entrepreneurship is based on the mentor's knowledge and experience, which allows the mentee to assess the opportunities and resources being at his/her disposable and use them to solve some particular problem or achieve a goal.

Globally, entrepreneurship plays a significant role in employment creation. When entrepreneurs succeed, economies thrive. They therefore need a support system that nurtures their potential and an environment suitable for sustainable entrepreneurship to take place. One of the key components that entrepreneurs could benefit from is mentoring. However, the understanding around mentorship, its benefits and impact is still not widespread across most developing nations [17]. The strong relationship between the mentor and the mentee create a safe environment for the growth and development of the mentee [18].

Mentoring does not just help young professionals gain the experience and wisdom they need in the workforce, it can also increase the likelihood of small business success. Working with a mentor at least five times greatly increases an entrepreneur's likelihood of business success. It has to be noted that the top three issues entrepreneurs asked their mentors for help with were**:** human resource issues (61%); growth/business expansion (59%) and start-up assistance (53%) [19].

The authors agree with the above-mentioned assertions and believe that mentoring is one of the most effective ways how to contribute to the number of new entrepreneurs and economic growth. Overall, entrepreneurship expands and develops if experienced entrepreneurs give guidance to beginners in entrepreneurship. Mentoring positively affects the national economy, as new enterprises are founded, unemployment declines and the competitiveness of enterprises increases.

The survey of entrepreneurs (mentors) done within the present research revealed that the potential mentors rated the importance of knowledge a mentor needs (Table 2) as "important" and "very important" and admitted they were competent in *business legislation*, 90.91% and 9.9%, respectively. The *knowledge of how to enter a new market and attract a new cooperation partner* was rated as "important" by 81.82% and as "very important" by 18.18% respondents.

TABLE 2. RATINGS OF IMPORTANCE OF KNOWLEDGE NEEDED BY A MENTOR IN REZEKNE MUNICIPALITY, SURVEY OF MENTORS (N=11), %

	Very important	**Important**	**Not important**	**No opinion**	**Total**
Accounting	18.18	54.55	27.27	-	100.00
Marketing	18.18	63.64	9.09	9.09	100.00
Entry into new markets, new cooperation partners	18.18	81.82	-	-	100.00
Personnel management	9.09	54.55	18.18	18.18	100.00
Business legislation	9.09	90.91			100.00

Establishment of a new enterprise and business start-up	9.09	54.55	27.27	9.09	100.00
Development of a business plan, project	18.18	72.73	9.09		100.00

Source: authors' calculations

An assessment of the problems the mentees would like to solve with the help of their mentors highlighted the overall problems of the entrepreneurial environment in Latgale region. Of the respondents, 21.6% wished to make new contacts and cooperation partners (Table 3), while 17.6% hoped to attract investments and financial resources for their enterprises with the help of their mentors; 11.8% expected that their mentors would reveal their personal potential and how to use it for business expansion. The mentees relatively rarely chose the reply option "Sufficiency of current assets" and "Use of technologies at work" (2%).

TABLE 3. ASSISTANCE IN SOLVING THE MOST ESSENTIAL PROBLEMS THANKS TO COOPERATION WITH MENTORS (N=19), (RESPONDENTS COULD CHOOSE SEVERAL REPLY OPTIONS)

Problem solutions [a]	Replies		Occurrence frequency, %
	Number	% of total	
New contacts and cooperation partners	11	21.6	57.9
Attraction of investments, funds for the enterprise	9	17.6	47.4
Problems related to sales, demand for goods and services	6	11.8	31.6
Sufficiency of current assets	2	3.9	10.5
Personnel	3	5.9	15.8
Use of technologies at work	1	2.0	5.3
Imports/ exports	3	5.9	15.8
Promotion of career growth	1	2.0	5.3
Build-up of knowledge of entrepreneurship	5	9.8	26.3
Revelation of personal potential and effective use of the potential in business expansion	6	11.8	31.6
Others	4	7.8	21.1
Total:	**51**	**100.0**	**268.4**

[a] Dichotomy group tabulated at value 1

Source: authors' calculations

L.Straujuma has pointed out that the professional quality of labour and enterprise productivity represent the key challenges to further economic growth in Latgale region. The quality of labour does not meet labour market requirements [20]. Reports on emigration give the same evidence – the most educated residents emigrate from Latgale region [21]. In this regard, a special attention has to be paid to a survey that revealed that the respondents did not consider labour and personnel problems to be important or urgent. Only 5.9% respondents believed it was a problem in Rezekne municipality. The authors explain it by a lack of experience in new entrepreneurs and the fact that 72.7% respondents represented small enterprises with employees ranging from 0 to 5.

To build up trust, a mentor has to demonstrate openness, honesty and frankness. Openness creates confidence and trust. However, mentoring is a two-way communication process whereby both sides benefit; therefore, potential mentors were asked a question – "What traits do you expect from/consider important in a mentee?" (Table 4).

TABLE 4. TRAITS MENTORS EXPECT FROM /CONSIDER IMPORTANT IN MENTEES (N=11), (RESPONDENTS COULD CHOOSE SEVERAL REPLY OPTIONS)

Traits [a]	Replies		Occurrence frequency, %
	Number	% of total	
Openness, friendliness, readiness to cooperate	8	25.8	72.7
Mentees share their thoughts and feelings	4	12.9	36.4
Mentees reveal their personalities and roles in their enterprises to their mentors	4	12.9	36.4
Mentees are able to assume responsibility for their training and cooperation	2	6.5	18.2
Mentees give feedback to their mentors on the activities done and the effects	5	16.1	45.5
Mentees are able to accept and use the challenges that have emerged during mentoring for their growth	5	16.1	45.5
Others	3	9.7	27.3
Total:	31	100.0	281.8

[a] Dichotomy group tabulated at value 1

Source: authors' calculations

Of the respondents, 25.8% considered "Openness, friendliness, readiness to cooperate" to be the most important trait of mentees. It was followed by "Mentees share their thoughts and feelings" and "Mentees reveal their personalities and roles in their enterprises to their mentors". The replies are consistent with what mentoring theory states – the role of mentors does not involve tackling mentees' problems instead of them. Mentors have to hear and listen and help mentees to find answers to problems themselves. This is a serious problem for mentors themselves.

The authors have found that mentoring in entrepreneurship in Rezekne municipality could contribute to the development of less-experienced enterprises. Mutual communication between potential mentors and mentees could avoid a lack of information and advice for the mentees and sharing experience could contribute to their initiative. Accordingly, it is necessary to continue the research begun by the authors, identifying and creating a database of potential mentors and mentees in the other municipalities of Latgale region who are

ready to engage in the business mentor network.

IV. Conclusions

Mentoring is a knowledge transfer process implemented by experienced mentors and mentees. Mentoring in entrepreneurship is based on the mentor's knowledge and experience, which allows the mentee to assess the opportunities and resources being at his/her disposable and use them to solve some particular problem or achieve a goal.

Mentoring is one of the most effective ways how to contribute to the number of new businesses and economic growth. Overall, entrepreneurship expands and develops if experienced entrepreneurs give guidance to beginners in entrepreneurship. Mentoring positively affects the national economy, as new enterprises are founded, unemployment declines and the competitiveness of enterprises increases.

The survey of entrepreneurs (mentors) done within the present research revealed that the potential mentors rated a mentor's knowledge of relevant business legislation and how to enter a new market and attract a new cooperation partner as "important" and "very important".

An assessment of the problems the mentees would like to solve with the help of their mentors highlighted the overall problems of the entrepreneurial environment in Latgale region. The mentees wished to make new contacts, acquire new cooperation partners and attract investments and funds with the help of their mentors as well as expected that their mentors would help them to reveal their personal potential and how to effectively use it in entrepreneurship. The key traits needed by mentees, the potential mentors referred to, confirmed the theoretical principles of mentoring – mentors have to hear and listen and to help their mentees to find answers to problems themselves.

Mentoring in entrepreneurship in Rezekne municipality could contribute to the development of less-experienced enterprises. Accordingly, it is necessary to continue the research begun by the authors, identifying and creating a database of potential mentors and mentees in the other municipalities of Latgale region who can and are ready to engage in the business mentor network.

The paper was produced with the financial support of Rezekne Academy of Technologies from the research grant "Mentoring Opportunities for Entrepreneurship Development in Rezekne Municipality".

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Environment. Technology. Resources. Rezekne, Latvia
Proceedings of the 12th International Scientific and Practical Conference. Volume I, 364-371

The Effect of Microeconomic Factors on Business Models in Fintech Industry

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***Abstract*—The variety of financial technology (FinTech) companies and their activities poses heterogeneity in the business models of them. Not only the business environment has been changing rapidly, the financial services sector influences and triggers changes as well. And it is hard to determine whether and which changes influence the business model disruptively and which evolutionary. To enable management decision making easier, methodology for identification of possible microeconomic risks and their influence on the current activity and the whole business model of the company has to be shaped accordingly. The aim of this research is to find out what and how microeconomic factors affect business modelling of the FinTech companies. In this research the authors used a continuous comparative analysis method as well as content analysis method [1]. In interviews, experts were asked to assess the significance of specific microeconomic factors by using the Likert's scale. As a result of the research, the difference of the influence as well as their dependencies and modifications on business modelling was determined. This result forms the basis for conclusions about the most important microeconomic impact factors, the areas of their influence and possible consequences that affect business modelling of the FinTech company.**

***Keywords*—business model, impact factor, microeconomic, FinTech.**

I. INTRODUCTION

Global investment in financial technology (FinTech) ventures tripled to $8 billion in 2018 [2] and clearly signify that the digital revolution has arrived in the financial services sector. The established financial services players are starting to take bold steps to engage with emerging innovations [3]. Young companies exploit new technology and this enables them to be global without having big assets. They can develop very fast by buying in services as and when they need them [4]. In just a few short years, Fintech companies have defined the direction, shape, and pace of change across almost every financial services subsector. Customers now expect seamless digital onboarding, rapid loan approvals, and free person-to-person payments—all innovations that Fintechs' made popular. And while they may not dominate the industry today, Fintechs' have succeeded as both standalone businesses and vital links in the financial services value chain [5]. Fintech is primed to have an impact. There are pockets of efficiency that could significantly move the needle in mainstream banking. Data, Security, Analytics, and Regulation are the four key areas of action [6]. Thanks to modelling, a clear picture of processes and relationships in the modelled area can be obtained, and the information can be used to maintain a stable position on the market, to increase the competitiveness of a company, or to reduce competition risks [7]. Business model is an excellent tool which entrepreneurs can use in order to adapt their activities to new market challenges, predict the consequences as well as improve their management for risks that the influence factors cause. Awareness and assessment of the factors makes it possible to timely develop alternative scenarios and diverse approaches. New technologies create new models of interaction. These models did not exist earlier because its economics doesn't fit or there are no technological possibilities [8]. These approaches are based on the analysis of potential scenarios of positive or negative actions, which in the near or distant future may work well in practice. In the literature [9], the possibility of using them is indicated in supporting the implementation of such management methods and tools as the assessment of the product life cycle, the analysis of market scenarios, the analysis of the marketing mix etc. [10]. But what factors are influencing Fintech themselves? What risks a FinTech company has to be prepared for to manage and mitigate? Which of them must be qualitatively and timely managed to ensure the sustainability of the business model? Which of them effect the business model disruptively and which provides the company new opportunities? The influencing factors have been discussed as part of the literature review has different influence on company's willingness to innovate its business model. Some of them act as drivers and stimulate companies to be more innovative, and others hinder innovation capabilities and consequently act as barriers [7].

The aim of this research is to find out what and how microeconomic factors affect business modelling of the FinTech companies.

In this research authors used a continuous comparative analysis method, sing open coding, level 2 coding, axial coding and content analysis method with inductive and deductive approach as well as content analysis method [2].

To achieve the goal the authors interviewed the

Print ISSN 1691-5402
Online ISSN 2256-070X
http://dx.doi.org/10.17770/etr2019vol1.4125

representatives of different FinTech companies. In these interviews, experts were asked to describe the most significant microeconomic risks focused on the company's business modelling and to assess the importance of them for each business model dimension by using the Likert's scale as well as to explain the dependencies and the consequences of their influence on different business model areas.

As a result of the research, these risks were arranged by the level of importance based on the expert's assessment. This aspect points out what risks must be paid particularly attention to by modelling business in Fintech; the difference of their influence and dependencies was determined. This aspect indicates possible consequences of the impact on FinTech company's business model and shows the week areas of business model dimensions which should be analysed appropriately while business modelling in order to timely manage them while implementing and working on international markets;

The result of this research forms the basis for conclusions about the most significant microeconomic risks and their impact on dimensions of an business model as well as makes recommendations possible for those FinTech-enthusiasts who are going to model their FinTech business internationally.

The tasks of the research are: to study the theoretical aspects of the concept of a business model; to define the most common microeconomic impact factors for each business model dimension that are crucial for modelling of an internationally operating FinTech business and determine those business model dimensions which are affected by the microeconomic impact factors the most, or rather, have to be taken into account by modelling business of a FinTech company.

Various methods were used in the research: the theoretical part consists of the scientific literature analysis. Semi-structured interviews with 3 FinTech experts (OC, MR, PB), representing the FinTech industry (E-Money Institution (EMI)) of Malta (OC), short-term lending company (PLK) of Russia (MR) and Payment Institution of Great Britain (PB), were conducted during the course of the research. The research data was processed by continuous comparative analysis, using open coding, level 2 coding, axial coding and content analysis method with inductive and deductive approach [2].

In interviews, experts were asked to describe the most significant risks focused on the company's cross-border activity and to assess the importance of them for each business model dimension by using the Likert's scale with points 15, where 1 – irrelevant; 2 – unimportant; 3 – moderate; 4 – important; 5 – very important. as well as to explain the dependencies and consequences of their influence on different business model areas.

The data is presented in the form of a diagram. The choice of experts was based on the diversity of their expertise (OC – 10 years, PB – 20 years, MR – 4 years). The companies represented by experts are completely different and unrelated to each other.

II. MATERIALS AND METHODS

Until now there is no consistent theoretical approach to the concept of a business model in the literature: it can be concluded that a business model is a logical and contemplated interplay of company's decisions, business activities and participants, which describes the place, the time and the reason of business [11]; the benefits for customers and partners [12]; the ways in which customers and partners benefit [13]; the mechanism of service creation and participants in its provision [14]; the way in which the benefit translates into profit [13]; profit reallocation way [15] and the involvement and placement of technologies to create company value and promote the operational efficiency of the company [16].

Entrepreneurship in FinTech branch starts with the launch of a new start-up and with the idea of like-minded people, pursuing the purpose to provide services that customers have never received from banks. This means that FinTech has certain *startup* characteristics: *"... innovative nature of the product or service; ... established by a team of multiple members; ... a common tendency to create business logic that nobody has ever had ... because everything is being neglected"* [17]. A business model is at the core of any successful *startup*, because no matter how good or unique an idea may seem, "*a startup must have a viable way of making money that is worthy enough for future investment and to sustain itself"* [18]. Questions like *"What business model works best with my idea?"* or *"How do I know if my startup is using the right model?"* are a few questions founders need to consider which will ultimately impact the overall success of their venture in the long run. *"The business model needs to tie to the consumer pain point and work better than the competition's"* [18].The content of the business model and its robustness are the success and failure of business in the company.

The concept "FinTech" has emerged relatively recently and expresses its essence, including "*... the provision of financial services through intensive use of the latest technology*" (Jhoon, 2015; Song, 2015; Shim and Shin, 2016). FinTech companies operate in the financial sector alongside banks and offer their customers payments, money transfers in electronic and virtual currency. These companies are recognizable as fast lenders or peer-to-peer platforms, in which clients manage their money as well as borrow and lend it to each other. Those are securities market consultants that compete with banks by offering a high consulting level through robots. FinTech companies are not only those who offer products or services but also those who develop them.

Beyond the responsibility for building properly business models, creating functional strategies and faultless business processes, managers have to integrate, blend and skilfully present them. It is possible to better understand the thinking of business partners and their mutual fit by mapping their thoughts. A mind map can help easily transform unrelated data on the company into useful information and knowledge. Using it in the process of constructing business models it provides the possibility

of presenting them in an attractive and interesting way, which facilitates effective communication [4].

III. RESULTS AND DISCUSSION

Four microeconomic factors - Supply and Demand, Labour, Production and Costs, Competition - were considered in this study as microeconomic impact factors that could play a significant role in the creation of an internationally operating business model of a FinTech company. Questions that were asked to the experts during semi structured interviews were based on these microeconomic factors. During the interviews, the authors managed to create thematic subcategories for which additional questions were asked, as well as an expert evaluation.

From all the Figures which can be seen below (Fig.1,2,3,4) it is possible to conclude that all of the examined microeconomic factors significantly influence the value creation dimension in the business model and that the value chain transforms inputs into products and services. "*The customer is the recipient of the product, which is the value created by the company's transformation process*" (Ramirez, 1999). The second most important dimension of the business model, subjected to factor influence, is the customer dimension.

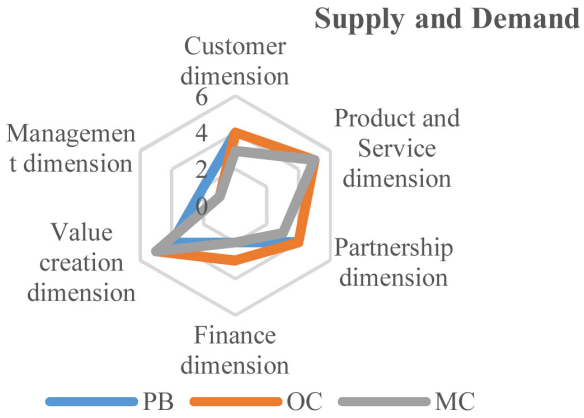

Fig. 1. Influence of Supply and Demand on business model dimensions

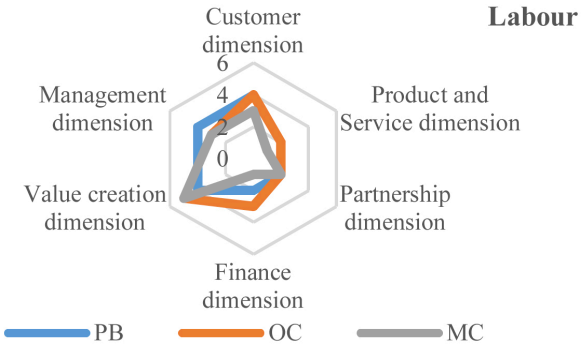

Fig. 2. Influence of Labour on business model dimensions

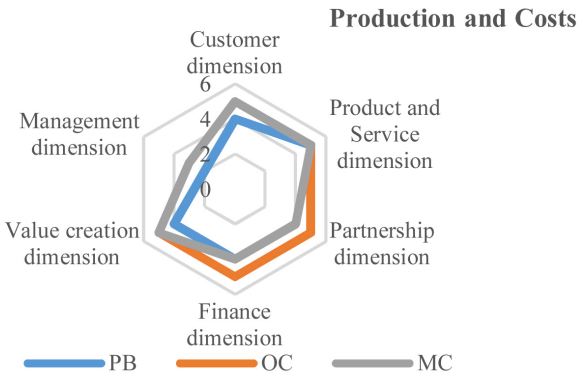

Fig. 3. Influence of Production and Costs on business model dimensions

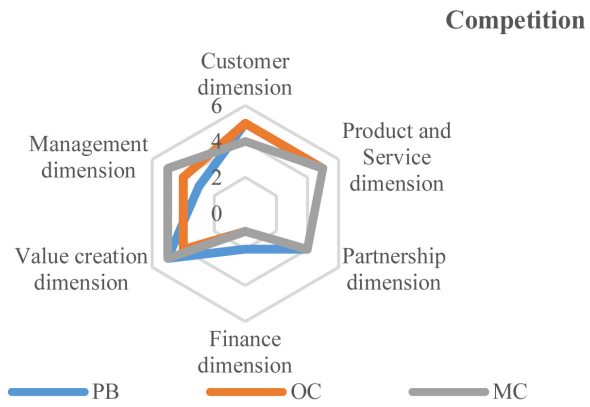

Fig. 4. Influence of Competition on business model dimensions

When developing a business model for an internationally operating FinTech company, the company must take into account that "*each market will have its own customer segment for which services will be offered*" (Interview with MR, 15.02.2019.). "*The range of customer segments*" in the market also shows "*the range of communication tools needed*" as well as "*the choice of collaboration partners*" (Interview with PB, 13.02.2019.). Based on the information provided by the experts, the company must also adapt its products and services as well as the service on each market separately. This means that a standardized and unified approach is not considered feasible. This fact also affects the financial performance of each market. The labour resources of each individual market are one of the marked aspects from the experts' point of view. The labour market "*influences the choice and qualifications of the company's employees*" as well as "*the peculiarities of culture and language*" (Interview with OC, 11.02.2019.). For example, OC emphasizes that, despite the proliferation of English, an internationally operating FinTech company must be ready to work in the local market language too "*because 'it is impossible to attract the necessary programmers in English on the Serbian market*" (OC). It also points at the need to adapt communication both within the company and to customers in the new market. The development of products and services and the associated costs also have a

significant impact on the customer dimension. "*If we can save on the technologies we use in all markets, we spend on labour recruitment for each market individually*" (OC) The variety of sales channels, which is formed in the business model of an internationally oriented company, also means "*additional expenses for maintaining the partnerships*" (Interview with PB, 13.02.2019.). In the value creation dimension, the impact of microeconomic factors is the most significant in the authors' view. The experts appreciate this aspect the most because FinTech's basic advantage is not "*the financial services they provide, but the service, speed, convenience and customer comfort through these services*" (Interview with OC, 11.02.2019.). Assuming that the business model generally reflects the way in which a company creates value, the dimension of value creation could be seen as a measure of the viability and sustainability of the business model. "*The twenty-first century value creation is dominated by companies that provide global networking services of various types*" (Interview with MR, 15.02.2019.).

To assess the impact of microeconomic factors on the business model's customer dimension, the authors originally asked the experts about the factors that companies must take into account while modelling their business and which affect the company's activities during the business modelling phase as well as the company's lifetime. Based on the information provided by the experts during the interviews, the authors succeeded in creating thematic categories of the most frequently mentioned microeconomic factors (Fig. 5, 6). The authors also asked the experts to evaluate these categories on Likert's scale to determine their significance and impact on each dimension of the business model. Evaluating the information provided by the experts and the frequency of words used in experts' answers, the authors were able to create a second level of thematic categories derived from the first ones. Using propitious situation and opportunity to repeat the interview with experts, the authors asked to evaluate these factors as well.

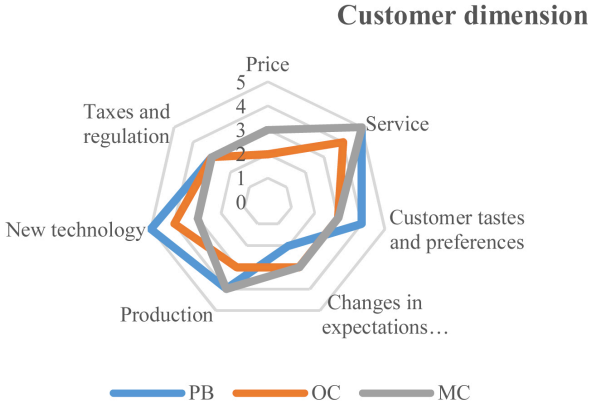

Fig. 5. Influence of microeconomic factors on customer dimension

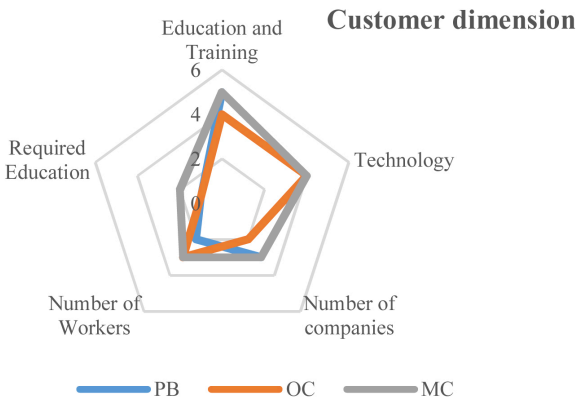

Fig. 6. Influence of microeconomic factors on customer dimension

As is evident, the most commonly discussed and analysed microeconomic factors that FinTech companies have to face when modelling their businesses are service, new technologies and a bit less pronounced – production aspect. Experts expressed unanimous opinion that the main focus of FinTech companies is "*concentrated on solution*" (Interview with MR, 15.02.2019.) that they offer their customers, "*on service*" (Interview with PB, 13.02.2019.) with which this solution is augmented and "*on technologies*" (Interview with PB, 13.02.2019.) that facilitate the provision of the service, "*speed and convenience*" (Interview with OC, 11.02.2019.) of using this service. By modelling business in the customer dimension and defining the customer segment itself, the most important factor, according to experts, is the level of service which is "*mostly the only difference from other competitors with similar solutions*" (Interview with PB, 13.02.2019.). "*Differences can be achieved with the quality of delivered service and service delivery speed, based on technologies*" (Interview with OC, 11.02.2019.). Technology is a major enabler because the company can build global delivery at scale, whilst also offering relevant data and higher delivery quality. "*Financial services are not tangible, they are bought by customers considering the emotional aspect*" (Interview with OC, 11.02.2019.) and only while customers are using them "*they get a sense of service quality and correspondence with the price*" (Interview with PB, 13.02.2019.). Relative on this, experts believe that the high level of the price does not affect the customer dimension negatively when the customer needs are satisfied and expectations fulfilled. When a company is working in a particular market niche, it has to consider and analyse "*the preferences of this segment*" (Interview with MR, 15.02.2019.), as "*this is the only way to meet specific needs*" (Interview with PB, 13.02.2019.). As for changes in customer expectations, experts believe that they are made by companies themselves, "*accustoming clients the convenience of their services*" (Interview with MR, 15.02.2019.). It is a kind of interaction with a client who "*has to have a tendency to be positively developed while using the current service from customer*" (Interview with OC, 11.02.2019.). "*If the company actively appeals to the customer and sees him as a value determinant and quality assessor, constantly ensuring positively feedback regarding the service and quality, it obtains the most valuable information for improving, changing and optimizing its service*" (Interview with MR, 15.02.2019.).

Experts attach great importance to training and

qualification of staff. However, the authors found that the experts did not evaluate the education of the employees as essential. This can be explained by the fact that the qualification provided by the company must be focused on the special aspects and profile of the FinTech industry. This "*can only be obtained by exchanging information with partners, participating in conferences and workshops with industry representatives*" (Interview with PB, 13.02.2019.). This indicates that there is also great potential in the field of education for the development of new education programs. Similar factors and their impact on business model can also be seen in the product and service dimension (Fig. 7, 8) where the employee training is assessed as very important as well. However, with regard to the required education, the opinions of experts differ. These differences can be explained by the fact that FinTech also employs financial specialists and analysts who are required to have the necessary education and whose job responsibilities are slightly different from those of other companies. With regard to the number of companies as an impact factor, experts consider it to be of moderate importance. According to OC, "*market participants always differ from each other and try to create a supply for certain customer needs*" (Interview with OC, 11.02.2019.). On the other hand, PB notes that "*the big number of competitors has a positive influence on stimulating demand and cooperation between competitors and on creating a new service as a symbiosis and innovation in the market*" (Interview with PB, 13.02.2019.).

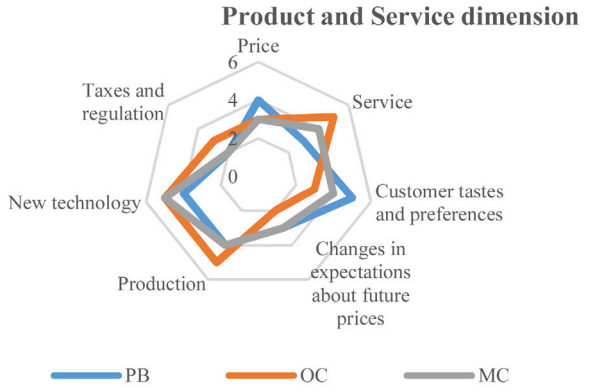

Fig. 7. Influence of microeconomic factors on Product and Service dimension

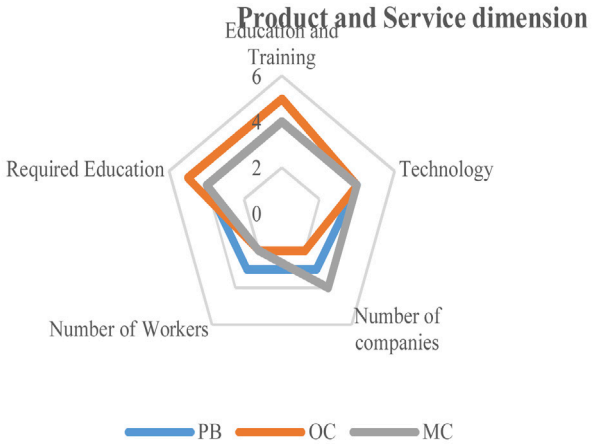

Fig. 8. Influence of microeconomic factors on Product and Service dimension

In terms of offered products and services, experts distinguished the great importance of the technologies used within the company. However, technology development in the company was assessed differently. MR believes that when it comes to development of a technological solution, the company tries to create a unique and unprecedented solution that includes both service features and competitive advantages. OC, in turn, believes that technology needs to be borrowed from competitors or co-operation partners, as it is possible to balance the financial aspect of the business model and the uniqueness is the service that complements this solution. With regard to customer tastes and expectations about the produced products and services, experts believe that this aspect is not a problem for FinTech companies, and the potential for customer expectations regarding technological financial solutions is still not exhausted, because the largest competitors of FinTech companies are banks where this aspect is not taken into account almost at all.

Speaking about the next business model dimension – the partnership dimension (Fig. 9, 10), experts unanimously pointed the importance of the number of similar companies in the market. OC expressed the view that "*there are still too little companies on the market and the choice of partners is difficult*" (Interview with OC, 11.02.2019.). "*There is nothing to choose from when it comes to something specific*". "*Those who are in the market offer the price that should be used*" (Interview with OC, 11.02.2019.). MR also noted the lack of cooperation partners working in the Kazakh market. "*It also has a negative impact on the quality of provided services*" (Interview with MR, 15.02.2019.).

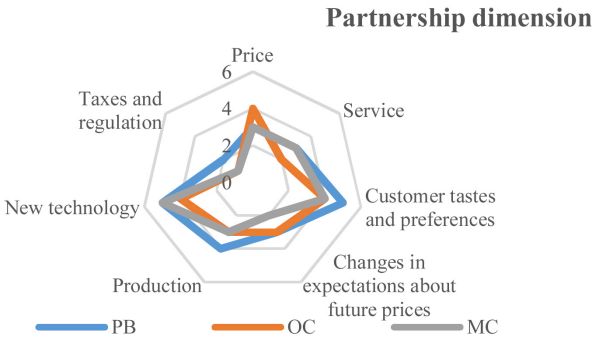

Fig. 9. Influence of microeconomic factors on partnership dimension

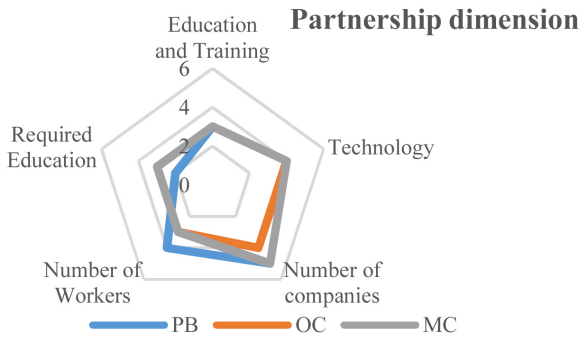

Fig. 10. Influence of microeconomic factors on partnership dimension

If a business model is set up to work in different markets, the company must be aware that the way to reach customers will be different in each market. The size of the market is also very important because it determines both the quantity and the habits of both consumers and competitors. Each market also determines the variety of partners that will be used to deliver the product to the end customer. "*With each new market, new sales channels also appear and the bid price changes*" (Interview with PB, 13.02.2019.). In order to remain competitive, it is also necessary "*to provide for a lower bid that will be presented for each stage of the service*" (Interview with PB, 13.02.2019.). It has to be understood that "*the cost of running a business with partners will always be lower in sales and marketing costs than working and maintaining direct relationships with the customer*" (Interview with MR, 15.02.2019.). From this point it can be concluded that lower price does not necessarily mean lower profit for the company.

No thematically categorized microeconomic factor that was created by the authors and based on the texts provided from the experts was given a particularly great impact on the partner dimension. Working on new products or improving existing ones or customizing customer needs - the choice of partners is crucial but "*the company always has the opportunity to seek for solutions around the world*" (Interview with OC, 11.02.2019.). Working in a market where the choice of partners is still poor "*partnership prices are more meaningful*" (Interview with PB, 13.02.2019.). According to OC, "the price at which a partnership is possible is inflexible" (Interview with OC, 11.02.2019.).

After evaluating expert opinions about the financial dimension of the business model, the authors can conclude that all the microeconomic factors that were considered and evaluated during the interviews have a significant impact on the financial aspect (Fig. 11, 12).

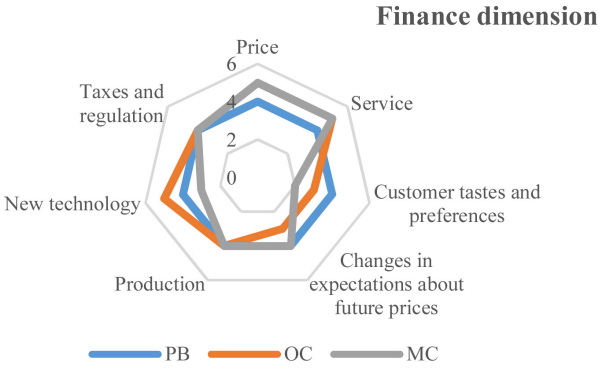

Fig. 11. Influence of microeconomic factors on finance dimension

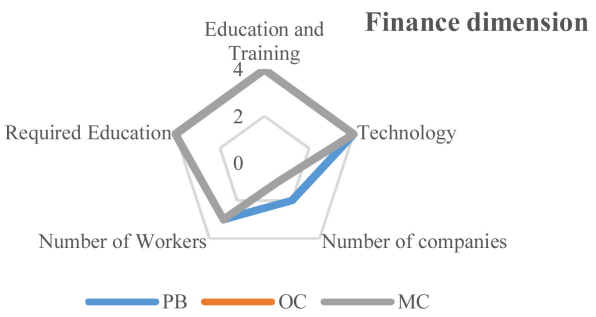

Fig. 12. Influence of microeconomic factors on finance dimension

In terms of financial resources, the company must anticipate both sales-related expenses when entering new markets and the overall market acquisition budget. It is not possible to clone a business model to each country completely. "*The needs and expectations of customers in financial services are those that differ from one market to another*" (Interview with MR, 15.02.2019.). They determine both the communication channels through which the customer has to be attracted and the sales tools that the customer is used to in the relevant market, as well as the culture of technology use in each market. For example, MR notes that "*Kazakhstan does not need very high technology to achieve significant results, as customers are not used to using it in the financial industry*" (Interview with MR, 15.02.2019.) and, subsequently, they have to be brought to them. For the technology used by the company in order to manage information and customer knowledge, the situation looks very different. "*We can surprise our customers with the very fast delivery of customer services"* (Interview with OC, 11.02.2019.).

Product value offer can meet the needs of consumers at a given moment. If the market is exhausted, "*it is possible to offer another product value by changing the product slightly or finding another application*" (Interview with PB, 13.02.2019.). While thinking about the value creation and the value of a product, it is necessary to understand what resources it requires, what distribution channels will be useful, how the relationship with the customers will be provided, what the product will be (Fig. 13, 14). If the entrepreneur is lucky and has a lot of resources, then all the ideas can be realized, but in times "*when the entrepreneur is limited in resources, he has to think how to achieve the best result in such situation. At this time, creative thinking and other views are often helpful*"

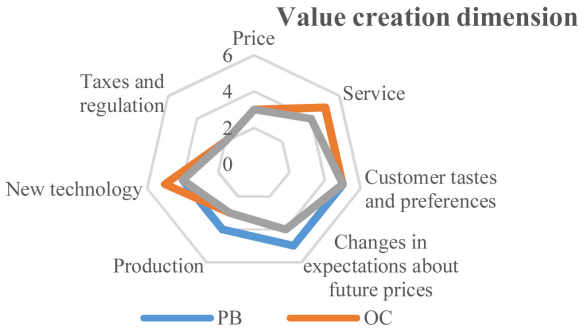

Fig. 13. Influence of microeconomic factors on finance dimension

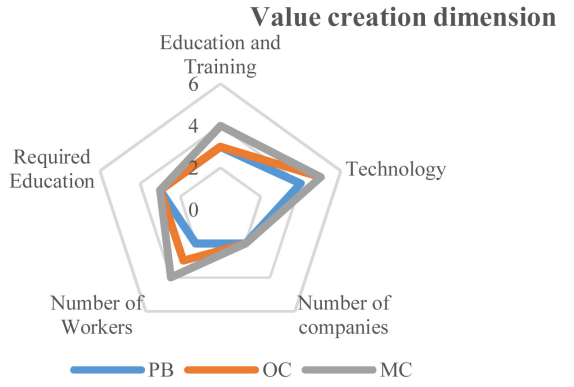

Fig. 14. Influence of microeconomic factors on finance dimension

"*Our greatest value in the company is the customer's desire to use our service even more and to recommend us as a service provider to other potential customers*" (Interview with OC, 11.02.2019.). "*By using the right technology tailored to the needs of the company and customer requirements, the company can deliver targeted activity in its market segment*" (Interview with MR, 15.02.2019.). In order to assess what technology is needed for a company, the "*strategic and future-oriented assessment of market potential of a company is crucial*" (Interview with PB, 13.02.2019.), as changes can occur in the market during the introduction of new technology in the company, which "*makes this technology invalid on a particular demand*" (Interview with MR, 15.02.2019.). Experts emphasize the importance of technology and the role of cooperation partners on the market, precisely in the dimension of value creation. This fact indicates that if a company wants to be successful in the long term, it needs to work with other market players. This is necessary to create service innovations, to exploit existing technologies in the marketplace and to jointly predict the market potential that still exists.

The above mentioned is closely related to the management of the company, which "*influences the success of the business model with its quality*" (Interview with PB, 13.02.2019.). Any wrong decision can negatively affect the success and sustainability of the business model in the market. The most important management role, according to experts, is "*the strategic vision of the future and the ability to retain employees in the company*" (Interview with OC, 11.02.2019.). Employees can be held by involving them in the decision-making process (Fig. 15, 16).

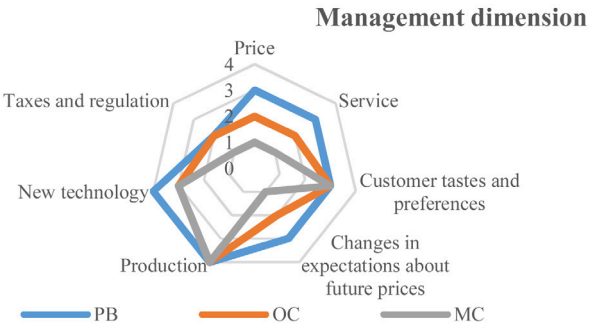

Fig. 15. Influence of microeconomic factors on Management dimension

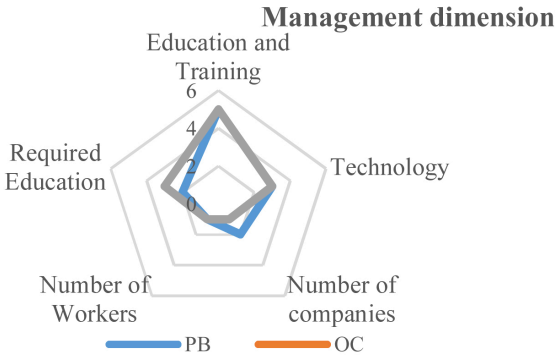

Fig. 16. Influence of microeconomic factors on Management dimension

IV. CONCLUSIONS

All of the examined microeconomic factors significantly influence the value dimension in the business model, because the value chain transforms inputs into products and services. Assuming that the business model generally reflects the way in which a company creates value, the value dimension could be seen as a measure of the viability and sustainability of the business model.

The company must also adapt its products and services as well as the service on each market separately. This means that a standardized and unified approach is not considered feasible. This fact also affects the financial performance of each market.

The labour resources of each individual market are one of the marked aspects. The labour market influences the choice and qualifications of the company's employees as well as the peculiarities of culture and language. Despite the proliferation of English, an internationally operating FinTech company must be ready to work in the local market language too. It also points at the need to adapt communication both within the company and to customers in the new market.

Technology is a major enabler because the company can build global delivery at scale, whilst also offering relevant data and higher delivery quality. Financial services are not tangible, they are bought by customers considering the emotional aspect and only while customers are using them "they get a sense of service quality and correspondence with the price.

The qualification provided by the company must be focused on the special aspects and profile of the FinTech industry. This can be obtained by exchanging information with partners, participating in conferences and workshops with industry representatives. This indicates that there is also great potential in the field of education for the development of new education programs.

If a business model is set up to work in different markets, the company must be aware that the way to reach customers will be different in each market. The size of the market is also very important because it determines both the quantity and the habits of both consumers and competitors. Each market also determines the variety of partners that will be used to deliver the product to the end customer. It has to be understood that the cost of running a business with partners will always be lower in sales and marketing costs than working and maintaining direct

relationships with the customer. From this point it can be concluded that lower price does not necessarily mean lower profit for the company.

Working on new products or improving existing ones or customizing customer needs - the choice of partners is crucial but the company always has the opportunity to seek for solutions around the world. Working in a market where the choice of partners is still poor partnership prices are more meaningful. This fact also affects the financial performance of each market. The price at which a partnership is possible is inflexible.

In terms of financial resources, the company must anticipate both sales-related expenses when entering new markets and the overall market acquisition budget. It is not possible to clone a business model to each country completely. The needs and expectations of customers in financial services are those that differ from one market to another. They determine both the communication channels through which the customer has to be attracted and the sales tools that the customer is used to in the relevant market, as well as the culture of technology use in each market.

By using the right technology tailored to the needs of the company and customer requirements, the company can deliver targeted activity in its market segment. In order to assess what technology is needed for a company, the strategic and future-oriented assessment of market potential of a company is crucial, as changes can occur in the market during the introduction of new technology in the company, which makes this technology invalid on a particular demand.

Experts emphasize the importance of technology and the role of cooperation partners on the market, precisely in the dimension of value creation. This fact indicates that if a company wants to be successful in the long term, it needs to work with other market players.

Management of the company influences the success of the business model with its quality. Any wrong decision can negatively affect the success and sustainability of the business model in the market.

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