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I

ENVIRONMENT AND RESOURCES

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Regional Cooperation in Dealing with Environmental Protection. E-government and Sustainable Development in Andean Countries

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Abstract. E-government for Sustainable Development is one of international cooperation strategy in dealing with environmental protection and ecological problems through enhanced citizen participation, better access and quality of services in order to achieve Green Governments. In this context, some countries are supported by international assistance to achieve this goal with benchmarking and benchlearning approaches. This research contributes to explain the relationship between improvements in governance influences in economic, social and environmental development and how such regional cooperation on the development of national information and communication technology (ICT) strategies and programs is related to E-government and Sustainable Development. This comparative study of Andean countries takes a Rational Neo-institutionalist perspective to look at longitudinal changes in these developing countries. Quantitative data such as E-government index is combined with qualitative information from reports and documents in order to empirically examine effects of e-government on sustainable development in these countries. The findings show that the strategies adopted by Ecuador have significantly contributed to its location within the references in progress of E-government and Sustainable Development in the region. The research suggests that E-government development has positive effects on better governance and sustainable development of Andeans countries. Advancement on E-government is not only a trait of developed countries but also serves as an enabler for sustainable development of developing countries.

Keywords: Andean countries, e-government, sustainable development.

I. INTRODUCTION

The United Nations (UN) and the World Bank (WB) conduct studies to identify countries' positioning on a wide range of characteristics, including factors such as information and communication technology, governance, economic growth, sustainable development, among others. These studies are carried out taking into account measurable factors within a comparative analysis between countries, which allows not to isolate the evaluation in a subjective and individual way and obtain results based on the region's environment in order to channel cooperation strategies among countries.

In order to maximize the acceptability of the results to the weights assigned in each study, classifications are based on criteria that are clearly understood and supported by regional realities that facilitate a comparative measurement and identify the strategies to be included and the applicability for each of nations as good practices to follow.

E-Government comprises one of the important factors of measurement of development of a country, for this reason the UN dedicates efforts to carry out a survey of information and have an analysis that allows to see the improvements developed in each country with the purpose of generating a strengthening Cooperation between nations in order to benefit the government-citizen relationship through technology [1].

Latin America countries promote strategies of change within the public administration in order to bring the government closer to the citizenry and the efforts undoubtedly mobilize several strategic sectors of the countries such as social assistance, education, health, production, among others; Improving international standards of service to the citizen and raising the quality of life of people in accordance with

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the objectives of the so-called Sustainable Development [2].

In recent years, proposals for improvement in public management have guided the decisions of governments towards innovation within platforms for access to information and to facilitate the operation of services to citizens. Some of the meetings between representatives of the member countries of the UN, are presented with collaborative approaches with exchange of experiences that support the innovation of public management at the global level [1], [2].

E-government for Sustainable Development is one of international cooperation strategy in dealing with environmental protection and ecological problems through enhanced citizen participation, better access and quality of services in order to achieve Green Governments [3], [4], [5]. Governments are finding new ways to effectively create public value through innovative, effective, inclusive, collaborative, open and citizen oriented service delivery and public policy decision-making leveraging the potential of modern technologies such as: i) Social Sustainability for example the Cyber Agriculture Wiki of Department of Agriculture in Sri Lanka [6]. Other initiatives are: E-education, E-health services, Security, Transportation, Community planning, Inclusive social safety nets, Services to vulnerable groups, Welfare networks, Youth engagement, and Silver innovation. ii) Economic Sustainability for example the Gov.uk of Government Digital Service in United Kingdom [7]. Other initiatives are: Online integrated business registration, Easy property registration systems, Open data licensed for commercial use, Easy tax payment systems, Innovative agricultural programmers, and Employment opportunities portals. iii) Environmental Sustainability for example the Eco Mileage Program of Seoul Metropolitan Government [8]. Other initiatives are: My Environment, Citizen-participating, Greenhouse emissions, Monitor energy, water consumption for savings, Green procurement, Disaster management.

Concerning the enhancement of the quality of governmental system services globally leads people increasingly have greater decision-making and spaces where experiences are disclosed and based on the services or products received and not only in reference to the private sector [9]. This has required the restructuring of the governmental apparatus and with it also the implementation of reforms in public administration and the introduction of an evaluation scheme of management associated with sustainable development in most countries worldwide [10].

The experience of the implementation of e-government in many developed countries, for instance, in Korea, United Kingdom, Denmark, France, Sweden, among other, show that many of the strategies implemented by these countries are acceptable and can be an example to follow for other nations in order to strengthen the sustainable development of the population [11], [12].

E-government Development Index (EGDI) established by the United Nations, is a reference of measurement that evaluates the attempts that member countries do in their objective to transform and revitalize public management leading results towards greater efficiency, transparency and accountability [13], [14].

Latin-American countries are experiencing stages of transformation product of series of strategies for improving EGDI showing that there is a trend in the region to improve the quality of public administration and the adoption of e-government in the institutional framework of the State [15].

Related to the Andean countries economic (GDP per capita) and environmental (CO2 emissions) situation, the official figures [16] indicate that Colombia, Ecuador and Peru show a similar trend, and the three almost reach the world average of the GDP per capita (13,679 USD-PPP constant 2011 international) in the studied period. In regard to the emissions these three countries also are under the world average (0.36 kg per 2011 PPP USD of GDP). At the time, as is known, Venezuela's enormous wealth of natural resources (petroleum) makes it one of the major economies in the region, with a GDP per capita higher than the world average (16,953 USD-PPP constant 2011 international), but also this country has the highest emission value of the region (0,37 kg per 2011 PPP USD of GDP) and, finally, Bolivia, which has been historically the least developed country in the region, has a GDP per capita of 5,665 USD-PPP constant 2011 international, which is less than half of the world average value and the second higher emission value of the region (0,30 kg per 2011 PPP USD of GDP) [17].

This work tries to analyze how e-government is developed in the Andean countries and its impacts over sustainable development in these countries. The studied period is from 2008 to 2015 taking into account the factor of measurement used by the UN EGDI and social, economic and environmental WB indicator.

II. MATERIALS AND METHODS

The first stage of this study includes a review of articles and a research conducted in areas of e-government international organizations like the United Nations Economic Commission for Latin America and the Caribbean (ECLAC), studies about the Organization of American States (OAS) and various publications concerning e-government in the Andeans countries in order to arrive at a better understanding of the economic and social conditions of these countries as well as their environment impacts. The basis of the study documents corresponds to the biennial reports published by UNDESA [13]. United Nations E-Government

Survey 2010 [18], United Nations E-Government Survey 2012 [15], Nations E-Government Survey 2014 [19] and Nations E-Government Survey 2016 [20]. In addition, a review of main Web portals and digital platforms of public institutions in the study group was made.

This study tries to investigate how the development of e-government affects the sustainable development of the Andeans Regions. Therefore, the conceptual framework is organized by the following broad aspects of development: governance (EGDI), economy (GDP per capita), society (CPIA policy and institutions for environmental sustainability and public sector management and institutions cluster average) and environment sustainability (CO2 emissions).

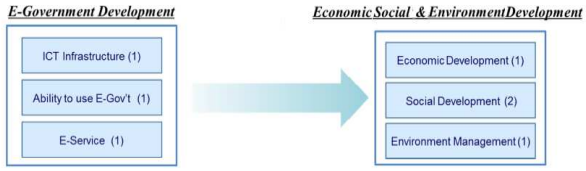

Fig. 1. Conceptual framework of E-Government Development and Economic, Social and Environmental Development

E-government impacts on national development as shown in Figure 1. First, the development of e-government has direct effects on the development of economy, society and environment management of a state.

The second stage of the study included a statistical test of significance among the effects of e-government on sustainable development of Andeans countries, the researchers conducted correlation analysis, covering the data of five countries (Bolivia, Colombia, Ecuador, Peru and Venezuela) from 2008 to 2015, corresponding to the periods 2008-2009 (P1), 2010-2011 (P2), 2012-2013 (P3) and 2014-2015 (P4).

A. Measurement of e-government development

The research approach adopts the EGDI of the UN E-Government Surveys as independent variables. According to the UN E-Government Surveys, the level of e-government development can be assessed in three areas or sub-indexes: i) Online Service (SOS), ii) ICT infrastructure (STI) and iii) Human Capital (SHC). The first component of EGDI based on the breadth of online services available on national websites such as government portals and websites of ministries for education, labor, social services, health, finance, and environment. The second component is based on the International Telecommunication Union (ITU)'s ICT Development Index (IDI). The telecommunication infrastructure factor consists of measures for internet users, main fixed-phone lines, mobile subscribers, fixed broadband subscriptions, and wireless broadband subscriptions. A personal computer index has been replaced by an index of fixed internet subscriptions for the 2012 edition of the UN E-Government Survey, and this component in turn was exchanged for an index of wireless broadband subscriptions in the UN E-Government Survey 2014. The last component is related to the ability to use e-government. Unfortunately, there is no worldwide e-awareness index that directly measures the ability to use e-government. Instead, the most of studies in this field uses adult literacy and the gross enrollment of primary, secondary, and tertiary schools as a proxy indicator in line with the UN E-Government Survey. In the UN E-Government Survey 2014, expected years of education and mean years of schooling are included in the human capital index.

B. Measurement of e-government development

Gross domestic product (GDP) per capita is used to indicate a country's level of economic development. The data is sourced from the World Bank [WB]. GDP per capita based on purchasing power parity (PPP). PPP GDP is gross domestic product converted to international dollars using purchasing power parity rates. An international dollar has the same purchasing power over GDP as the U.S. dollar has in the United States. GDP at purchaser's prices is the sum of gross value added by all resident producers in the economy plus any product taxes and minus any subsidies not included in the value of the products. It is calculated without making deductions for depreciation of fabricated assets or for depletion and degradation of natural resources. Data are in constant 2011 international dollars [WB].

C. Measurement of social development

The research approach adopts two World Bank [WB] government indicators: i) the policy and institutions for environmental sustainability rating and ii) the public-sector management and institutions cluster both bases on CPIA (Country Policy and Institutional Assessment) survey. The CPIA exercise is intended to capture the quality of a country's policies and institutional arrangements, focusing on key elements that are within the country's control, rather than on outcomes (such as economic growth rates) that are influenced by events beyond the country's control. More specifically, the CPIA measures the extent to which a country's policy and institutional framework supports sustainable growth and poverty reduction and, consequently, the effective use of development assistance. Policy and institutions for environmental sustainability assess the extent to which environmental policies foster the protection and sustainable use of natural resources and the management of pollution. The public sector management and institutions cluster includes property rights and rule-based governance, quality of budgetary and financial management, efficiency of revenue mobilization, quality of public administration, and transparency, accountability, and corruption in the public sector. By data availability

issues was used a Latin-American average on these components, except by Bolivia.

D. Measurement of environment sustainability

CO2 emissions (kg per 2011 PPP $ of GDP) is used to indicate a country's level of environmental sustainability. Carbon dioxide emissions are those stemming from the burning of fossil fuels and the manufacture of cement. They include carbon dioxide produced during consumption of solid, liquid, and gas fuels and gas flaring [WB]. This specific index is a proxy of how an Economy pollutes in order to generate a unit of GDP.

III. RESULTS AND DISCUSSION

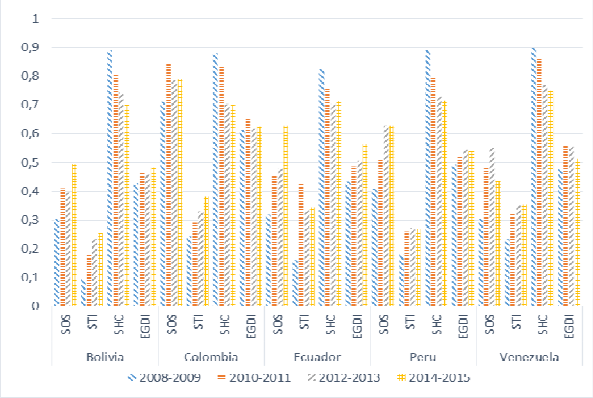

Fig. 2. EGDI evolution in Andeans Countries (2008-2015)

Colombia is the country with the highest EGDI average value in the region (0.63). However, Ecuador is that most developed with a rate grow average of 8.35% (see Fig. 2). Strategies for improving the technological infrastructure are limited by economic factor in the region, however, regarding to Online Service Colombia has been the leader in the region with the highest SOS average value (0.78), but Ecuador has presented the best improvements by the analysis period with a rate grow average of 19.72%. Ecuador has the highest STI average value in the region (0.32), but Bolivia has presented the best improvements by the analysis period with a rate grow average of 26.71%. Human Capital has been important in the implementation of e-government strategies, Venezuela has remained in the top positions in the process of evaluating this factor (0.82), note that in the entire region suffered a setback in this SHC indicator.

It is identified that the strategies adopted by Ecuador have significantly contributed to its location within the references in progress of e-government in the region, the momentum that has been given to government portals in this country has allowed a more participatory society in the development of public policy, making citizens affirm the perception of transparency and closeness of government to the citizen (see Figure 2).

Table 1.
Correlation Matrix (Pearson) for Ecuador

Variables	SOS	STI	SHC	EGDI	GDP-pc	CPIA-1	CPIA-2	CO2/USD
SOS	1	0.625	-0.841	0.998	0.915	-0.854	-0.951	-0.576
STI	0.625	1	-0.689	0.603	0.439	-0.627	-0.367	0.257
SHC	-0.841	-0.689	1	-0.865	-0.917	0.996	0.792	0.424
EGDI	0.998	0.603	-0.865	1	0.940	-0.880	-0.963	-0.608
GDP-pc	0.915	0.439	-0.917	0.940	1	-0.946	-0.958	-0.738
CPIA-1	-0.854	-0.627	0.996	-0.880	-0.946	1	0.831	0.504
CPIA-2	-0.951	-0.367	0.792	-0.963	-0.958	0.831	1	0.800
CO2/USD	-0.576	0.257	0.424	-0.608	-0.738	0.504	0.800	1

Values in bold are significantly different from 0 with a significance level alpha=0.05

Table 1 shows that Ecuadorian e-government development indices exhibit a strong correlation, whether positive or negative, with economic and social development indices as well as environment development indices. The EGDI show the highest magnitude of correlation with the economic develop indices (GDP-pc =0 .940) and negative correlation with the environmental index (CO2/USD = -0.608). The above is in concordance with the approach of E-government for Sustainable Development (see Fig. 3 and Fig. 4). Nevertheless the finding show a negative correlation between EGDI and the two social develop index that has been used. Note that EGDI is a composite index, so that, the major contribute to the dynamic above is due to SOS correlation with the correspondent indicators (GDP-pc = 0.915 and CO2/USD = -0.576).

Colombia has begun the implementation phase of technology projects focused on citizens, many of the efforts involving simplifying procedures and automation to generate concrete benefits for citizens through online services (see Figure 2).

Table 2.
Correlation Matrix (Pearson) for Colombia

Variables	SOS	STI	SHC	EGDI	GDP-pc	CPIA-1	CPIA-2	CO2/USD
SOS	**1**	0,438	-0,305	0,848	0,372	-0,544	-0,269	0,430
STI	0,438	**1**	-0,927	-0,018	**0,996**	-0,914	**-0,979**	**0,999**
SHC	-0,305	-0,927	**1**	0,234	-0,948	**0,963**	0,894	-0,943
EGDI	0,848	0,018	-0,234	**1**	0,101	-0,022	0,159	-0,040
GDP-pc	0,372	**0,996**	-0,948	-0,101	**1**	-0,917	**-0,984**	**0,998**
CPIA-1	-0,544	-0,914	**0,963**	0,022	-0,917	**1**	0,831	-0,928
CPIA-2	0,269	**0,979**	-0,894	-0,159	**0,984**	0,831	**1**	**-0,976**
CO2/USD	0,430	**0,999**	-0,943	-0,040	**0,998**	-0,928	**-0,976**	**1**

Values in bold are significantly different from 0 with a significance level alpha=0.05

Table 2 shows that although Colombia historically leads the EDGI in the region, this country has not been the highest developed in the studied period.

Therefore, the EGDI does not show significant correlation with the economic develop index (GDP-pc = -0.101) and with the environmental index (CO2 / USD = -0.004). Besides, the finding show a no correlation between EGDI and the two social develop indices that have been used. Note that there is a significant and contradictory correlation between STI and SHC with the rest of indices. The above show that in Colombia case the finding not support the approach of E-government for Sustainable Development.

Peru has a consolidated organizational structure that allows articulate directly on issues of government policy to implement e-government projects; however, the limitations of this country are generated by citizens' access to technology tools (see Table. 3).

Table 3.
Correlation Matrix (Pearson) for Peru

Variables	SOS	STI	SHC	EGDI	GDP-pc	CPIA-1	CPIA-2	CO2/USD
SOS	**1**	0,919	**-0,993**	**0,983**	**0,981**	**-0,999**	-0,860	-0,762
STI	0,919	**1**	-0,947	**-0,967**	0,872	-0,931	-0,691	-0,453
SHC	**-0,993**	-0,947	**1**	**-0,984**	**-0,982**	**0,992**	0,866	0,714
EGDI	**0,983**	**-0,967**	**-0,984**	**1**	0,938	**-0,991**	-0,767	-0,635
GDP-pc	**0,981**	0,872	**-0,982**	0,938	**1**	**-0,970**	-0,941	-0,822
CPIA-1	**-0,999**	-0,931	**-0,992**	**-0,991**	**-0,970**	**1**	0,831	0,734
CPIA-2	-0,860	-0,691	-0,866	-0,767	-0,941	-0,831	**1**	0,881
CO2/USD	-0,762	-0,453	-0,714	-0,635	-0,822	-0,734	-0,881	**1**

Values in bold are significantly different from 0 with a significance level alpha=0.05

Table 3 shows that Peru's e-government development indices exhibit a strong correlation, whether positive or negative, with economic and social development indices as well as environment development indices. The EGDI show the highest magnitude of correlation with the economic develop index (GDP-pc =0 .938) and negative correlation with the environmental index (CO2/USD = -0.635). The above is in concordance with the approach of E-government for Sustainable Development (see Fig. 3 and Fig. 4). Nevertheless the finding show a negative correlation between EGDI and the two social develop indices that has been used. Note that EGDI is a composite index, so that, the major contribute to the dynamic above is due to SOS correlation with the correspondent indicators (GDP-pc = 0.981 and CO2/USD = -0.762).

Venezuela has managed its governmental structure with regulatory mechanisms to imposing enforce implementation strategies, however, the positioning obtained within EGDI assessment is directly linked to the subscript of Human Capital (see Figure 2).

Table 4.
CORRELATION MATRIX (PEARSON) FOR VENEZUELA

Variables	SOS	STI	SHC	EGDI	GDP-pc	CPIA-1	CPIA-2	CO2/USD
SOS	**1**	0,855	-0,605	0,944	-0,874	-0,819	-0,375	0,200
STI	0,855	**1**	-0,859	0,724	**-0,968**	**-0,967**	-0,781	-0,011
SHC	-0,605	-0,859	**1**	-0,336	-0,704	-0,948	-0,929	-0,519
EGDI	0,944	0,724	-0,336	**1**	-0,825	-0,616	-0,136	0,510
GDP-pc	-0,874	**-0,968**	0,704	-0,825	**1**	-0,875	-0,644	-0,241
CPIA-1	-0,819	**-0,967**	0,948	-0,616	-0,875	**1**	-0,831	-0,250
CPIA-2	-0,375	-0,781	0,929	-0,136	-0,644	-0,831	**1**	-0,476
CO2/USD	-0,200	-0,011	-0,519	-0,510	-0,241	-0,250	-0,476	**1**

Values in bold are significantly different from 0 with a significance level alpha=0.05

Table 4 shows that although Venezuela historically leads the GDP-pc in the region, this are not related with a progress in improvement in governance, social (negative correlation) neither environmental (positive correlation) aspects of the development and its economic develop is due to Venezuela's enormous wealth of natural resources (petroleum). Besides, the finding show that SHC has high correlation with the economic and social index that has been used. The above is in concordance with the approach of E-government for Sustainable Development (see Fig. 3 and Fig. 4).

Bolivia has worked in the development of the National Governance Program (PRONAGOB), where the state is a facilitator and manager of the sectors of society work in partnership and integration in decision-making; it has not been managed by government agencies, which has led to limited progress in this regard (see Fig. 2).

Table 5.
Correlation Matrix (Pearson) for Bolivia

Variables	SOS	STI	SHC	EGDI	GDP-pc	CPIA-1	CPIA-2	CO2/USD
SOS	**1**	0,889	-0,906	**0,989**	0,915	0,914	-0,914	0,857
STI	0,889	**1**	**-0,993**	0,878	0,750	**0,964**	**-0,964**	**0,957**
SHC	-0,906	**-0,993**	**1**	-0,879	-0,814	**-0,989**	**0,989**	**-0,983**
EGDI	**0,989**	0,878	-0,879	**1**	0,851	0,869	-0,869	0,805
GDP-pc	0,915	0,750	-0,814	0,851	**1**	0,879	-0,879	0,836
CPIA-1	0,914	**0,964**	**-0,989**	0,869	0,879	**1**	**-1,000**	**0,993**
CPIA-2	-0,914	**-0,964**	**0,989**	-0,869	-0,879	**-1,000**	**1**	**-0,993**
CO2/USD	0,857	**0,957**	**-0,983**	0,805	0,836	**0,993**	**-0,993**	**1**

Values in bold are significantly different from 0 with a significance level alpha=0.05

Table 5 shows that Bolivia's e-government development indices exhibit a strong correlation, whether positive or negative, with economic and social development indices as well as environment development indices. The EGDI show the highest magnitude of correlation with the economic develop

index (GDP-pc =0 .851) and with one of the social index (CPIA-1 = 0.869). The above is in concordance with the approach of E-government for economic and social development (see Fig. 3 and Fig. 4). Nevertheless the finding show a negative correlation between EGDI and the other social develop indices and a positive correlation with the environmental index that has been used.

CORRELATION MATRIX(PEARSON):

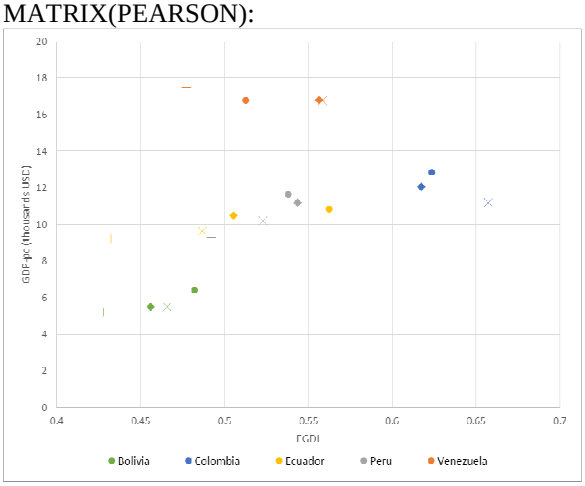

Fig. 3. Scatter plot of GDP per capita vs. EGDI (2008-2015). Scatter plot of GDP per capita vs. EGDI (2008-2015). Cross marks correspond to P1, X marks correspond to P2, diamond marks correspond to P3 and circle marks correspond to P4.

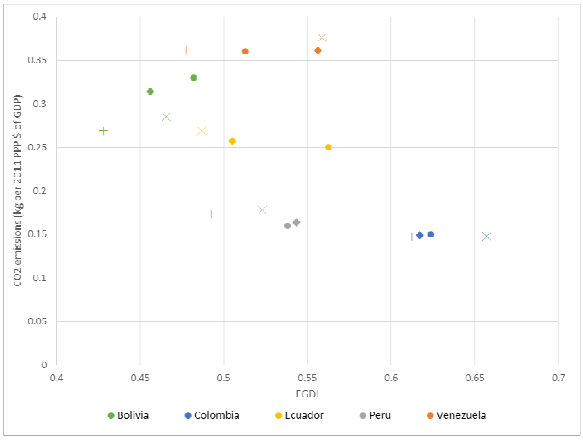

Fig. 4. Scatter plot of CO2 emissions (kg per 2011 PPP $ of GDP) vs. EGDI (2008-2015). Scatter plot of GDP per capita vs. EGDI (2008-2015). Cross marks correspond to P1, X marks correspond to P2, diamond marks correspond to P3 and circle marks correspond to P4.

IV. CONCLUSION

Taking as a reference the indicator of e-government development, EGDI proposed by UNDESA it was attempted to identify and describe the progress of the Andean countries and the strategies implemented during the period 2008-2015 as development policies of government management. The aim of this study was to analyze the relationship of EGDI with a so called Sustainable Development (social, economic and environmental). The finding shows that two countries (Ecuador and Peru) had strong correlation between an e-governance developed and sustainable develop (social, economic and environmental). However, Colombia is the country with the highest EGDI average value in the region (0.63). But, Ecuador is that most developed with a rate grow average of 8.35% on the studied period.

The biggest overall progress by the ranking provided by the EGDI evidenced by certain countries by the region is due to the development of different actions and strategies by each of the sub-indexes so that in the case of online services, Colombia, Ecuador and Peru at the end of the studied period were those that optimized the use of electronic channels for the completion of formalities including more than obtaining information and services, participation in decision-making in public policy.

The results indicate that e-government development fosters a more capable and transparent government and contribute to lead to sustainable development in terms of economic, social, and environmental development. This study also identified some key factors of successful e-government development in Andeans countries by a correlational and comparative analysis.

Among them, the results show that evidenced benefits that have been obtained in mainstreaming e-government strategy in each of the countries of this study were: i) the transformation of the obsolete administration to the efficient and transparent management; ii) Improved quality of services provided; iii) Reduction of bureaucracy and strengthening capacities of the population; iv) optimization of state resources and improving response times in the procedures required by citizen; v) a substantial improvement in terms of responsiveness and answering the needs of citizens by public institutions; vi) transparent and streamlined processes within the government apparatus which generates trust and cooperation from the citizenry; vii) creation and / or improvement of accountability processes; iix) establishment and strengthening of spaces and mechanisms for citizen participation in decision making that directly affect the benefit of the community. Based on these findings, this study suggest the following policy recommendations for sustainable development of Andeans countries thorough the advancement of e-government: i) Continuous political commitment to e-government development. ii) ICT/E-government infrastructures for sustainable development. iii) International cooperation and Andean platform of e-government development.

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REFERENCES

[1] D.L. Rabina, "United Nations Global E-Government Readiness Report 2005: From E-Government to E-Inclusion. New York: Department of Economic and Social Affairs," in Government Information Quarterly, vol.24, 2007, pp.903-904.

[2] C. Sproles, "Trends in Sustainable Development. Department of Economic and Social Affairs, Division for Sustainable Development. United Nations," in Government Information Quarterly, vol.25, 2008, pp.337-338.

[3] Y.B. Lee, "E-Government for Promoting Sustainable Development in Small Island Developing States (SIDS)", in Background Paper For the Special Event of the 69th Session of the United Nations General Assembly Second Committee, 2014.

[4] H. Choi, M. J. Park, J. J. Rho, H. Zo, "Rethinking the assessment of e-government implementation in developing countries from the perspective of the design–reality gap: Applications in the Indonesian e-procurement system," in Telecommunications Policy, vol.40, 2016, pp. 644.-660

[5] D. L. Baker, "Advancing e-government performance in the United States through enhanced usability benchmarks," in Government Information Quarterly, vol.26, 2016, pp. 82–88.

[6] Department of Agriculture, Government of Sri Lanka, "Official Department of Agriculture, Government of Sri Lanka Webpage". 2017, available online: https://www.doa.gov.lk/index.php/en/

[7] Government Digital Service in United Kingdom, "Gov.uk". 2017, available online: https://www.gov.uk/government/organizations/government-digital-service

[8] Seoul Metropolitan Government, "Eco Mileage Program". 2017, available online: https://seulsolution.krwww.gov.uk

[9] F. Sá, Á. Rocha, M. P. Cota, "From the quality of traditional services to the quality of local e-Government online services: A literature review," in Government Information Quarterly, vol. 33, 2016, pp.149-160.

[10] D. Arduini, M. Denni, M. Lucchese, A. Nurra, A. Zanfei, "The role of technology, organization and contextual factors in the development of e-Government services: An empirical analysis on Italian Local Public Administrations," in Structural change and Economic Dynamics, vol. 27, 2013, pp.177-189.

[11] E. Bonsón, L. Torres, S. Royo, F. Flores, „Local e-government 2.0: Social media and corporate transparency in municipalities," in Government Information Quarterly, vol. 29, 2012,pp. 123–132.

[12] H. Zhang, X. Xu, J. Xiao, "Diffusion of e-government: A literature review and directions for future directions," in Government Information Quarterly, vol. 31, 2014, pp.631-636.

[13] United Nations Department of Economic and Social Affairs, "Estudio de las Naciones Unidas sobre el Gobierno Electrónico," 2012, avaliable online https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2012-Survey/Complete-Survey-Spanish-2012.pdf

[14] A. Ayanso, D. Chatterjee, D. I. Cho, "E-Government readiness index: A methodology and analysis," in Government Information Quarterly, vol. 28, 2011, pp. 522–532.

[15] United Nations Department of Economic and Social Affairs, "E-government Survey 2012 e-government for the people," 2012, pp.164, available online https://publicadministration.un.org/egovkb/Portals/egovkb/Documents/un/2012-Survey/unpan048065.pdf

[16] World Bank, "World Development Indicators (WDI)", 2016, available online http://datacatalog.worldbank.org

[17] A. Robalino-López, J.E. García-Ramos, Antonio A. Golpe, A. Mena-Nieto, "CO2 emissions convergence among 10 South American countries. A study of Kaya components (1980–2010)," in Carbon Management, vol.7, 2016, pp 1-12.

[18] United Nations Department of Economic and Social Affairs, "E-government Survey 2010 leveraginge-government at a time of financial and economic crisis," 2010, pp.124, available online https://publicadministration.un.org/egovkb/portals/egovkb/documents/un/2010-survey/complete-survey.pdf

[19] United Nations Department of Economic and Social Affairs – Division for Public Administration and Development Management, "E-government Survey 2014," 2014, available online https://publicadministration.un.org/egovkb/en-us/reports/un-e-government-survey-2014

[20] United Nations Department of Economic and Social Affairs – Division for Public Administration and Development Management, "E-government Survey 2016," 2016, available online https://publicadministration.un.org/egovkb/en-us/reports/un-e-government-survey-2016

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A Study of Coast Protection Constructions Built with the use of Recycled Construction Materials and their Negative Impact

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Abstract. Different types of materials are used in hydraulic structures and coast protection constructions. These materials can be of natural (e.g. stone) and artificial origin (concrete, metal). The main trends typical for building construction now are as follows: cutting a share of natural materials and reusing waste products of dismantling construction objects.

As a result of recycling it is possible to produce building materials that look like and have properties characteristic of natural stone materials, gravel, in particular. While gravel is being processed, it is possible to predict that it would obtain such characteristics as grade, frost resistance and strength. Reuse of recycled construction materials is a challenge, because this type of waste can hardly be reduced in volume and requires considerable space for burial.

We propose to use gravel produced by processing in hydraulic engineering objects, i.e. in coast protection constructions. For that, we analyzed waste materials characteristics to justify their use in hydraulic structures. The research proved that strength of gravel produced by processing was sufficient enough. On the other hand, its frost resistance and fineness did not satisfy the requirements to materials used in coast protective structures. Besides, the construction of such structures causes water pollution as inert materials placed in waterbodies increase water turbidity. As a large part of the structure is located directly in the waterbody, during the period of the construction inert materials are supposed to be dumped. In this period the water body is filled with a significant amount of fine particles, which leads to an increase in turbidity at the construction site.

Thus, we come to the conclusion that it is possible to reuse recycled construction materials in hydraulic engineering structures only on condition of their additional after-treatment processing. We offer to mix gravel produced by processing with cement mortal. As a result we obtain no-fines concrete, which is further processed by hot procedure (with bituminous materials).

No-fines concrete can be produced in the form of precast units of 1,4×1,4×0,5 m. The use of prefabricated units will allow to avoid waterbody pollution and protect it from fine particles. Further processing by bituminous materials will enhance its frost resistance and reliability, which in turn will prevent contamination of the water body in the period of coast protection constructions usage.

Keywords: coast protection, waterbody, industrial wastes, pollution, gravel, asphalt concrete.

I. INTRODUCTION

Different kinds of materials can be used when erecting waterworks, including coast protection structures [1, 2]:

- of natural origin: stone,

of artificial origin: concrete, metal, etc.

The most promising trends of construction are aimed at reducing the share of newly developed natural materials and increasing reuse of such products from recycled materials as wastes of construction objects dismantling.

Our studies [3, 4], devoted to the possibility of reusing products of construction structures dismantling, put forward technologies of these structures crushing . As a result of recycling it is possible to produce building materials that look like and have properties characteristic of natural stone materials, gravel, in particular.

The use of wastes in the form of gravel in hydraulic structures is associated with water pollution. The reason for that lies in the fact that inert materials with fine parts enhancing turbidity are used in the construction of such waterbodies.

Thus, it is actual to undertake a research in this field and find ways to reduce the negative impact of the construction of coast protection structures using products of recycling building materials.

II. MATERIALS AND METHODS

Reuse of recycled construction materials is a challenge, because this type of waste can hardly be reduced in volume and requires considerable space for burial.

We propose to use gravel produced by processing in hydraulic engineering objects, i.e. in coast protection constructions. For that, we analyzed waste

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materials characteristics to justify their use in hydraulic structures. Table 1 presents data on the composition of the produced gravel.

Table I
The composition of the produced gravel.

Type of material	Content % (no more)
Concrete and reinforced concrete	0-95
Brick	0-95
Slate	5
Metal	2
Polymers	1
Wood	1
Glass	1

After reviewing the requirements for materials used in hydraulic structures, the authors tried to reduce negative impact of building coast protection structures while using products of recycling construction materials and put forward the following requirements:

- size of material should not be less than 100-400 mm;
- its strength should not be less than 400 kg/m^3;
- its frost resistance should be of at least 100 cycles.

Preliminary screen separation of crushed products makes it possible to reduce the volume of fine dispersed phase, which in its turn, reduces the water body pollution.

Low frost resistant properties of the obtained gravel lead to the conclusion that as a result of materials destruction there occur materials washing out into a water object and its repeated contamination during the period of operation. In this connection, the study of frost resistant properties of crushed wastes of building structures seems quite actual.

When performing research, we used:

- freezing chamber, providing and maintaining the temperature up to minus (18 ± 2) °C;
- drying chamber;
- analytical balances;
- sieves;
- a bath for saturating the water and for thawing;
- a metallic vessel.

An analytical sample of crushed wastes was put into a metal container and covered with water at a temperature of +20°C.

After the period of 48 hours, the product was moved into the freezing chamber at a temperature of -18°C. The freezing cycle rate was four hours.

After that, the samples were heated to a temperature of +20ºC and were matured for at least two hours. Further the test cycles were repeated.

After every five cycles, the samples were dried to their constant weight, screened out through a control sieve and were left there before further testing. Grains the the samples which had a fresh surface of fracture were considered being of low frost-resistance.

The loss of samples weight ΔmΔmΔm,%, was determined from the formula (1):

$$\Delta m = \frac{m - m_1}{m} \times 100\% \qquad (1)$$

where m is the mass of the sample before testing, g;
m_1 if the weight of sieve residue after a cycle of freezing and thawing, g.

III. RESULTS AND DISCUSSION

The research results of frost resistance of recycled construction materials are shown in Table 2.

Table II
The research results of frost resistance of construction materials crushed wastes

The number of test cycles	Weight, g.	Weight loss, %
0	1684	0
15	1674	0.59
30	1672	0.71
45	**1570**	**6.76**
75	**1530**	**9.14**

The data analysis of Table 2 show that the value of frost resistance is only 30 cycles, with the required amount of 100 cycles. Thus, it can be concluded that a structure built of recycling construction materials will cause pollution.

Therefore, it is required to improve properties of recycling construction materials. To do this, recycling construction materials should acquire desired characteristics of size, fineness, frost resistance, durability and strength.

We suggest processing these materials with cement mortar. As a result, we' ll get a material with different characteristics (see Figure 1). Its frost resistance properties are given in Table 3.

Fig. 1. Type of coarse-pored concrete

Table III
Research results of frost resistance of no-fines concrete obtained from building structures wastes

The number of test cycles	Weight, g.	Weight loss, %
0	1698	0
15	1684	2.0
30	1674	3.44
45	1664	4.87
75	**1652**	**6.59**

The data analysis of Table 3 show that the value of frost resistance increased up to 50 cycles.

We also studied strength characteristics of no-fines concrete [5]. During the tests, samples of no-fines concrete were crushed at a press. Average strength of 20-40mm gravel with cement consumption of 150 kg/m^3 equaled 45 kg/cm^2.

Due to the connection between factions of no-fines concrete, it possible to use products of less than 100 mm size in ice and wave conditions.

Besides, no-fines concrete can be made in the form of precast units of 1,4×1,4×0,5 m (with account of its sustainability to ice loads) [6] in a concrete plant, delivered to a place of stacking and assembled on a coast protection site.

The proposed technology eliminates washout or demolition of fine particles into the water body and its consequent pollution.

However, according to Table 3, it is not enough to use only no-fines concrete In this regard, we also propose to process slabs of no-fines concrete by a hot procedure with bituminous materials.

IV. CONCLUSION

1. Reuse of recycled construction materials is a challenge, because this type of waste can hardly be reduced in volume and requires considerable space for burial.
2. As a result of crushing it is possible to produce building materials that look like and have properties characteristic of natural stone materials, gravel, in particular.
3. It is not possible to use recycled construction materials in hydraulic engineering structures without additional processing as it will lead to a waterbody pollution with fine particles contained on the surface of large grains.
4. To reduce a negative impact of using recycled construction materials in hydraulic engineering structures, it is required to improve these materials.
5. In the course of further wastes processing after crushing, it is possible to form in them such improved features as grade, frost resistance and strength.
6. To improve the properties of waste products, we offer to mix them with cement mortal. As a result we obtain no-fines concrete, which is further processed by hot procedure (with bituminous materials).
7. No-fines concrete can be produced in the form of precast units of 1,4×1,4×0,5 m. The use of prefabricated units will allow to avoid waterbody pollution and protect it from fine particles. Further processing by bituminous materials will enhance its frost resistance and reliability, which in turn will prevent contamination of the water body in the period of coast protection constructions usage.

REFERENCES

[1.] Balzannikov M.I., Mikhasek A.A. The use of modified composite materials in building hydraulic engineering structures. Procedia Engineering, V.91, 2014, pp.183-187.

[2.] Mikhasek A.A., Smyvalov A.A. Basis of selection design of coast protection structures from composite materials. Scientific Survey, 14, 2015, pp.102-109.

[3.] Mikhasek A.A., Galitskova Yu.M. Using wastes in industrial and hydraulic facilities construction. Industrial and civil engineering, 6, 2015, pp.31-34.

[4.] Mikhasek A.A., Galiyskova Yu.M., Tutova O.A. The use of crusher-run aggregates of reinforced concrete frames when reconstructing hydraulic structures. Procedia Engineering. V.153, 2016, pp.456-460.

[5.] Shabanov V.A., Mikhasek A.A. Technology of water-repellent barrier design in "hard emcoastments». Installation and special works, 11, 2006, pp. 11-13.

[6.] Balzannikov M.I., Kholopov I.S., Rodionov M.V., Litvinova M.G. Theoretical studies of the work of coast-protecting concrete-filled textile mats in conditions of ice impacts. Scientific Survey, 22, 2015, pp. 65-71.

[7.] Balzannikov M.I., Popov V.P., Mikhasek A.A. Study results assessment of quick-hardening liquids penetration into soil elements of hydraulic engineering constructions. Procedia Engineering, V. 153, 2016, pp. 71-76.

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Environmental Management in Joint Streams Regulation by two Hydroelectric Complexes

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Abstract. Lowland river water power developments are usually built to solve complex tasks on the basis of the requirements of rational use of water resources. First of all, operating conditions of hydroelectric complex structures should provide safety and economic efficiency in their work. Besides, they are aimed to satisfy various demands of water consumers. It is particularly important that behaviour of hydroelectric complex structures should satisfy contemporary requirements of environmental security.

The most important task here is to create favourable ecological conditions of life for people who live in settlements located in the zone of influence of two hydroelectric complexes located on different rivers. Here, to achieve environmental targets it is necessary to interlink modes of operation of these water storage control structures.

There are two water power developments built in the Republic of Bashkortostan, Russia, in the middle flow of the Belaya River. Both of them have considerable impact on the formation of level mode and different consumers' water supply. They are Umaguzinskiy and Nugushskiy water power developments.

Both hydroelectric complexes and their water reservoirs together satisfy the following generally accepted requirements of water consumers:

- ***they prevent the lowering of the water level in the river Belaya (during low streamflow period) below the minimum values required to ensure proper water supply for industrial enterprises;***
- ***they generate electric power and provide industries and cities with electricity. To do that each water-economic complex has its own water reservoir and a set of retaining structures and required culvert installations.***

In addition, the following environmental requirements are imposed on co-regulation of water runoff:

- ***protection of waterfronts of the towns Meleuz, Salavat, Ishimbay and Sterlitamak from flooding in flood season;***
- ***protection of the territories of refineries in flood season (during water rise).***

Umaguzinskiy water power development has the following water sluices to control water stream: 1) submerged flood-discharge outlet; 2) shore flood spillway; 3) aggregates of powerhouse. General water carrying capacity of hydroelectric complex structures is 3915 м^3/с. Nugushskiy hydroelectric complex consists of hydraulic engineering structure power room (1) and left shore spillway (2). Combined water carrying capacity of all hydroelectric complex structures here is 1250 м^3/с.

The authors investigated operation modes of Nugushskiy and Umaguzinskiy water power developments when linked into one water-economic complex and came to the conclusion that modes of operation of these water storage control structures should be adjusted in accordance with the operational condition of the main pressure installations and of downstream flood-control facilities. In particular, it is necessary to take into account the unfinished state of flood prevention measures in the middle reaches of the river Belaya.

Keywords: hydroelectric complex, water reservoir, culvert, flow regulation, water level, ecological safety.

I. INTRODUCTION

Thee are many rivers with high hydroelectric potential in the Russian Federation (see Table 1). This potential is mostly realized in the Central Plains of the country [1, 2]. Lowland river water power developments are usually built to solve complex tasks on the basis of the requirements of rational use of water resources. First of all, operating conditions of hydroelectric complex structures should provide safety and economical efficiency in their work. Besides, they are aimed to satisfy various demands of water consumers [3, 4, 5, 6, 7]. It is also very important that the behaviour of hydroelectric complex structures should meet modern requirements of environmental safety [8, 9, 10, 11, 12].

Rules of water resources use are usually developed for each particular hydroelectric complex and are applied to a standard operational period. These rules provide detailed characteristics of this certain reservoir and its capabilities, the main watercourse of the river settings, composition and description of retaining and culvert constructions of hydro-unit security requirements in the upper and lower ponds of waterworks, characteristics of water users and water

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consumption, detailed regulation of runoff and reservoir operation regime for different periods of the year as well as different amounts of water in a flood, a list of necessary activities during flood season, etc. [13].

Table I
Hydropower resources of the rivers of the Russian Federation [1]

River	Energy potential, bln. kW-h
The Enisey	158.3
The Lena	144.0
The Angara	93.9
The Amur	82.9
The Volga	54.3
The Ob	51.4
The Vitim	50.7
The Nizhnyaya Tunguska	41.0
The Kolyma	39.8
The Indigirka	39.6
The Katun	31.0
The Irtysh	25.2
The Vilyuy	22.5
The Podkamennaya Tunguska	18.0
The Zeya	17.4
The Tom	15.2
The Bureya	14.6
The Kama	12.7
The Pechora	12.3
The Oka	11.0
The Terek	10.9
The Kuban	10.7
The Anadyr	10.2

Fig. 1. Diagram of the Volga-Kama cascade of hydroelectric power stations

Such rules are widely recognized for particular hydroelectric complexes that operate independently from other installations. However, there are a lot of rivers in the country with a whole cascade of hydroelectric facilities on them. For example, the most famous and significant largest cascade in respect to its catchment-basin and total capacity of hydroelectric power plants is the Volga-Kama cascade of HPS (see Figure 1). Here the task of rational distribution of water resources is quite complex because controlling of one reservoir must be linked to conditions and work of related reservoirs located both upstream and downstream [14, 15].

Even more challenging is the management of water resources which are not consistently located in a cascade not one after another, but are waterworks built on different rivers which merge together into one river downstream.

Such reservoirs are replenished from different catchment basins, whchi as a rule have different characteristics. Therefore, when joint management regimes of reservoirs is used, it is extremely important to forecast runoff during periods of high water [16]. Even more important is the task of creating favourable ecological conditions of life of the population in the settlements which territory is located in the zone of influence of overall joint afterbay of such hydroelectric complexes.

II. MATERIALS AND METHODS

There are two water power developments: Umaguzinskiy and Nugushskiy in the Republic of Bashkortostan, Russia, in the middle flow of the Belaya River. Both hydroelectric complexes as well as their water reservoirs are located on the territory of the Bashkir National Park (see Figure 2).

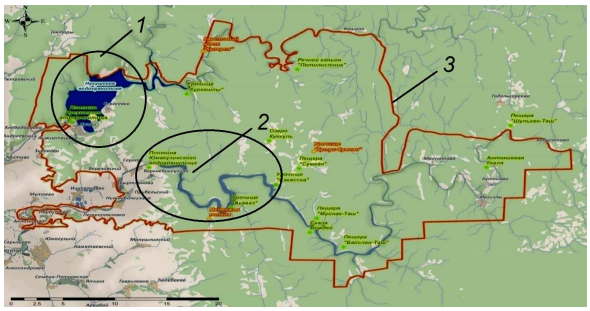

Fig. 2. Umaguzinskiy and Nugushskiy water power developments located on the territory of the National Park “Bashkiriya” 1 – Nugushskiy water power development and its reservoir; 2 – Umaguzinskiy water power development and its reservoir; 3 – the boundary of the National Park

In this context, great importance in determining the operational mode of hydropower work of meeting the objectives of the regulation of the flow is given to ensuring environmental safety requirements. The leading position here lies with the preservation of acceptable water-levels on the territory of the lower afterbay, which for these units is a joint afterbay.

Nugushskiy water power development (the first of the two) was being built from 1961 to 1967. Its water storage basin has useful storage capacity of 365 ml m^3. This water power development consists of the following water-retaining structures and culverts: the phreatic dam, the hydraulic engineering structure power room (run-of-river-type with three hydraulic turbines), left shore concrete spillway (see Figure 3).

Combined water carrying capacity of all hydroelectric complex structures here is 1250 $м^3/с$.

Fig. 3. Water flow through the supercharger dam of Nugushskiy water power development [13]

The research consisted of field studies of hydroelectric complexes operating modes, of the state of the structures, of coming water discharge in the reservoir and passing water discharge to lower afterbay. The tests also included measurements of water levels in the reservoir and other parameters. The researchers recorded water levels in the downstream near to residential settlements and industrial enterprises. Figure 4 shows examples of changes in water level in the reservoir for different hydroeconomic years (starting in March).

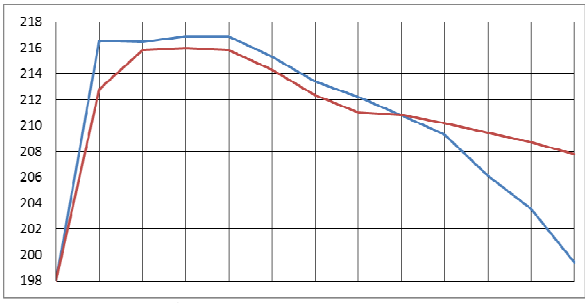

Fig. 4. Variations of water level (m) in Nugushskiy water reservoir during a hydroeconomic year

Observation yielded the following results: The reservoir of Nugushskiy water power development was filled in full. During seasonal flood considerable water amount was discharged into the afterbay. This has resulted in the fact that nature protection requirements were not fully fulfilled. In particular, the coastal area around ehe cities of Meleuz, Salavat, Ishimbay and Sterlitamak was not protected from flooding in flood season, as well as the protection of the territories of industrial enterprises in the season of higt water during floods. Moreover, the devastating flood of 1978 and 1990, as well as periods of dry low-water periods in 1955 and 1975 years caused serious damage to the national economy of the region.

Before the construction of Umaguzinskiy hydroelectric complex in the middle flow of the Belaya River (in the downstream of Nugushskiy hydroelectric complex) the minimal demanded water discharge to maintain the water-level (required for water extraction by industrial enterprises and public water supply) in the low streamflow period was not provided.

Therefore, it was decided to build Umaguzinskiy water power development. The main task of the construction of the reservoir was to build a water reservoir capable to reduce the negative impact of river flow at the objects of national economy (at the expense of the annual flow) and increase water discharge in the after in low-water periods.

III. RESULTS AND DISCUSSION

Umaguzinskiy water power development was being built from 2003 to 2007. It includes a rock-fill dam which is 63m height and 605 length and which blocks the river right when it passes the barrows. Figure 5 shows a general view of the dam. The dam formed a headwall and it led to a water reservoir formation with a useful storage capacity of 435 ml m^3. The water reservoir was located in a narrow dale (see Figure 6). Hence, it was possible to avoid large area flooding thus minimizing environmental damage [17, 18, 19].

Fig. 5. A view of the dam of Umaguzinskiy hydroelectric complex (photo taken by the author)

Umaguzinskiy water power development has the following water sluices to control water stream: 1) submerged flood-discharge outlet; 2) shore flood spillway; 3) hydroelectric power station powerhouse.

Hydroelectric power station powerhouse is located on the left bank of the dam. It contains three hydraulic turbines have the maximum 130 м3/с water flow capacity and provide installed capacity of 45 kVt with rated head of 40 m. Its maximal water flow capacity of flood-discharge outlet is 130 $м^3$/с and can be reached only in overflow spring flood-time. The water flows through three tunnel pressure turbine passages (with 3.2 m diameter).

Fig. 6. A view of Umaguzinskiy water reservoir (photo taken by the author)

Into the turbine water passageways, water comes from submerged flood-discharge outlets. The entrance of the tunnel is designed as a portal and is placed at the left bank (see Figure 5). The spillway of tunnel submerged flood-discharge outlet goes through rock masses and ends as a portal outlet containing mechanical equipment. This submerged flood-discharge outlet is used in rare flood periods of low water levels. Its maximal water flow capacity of flood-discharge outlet reaches 1465 $м^3/с$. Parameters of hydraulic structures were substantiated in accordance with the requirements of generally accepted methods with account of ensuring the reliability of their work [20, 21].

After Umaguzinskiy water power development had been constructed, river flow control function was put on both reservoirs. Besides, the following environmental requirements were laid down on the joint use of water resources:

- protection of waterfronts of the towns Meleuz, Salavat, Ishimbay and Sterlitamak from flooding in flood season;
- protection of the territories of refineries in flood season (during water rise).

In the initial period of Umaguzinskiy water power development operation extra problems in the area of environmental requirements appeared. The thing is that the project involved a comprehensive approach to the protection of the coastal territories of the afterbay. The approach included both flow co-regulation by two hydroelectric complexes and flood control constructions building around the above-mentioned cities. These requirements were taken into account when introducing the rules of Umaguzinskiy reservoir operation. Still, these bank protective structures were not put into operation at that time. In this regard, it was required to make corrections in the rules for the period of completion of flood prevention measures.

It was decided to develop methods of control for modes of the water regulating complex, consisting of two reservoirs and having shared water area of influence in the middle reach of the river Belaya, for operating conditions different from the project.

The task was based on the analysis of conditions under which water consumers of both downstream and upstream sides of hydroelectric complexes could operate in a usual way. The requirements of the above mentioned settlements located in the zone of possible flooding were taken into account, as well as requirements of industrial enterprises, population and agriculture, electricity consumers and fisheries enterprises which suffered from water deficit the low-water period. The facts that Umaguzinskiy water reservoir is located on the territory of the National Park “Bashkiriya” and longstanding irregularity of the river flow were also taken into account (see Figure 7). The developed method of regulating modes of water reservoir consisting of two reservoirs control included the following stages for the period of floods [16, 23]: 1. Obtaining an official forecast of runoff in the flood period. 2. Defining a similar year. For a similar hydroeconomic year the authors calculated water discharge coefficient K, showing run-off excess in Umaguzinskiy water reservoir above the drain in line of discharge gauging station of Nugushskiy hydroelectric complex. Determination of the average flow rate in the control range of Sterlitamak discharge gauging station. 4. Using the drains coefficient, the forecast of maximum runoff in the flood period for reservoirs was adjusted. 5. Using the table of data for the flood period in the upper and middle reaches of the main watercourse the reserchers identified water discharge and water level mark at the highest point of the upper discharge gauging station (№1). 6. With account of the "travelling wave" t for the lower discharge gouging station (№2) the researchers defined the corresponding water-level. 7. Current information on water levels at gauging stations was taken every day. 8. Water inflow to discharge gauging station №3 was thoroughly counted. 9. The water level on discharge gauging station №3 was measured. 10. With account of the "travelling wave" the researchers measured the afterbay level of Umaguzinskiy hydroelectric complex (№3). 11. According to a certain level of water in the control range of Sterlitamak discharge gauging station the perspective water discharge was defined (for a day ahead). This discharge rate was compared with a possible maximum value allowed by environmental conditions. If the expected discharge exceeded the allowable amount, then corresponding corrections were made for the discharged water coming through Umaguzinskiy hydroelectric complex outlet. Thus, the methodology established the relationship between the natural flow of the upper reaches of the watercourse and the strong flow of the middle reaches of the watercourse in the monitoring section.

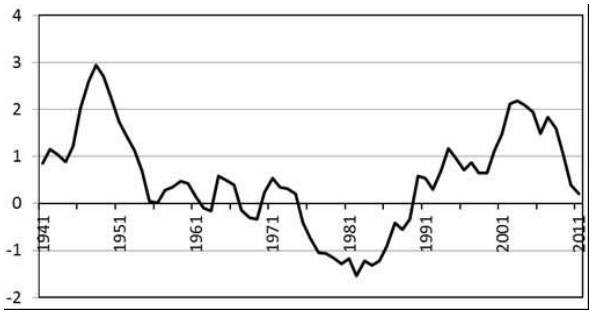

Fig. 7. Differential integral curve in relative values showing the Belaya river runoff in line of Umaguzinskiy reservoir [22]

Analysis of the actual application of this methodology showed that the difference between estimated and actual flood amount at the Umaguzinskiy hydroelectric complex in 2012 did not exceed 4.5%, which demonstrates the high practical relevance of the developed method.

IV. CONCLUSION

1. A critical requirement when operating hydroelectric complexes and their reservoirs is ensuring environmental security. It is required to carefully analyze conditions of creating favourable environmental regimes for settlements which territory is situated in the zone of influence of two hydroelectric complexes built on different rivers with different characteristics of catchment basins. Working modes of transmission facilities of these hydroelectric complexes should bee mutually linked.
2. For Umaguzinskiy and Nugushskiy water power developments built in the Republic of Bashkortostan, Russia, in the middle flow of the Belaya River ecological requirements are as follows: - protection of waterfronts of the towns Meleuz, Salavat, Ishimbay and Sterlitamak as well as industrial enterprises from flooding in flood season; With the purpose of rational use of water resources of the joint regulating complex and environmental requirements compliance, an advanced methodology for the period of incompleteness of all flood prevention measures has been developed in this research. The use of the proposed methodology has proved its high practical value.

REFERENCES

[1.] Vasilyev Yu.S., Elistratov V.V. Hydroelectric installations. Published by St Petersburg Polytechnic University. SPb., 2011.
[2.] Elistratov V.V. Renewable energy. SPb.: IZD-vo «Nauka», ed. 2, 2013, 308 p.
[3.] Vasilyev Yu.S., Kubyshkin L.I. The technology design of hydropower facilities. Hydrotechnical construction, 7, 2014, pp. 2-8.
[4.] Balzannikov M.I. , Yurov V.M. , Mikhasek A.A. Pecularities of joint streams regulation by hydroelectric complexes. Scientific Survey, 3, 2015, pp. 101-108.
[5.] Svitala F., Evdokimov S.V., Galitskova Yu.M. Peculiarities of hydraulic structures and aggregate buildings designs of the first hydroelectric plants. Industrial and civil engineering, 12, 2014, pp. 87-90.
[6.] Evdokimov S.V. New construction of power plants based on renewable energy sources ensuring the efficiency and reliability of their work. Industrial and civil engineering, 8, 2010, pp. 35-38.
[7.] Balzannikov M.I., Ivanov B.G., Mikhasek A.A. Control system of hydraulic engineering structures. Vestnik MGSU, 7, 2012, pp. 119-124.
[8.] Balzannikov M.I., Rodionov M.V., Seliverstov V.A.. Increasing the environmental safety of earth hydrotechnical structures. Urban Construction and Architecture, 1, 2011, pp. 100-105.
[9.] Evdokimov S.V., Dormidontova T.V. Evaluation of reliability of hydraulic structures. Urban Construction and Architecture, 1, 2012, pp. 49-53.
[10.] Evdokimov S.V., Dormidontova T.V. Criteria for evaluating the reliability and technical condition of hydrotechnical constructions. Urban Construction and Architecture, 2, 2012, pp. 105-109.
[11.] Balzannikov M.I. Power plants based on renewable energy sources and their impacts on environment. Vestnik Volgogr. st.. archit.-builds. un. Architecture and civil engineering, Vol. 31(50), Part 1, 2013, pp. 336-342.
[12.] Balzannikov M.I., Evdokimov S.V., Galitskova Yu.M. Development of renewable energy as an important contribution to environmental protection. Industrial and civil engineering, 3, 2014, pp. 16-19.
[13.] Balzannikov M.I., Yurov V.M., Mikhasek A.A. On structures and control methods of joint streams regulation by two water power developments in satisfying water consumers' demands. Procedia Engineering, V. 111, 2015, pp. 82-88.
[14.] Elistratov V.V., Maslikov V.I., Sidorenko G.I. Water-power modes of the Volga-Kama cascade of HPP. Hydraulic engineering, 11, 2014, pp 11-15.
[15.] Maslikov V.I., Sidorenko G.I. Analysis of water and energy modes Zhigulevsk hydroelectric power station and connections of electricity with water flow. Urban Construction and Architecture, 2, 2015, pp. 73-80.
[16.] Yurov V.M. Improving management regimes of two reservoirs as a single waterregulating complex (with the river Belaya as an example). Dissertation for a scientific degree of candidate of technical sciences. Samara, SGASU, 2014, 23 p.
[17.] Balzannikov M.I. Reservoirs of energy facilities and their impact on the environment. Energy audit,1, 2007, pp. 32-35.
[18.] Sobol I.S. Pecualarities of long-term dynamics of the shores of small plain reservoirs in the European territory of Russia. Privolzhsky scientific journal, 2, 2013, pp. 65-67.
[19.] Sobol S.V., Fevralev A.V., Sobol I.S., Sidorov N.P. Development of the scheme of complex use and protection of water objects of the Sura river basin. Privolzhsky scientific journal, 4, 2013, pp. 124-129.
[20.] Vasilyev Yu.S., Sidorenko G.I., Frolov V.V. Justification methods for small hydroelectric power station. Scientific and technical statements, St. Petersburg State Polytechnic University, 147-1, 2012, pp. 76-84.
[21.] Balzannikov M.I., Rodionov M.V., Senitskiy Yu.E. Incresing operational reliability of hydroengineering facilities with groundwater dams. Privolzhsky scientific journal, 2, 2012, pp. 35-40.
[22.] Abdrakhmanov R.F., Tur V.A., Yurov V.M. Jumaguzinskoe reservoir. Formation of hydrological and hydrochemical regimes. Ufa: Informreklama, 2008, 152 p.
[23.] Yurov V.M. Improving control methods of regulating water control complex modes in the middle flow of the river Belaya. Urban Construction and Architecture, 3, 2014, pp. 77-82.

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Displacement Effects of Latvian Rural Development Programme 2007-2013

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Abstract. Periodic evaluation of EU Member States Rural Development Programme (RDP) specific policy interventions is considered crucial in policy development. The main reasons for the evaluation of specific policy interventions are the assessment of a programme's impact, the improvement of programme management and administration, identification of necessary improvements in the delivery of interventions and meeting the accountability. The core question to be answered in programme evaluation is whether the stated objectives are accomplished by particular intervention (support or „treatment" provided to programme participants). The main problem in the process of evaluation is the assessment of the counterfactual outcome by modelling the situation where treatment is absent. The counterfactual outcome has to be estimated by statistical methods as it is usually not observed. General equilibrium effects occur when a programme affects units other than its participants. The most important possible impacts are the substitution effect and the displacement effect. Displacement effects are unplanned and indirect. They usually play a more important role in the evaluation at the programme level than in the evaluation of RDP individual measures. Displacement effect is the programme effect that occurs in a programme area at expense of another area. It takes place if farms located in one geographical area, which is not a subject to RD support, becomes adversely affected by a support provided to farms located in another geographically area. The existing study provides an assessment of the displacement effects on the employment in unsupported units at the programme level after the net effects on the employment calculated at the measure level are aggregated over the entire programme.

Keywords: policy evaluation, propensity score matching, counterfactual analysis, displacement effects.

I. INTRODUCTION

Periodic evaluation of EU Member States Rural Development Programme (RDP) specific policy interventions is considered crucial in policy development. The main reasons for the evaluation of specific policy interventions are the assessment of a programme's impact, the improvement of programme management and administration, identification of necessary improvements in the delivery of interventions and meeting the accountability. According to the EU definition, programme evaluation is a process that culminates in a judgment (assessment) of policy interventions according to their results, impacts and the needs. In the case of rural development (RDP) programmes, EU regulations distinguish between ex-ante, midterm, ex-post and ongoing evaluations. The existing study is considered a part of an ongoing evaluation which would provide the grounds for the ex-post evaluation of Latvian Rural Development Programme 2007-2013. The core question to be answered in programme evaluation is whether the stated objectives are accomplished by particular intervention (support or „treatment" provided to programme participants). The main problem in the process of evaluation is the assessment of the counterfactual outcome by modelling the situation where treatment is absent. The counterfactual outcome has to be estimated by statistical methods as it is usually not observed.

The core element of the EC evaluation framework are Common Evaluation Questions (CEQ) pre-defined by the EC and programme-specific questions defined by national programme authorities. The evaluation questions focus on a direct effect of the RD programme on specific result indicators. The answer to the crucial evaluation question on the contribution of the programme to the growth of the whole rural economy has to be provided by the measuring the net effects of the programme support on the Gross Value Added (GVA) in supported units.

As mostly the evaluation is focused on the assessment of the direct and planned effects of the policy interventions, the evaluation can produce biased results. Standard propensity score matching methods assume that outcomes for non-participants in the control group are not affected by the programme (no general equilibrium effects). If general equilibrium effects had occurred during the implementation of a given RD programme with substantial impact (positive or negative) on farms which did not participate in this programme, partial equilibrium evaluation techniques such as standard

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PSM would produce biased estimates of programme effects.

General equilibrium effects occur when a programme affects persons/enterprises other than its participants [15]. The most important possible impacts are the substitution effect and the displacement effect [2]. Displacement effects are unplanned and indirect. They usually play a more important role in the evaluation at the programme level than in the evaluation of RDP individual measures. Displacement effect is normally defined as the effect obtained in favour of direct programme beneficiaries but at the expense of units that do not qualify or participate in a given intervention. It occurs if, due to support provided from RDP employment shifts at the detriment of non-supported or non-eligible units usually located in close neighbourhood of units directly supported by a given programme.

The existing study provides an assessment of the displacement effects on the employment in unsupported units at the programme level after the net effects on the employment calculated at the measure level are aggregated over the entire programme.

II. MATERIALS AND METHODS

To measure causal effects of programme or policy intervention, a potential outcome model is appropriate. The model was proposed by Roy [13] and further developed by Rubin [14] and Holland [5]. Using the potential outcome model, the causal effect of a given programme on unit can be expressed with basic evaluation formula:

$$e_i = Y_i(1) - Y_i(0), \quad (1)$$

where:

$Y_i(1)$ - potential outcome for unit i in case of participation in RDP (programme participants),

$Y_i(0)$ - potential outcome for unit i in case of non participation in RDP (counterfactual),

e_i - the effect of programme participation on unit i, relative to effect of non-participation on the basis of a response variable Y .

In evaluation it is relatively easy to obtain for programme beneficiaries the information about $Y_i(1)$ but it is very difficult to estimate $Y_i(0)$ which for programme beneficiaries is not directly observable.

The outcome for a participating unit can be observed directly and it is expressed by formula:

$$e_i = (Y2 - Y1), \quad (2)$$

where:

$Y1$ - value of the outcome variable at programme starting period for a participating unit,

$Y2$ - value of the outcome variable at programme ending period.

The outcome for the same unit without the participation can be interpreted as a result of other factors which may simultaneously affect observable impact variables and it is expressed by formula:

$$e_i = Y3 - Y1, \quad (3)$$

$Y3$ - value of the outcome variable for the same unit without a participation.

The unit can only be observed in one of two possible situations: being supported (participating) or not-supported (without a participation) which means that the real programme effect can be expressed as a difference between the outcome with a participation and outcome without a participation:

$$e_i = (Y2 - Y1) - (Y3 - Y1) = (Y2 - Y3), \quad (4)$$

The real programme effect (*Y2 – Y3)* cannot be directly observed.

The effectiveness of interventions on outcomes of interest can be evaluated by propensity score matching (PSM). Multiple regression is the most common method for estimating the programme support effect. PSM is a rigorous nonexperimental method. The data for PSM usually are pooled in a panel both from programme participants and non-participants. The non-participating or „untreated" units constitute the „control" group while participants are included in „treatment" group. The information from control group is used to assess what would be the outcome of interest for participants in the absence of the programme. The difference in outcomes for both groups is evaluated by comparison of relatively similar units in these groups. To successfully mitigate the potential bias, unit matching has to be based not on a single or a few characteristics but on a full range of available covariates that have potential impact. The propensity score is then defined as the probability of receiving the treatment by the given unit. Thus the matching is reduced to a single variable, and matching on entire set of covariates is no longer necessary. The method was developed by Rosenbaum and Rubin [11]. They introduced balancing score as a function of covariates that provides the same distributions of covariates in both groups. Imbens [6] suggested four step procedure for implementing the PSM:

1. selection of observational covariates and estimation of propensity scores,
2. stratification of propensity scores and testing of balancing properties in each block,
3. calculation of the Average Treatment on Treated (ATT) by matching,
4. sensitivity test for robustness of estimated ATT effects.

If the balancing properties of covariates are not satisfied in all strata, the test has to be repeated with different number of strata. If the balancing properties are not satisfied again, estimation of propensity scores has to be repeated with modified list of covariates by adding higher order (squared) covariates. After getting all covariates balanced in every stratum, causal effects can be estimated by nearest neighbor matching (NNM), radius matching (RM) or kernel matching (KM).

NN matching computes the ATT by finding the unit in the control group whose propensity score is nearest (absolute value of difference is minimal) for every unit in treatment group. Larger number of comparison units from control group decreases the variance of the estimator. At the same time, the bias of the estimator increases. Furthermore, one needs to choose between matching with replacement and matching without replacement [3]. When there are few comparison units, matching without replacement will force us to match treated units to the comparison ones that are quite different in propensity scores. This enhances the likelihood of bad matches (increase the bias of the estimator), but it could also decrease the variance of the estimator. Thus, matching without replacement decreases the variance of the estimator at the cost of increasing the estimation bias. In contrast, because matching with replacement allows one comparison unit to be matched more than once with each nearest treatment unit, matching with replacement can minimize the distance between the treatment unit and the matched comparison unit. This will reduce bias of the estimator but increase variance of the estimator.

In RM, the units in both groups are matched when the propensity scores in control group fall in the predefined radius of the units in treatment group. The larger the radius is, the more matches can be found. More matches typically increase the likelihood of finding bad matches, which raises the bias of the estimator but decreases the variance of the estimator.

In KM, all units in treatment group are matched with the weighted average of all units in control group. The weights are determined by distance of propensity scores, bandwidth parameter and a kernel function. Choosing an appropriate bandwidth is crucial because a wider bandwidth will produce a smoother function at the cost of tracking data less closely. Typically, wider bandwidth increases chance of bad matches so that the bias of the estimator will also be high. Yet, more comparison units due to wider bandwidth will also decrease the variance of the estimator.

In general, selection of the matching technique is empirical and it largely depends on the results obtained.

The PSM method first has been empirically applied by Heckman, Ichimura, Smith and Todd [4] in the estimations of training programmes on future income in the USA labor market. Subsequently, similar studies on the USA labor market were carried out by Dehejia and Wahba [3], and a few other researchers.

The modules for calculating propensity scores and matching for use in STATA software were developed by Becker and Ichino [1]. It is common first to run the pscore module which estimates the propensity scores and tests the satisfying of the balancing properties. If the balancing properties are satisfied then ATT can be estimated with one or more of the *att** modules. The modules attnd or attnw, attr and attk assume nearest neighbor, radius and kernel matching, respectively. After the calculation of ATT, the module *mhbounds* developed by Rosenbaum [12]provides sensitivity analysis with Rosenbaum bounds with Mantel and Haenszel [7] test statistic.

As the direct planned impact of the programme on employment is measured by the Annual Working Units (AWU), this result indicator is used also in measuring displacement effects. Michalek [8] proposes the following steps in the estimation of displacement effects:

- identification of supported units j in the area with high intensity of support;
- identification of non-supported units k in the area with high intensity of support, which match with units j;
- identification of non-supported units m in the area with low intensity of support, which match with units j;
- calculation of DiD-ATT between units j and units k as well as between units j and units m;

The lack of displacement effects would result in similar differences in DiD-ATT between units j and k compared with j and m.

The estimation of the indirect effects including displacement effects was effectively carried out following the procedure suggested above for Slovakian SAPARD programme [9] and farm support measures of programmes in selected countries [10].

III. RESULTS AND DISCUSSION

The data on participants and non-participants of Latvian Rural Development Programme are sourced from FADN database (Axis 1 and Axis 2 measures) and State Revenue (Axis 3 measures). The Axis 4 measures due to their specific support are not included in the assessment. The calculations are provided in two blocks for FADN data and State Revenue data as the all relevant information on programme participants and non-participants regarding their structure and performance from 2007 to 2013 differs depending upon the source.

First, as the information should cover periods before and after the implementation of the programme, certain number of relevant units was selected from both data sets. The employment was selected as a dependent variable.

As there were no districts without programme support, breakdown of districts by participation and non-participation was based upon the intensity of support.

The most common measure of the intensity of programme support is the average per capita public financing allocated to the statistical districts of the country.

The assessment of the displacement effects for the Axis1 and Axis2 measures is based upon the average

per capita support provided to the districts within the Axis1 and Axis2 measures. The 119 districts are divided in two sets based on the 90% threshold of the average per capita support. The set of the high support intensity consists of 60 districts where the intensity exceeds 90% of the average. The set of the low support intensity consists of 59 districts where the intensity is below the 90% of the average.

The principal layout of the algorythm for assessment of the Axis1 and Axis2 displacement effects is mapped on Fig. 1.

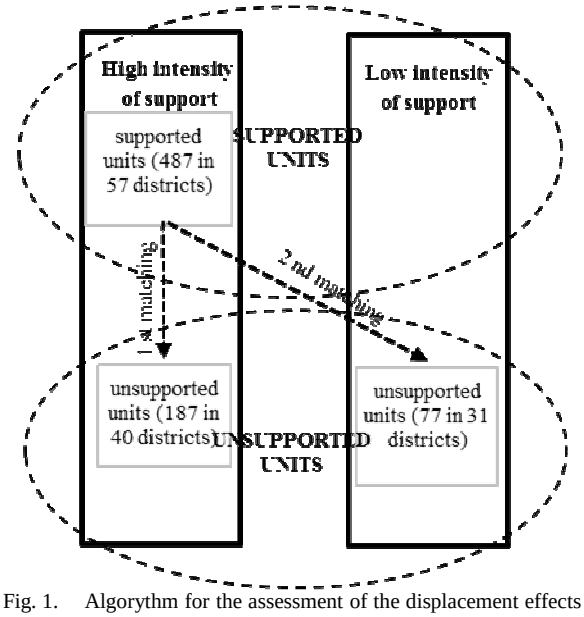

Fig. 1. Algorythm for the assessment of the displacement effects for the Axis1 and Axis2 measures

First, the 487 supported units in 57 districts with high intensity of support were identified. Second, the 187 unsupported units were identified in 40 districts with high intensity of support. Third, the 77 unsupported units were identified in 31 districts with low intensity of support.

The first matching was provided for the supported and unsupported units in the area of high support intensity. With respect to propensity score matching (PSM-DiD method), in total, 52 variables related to unit structure which were considered critical for comparability of economic performance were selected for use in matching process.

Although only 2 and 3 variables proved statistically significant at 5% and 10% level, respectively, after Logit regression, dropping the variables with lower significance levels caused a loss of balancing properties in one or more blocks. Similarly, adding of higher order covariates caused the loss of balancing properties. Therefore, the original specification of Logit function was preferred.

For the treated units, control units and total for each of iterated five blocks the computed z-value does not exceed the critical value for the 5% confidence interval.

The common support option has been selected. This restriction implies that the test of the balancing property is performed only on the observations whose propensity score belongs to the intersection of the propensity scores in both groups. With the given specification the balancing property was satisfied.

Matching with the radius (R=0.1) method was selected based upon the t-test results.

The results of the matching supported and unsupported units in the area with high intensity of support are shown in Table 1.

Table 1
Average changes in employment of supported (T=1) and non-supported (T=0) units of Axis1 and Axis2 measures in the area of high programme support

	Employment (AWU)		
	2007	2013	DiD (2014-2007)
Unmatched supported units in high intensity region (P=1) (487)	6.04	5.64	-0.39
Unmatched unsupported units in high intensity region (P=0) (187)	5.86	5.18	-0.68
Total Ø (674)	5.99	5.51	-0.47
Difference (1-0)	0.18	0.46	0.28
Difference (1-Ø)	0.05	0.13	0.08
Matched supported units in high intensity region (M=1) (487)	6.04	5.64	-0.39
Matched unsupported units in high intensity region (M=0) (187)	2.77	3.05	0.29
ATT	3.27	2.59	-0.68

The ATT effect on the employment of supported units in the area of high intensity of programme support evaluated by PSM-DiD method is negative at 0.68 AWU per unit. It means that unsupported units in this area are affected positively in terms of employment. Using the simple difference-in-differences estimator without matching would lead to an erroneous assumption that the effect on supported units is positive at 0.28 AWU.

The second matching was provided for the supported units in the area of high support intensity and the unsupported units in the area of low support intensity. With respect to propensity score matching (PSM-DiD method), in total, 52 variables related to unit structure which were considered critical for comparability of economic performance were selected for use in matching process.

Although only 9 and 11 variables proved statistically significant at 5% and 10% level, respectively, after Logit regression, dropping the variables with lower significance levels caused a loss of balancing properties in one or more blocks. Similarly, adding of higher order covariates caused the loss of balancing properties. Therefore, the original specification of Logit function was preferred.

For the treated units, control units and total for each of iterated five blocks the computed z-value does not exceed the critical value for the 5% confidence interval.

The common support option has been selected. This restriction implies that the test of the balancing property is performed only on the observations whose propensity score belongs to the intersection of the propensity scores in both groups. With the given specification the balancing property was satisfied.

Matching with the radius (R=0.01) method was selected based upon the t-test results.

The results of the matching supported units in the area of high intensity of support to unsupported units are shown in Table 2.

Table 2
Average changes in employment of supported (T=1) units in the area with high level of support and non-supported (T=0) units in the area of low level of support of Axis1 and Axis2 measures

	Employment (AWU)		
	2007	2013	DiD (2014-2007)
Unmatched supported units in high intensity region (P=1) (61)	6.04	5.64	-0.39
Unmatched non-supported units in low intensity region (P=0) (23)	7.61	5.05	-2.56
Total Ø (84)	6.25	5.56	-0.69
Difference (1-0)	-1.57	0.59	2.16
Difference (1-Ø)	-0.21	0.08	0.30
Matched supported units in high intensity region (M=1) (58)	6.04	5.64	-0.39
Matched non-supported units in low intensity region (M=0) (23)	2.85	2.31	-0.54
ATT	3.19	3.33	0.14

The ATT effect on the employment of supported units in the area of high intensity of programme support evaluated by PSM-DiD method is positive at 0.14 AWU per unit. It means that unsupported units in this area are affected negatively in terms of employment. Using the simple difference-in-differences estimator without matching would lead to an erroneous assumption that the effect on supported units is positive at 2.16 AWU.

As it is assumed that the lack of displacement effects would result in similar calculated effects from both matchings, the difference in the results points to considerable displacement effects. The employment situation in unsupported farms located in the areas with high intensity of support is not deteriorating relative to unsupported farms in the areas with low intensity of support.

The estimated displacement effect on the employment of supported units is calculated as a difference between ATT effects for the first and second matching. The estimated effect is positive at 0.82 AWU.

The estimated displacement effect at the axis level (Axis1 and Axis2) is calculated by multiplying the calculated difference in ATT to the total number of unsupported farms in areas with low intensity of programme support. The number of such farms amount to a 3,409. The calculated displacement effect at the axis level (Axis1 and Axis2) is positive at 2,795 AWU. It means the programme support in regions with high intensity of programme support has positively affected the employment in non-supported units in direct neighborhood of supported units.

The assessment of the displacement effects for the Axis3 measures is based upon the average per capita support provided to the districts within the Axis3 measures. The 119 districts are divided in two sets based on the 90% threshold of the average per capita support. The set of the high support intensity consists of 60 districts where the intensity exceeds 90% of the average. The set of the low support intensity consists of 59 districts where the intensity is below the 90% of the average.

First, the 202 supported units in 45 districts with high intensity of support were identified. Second, the 95 unsupported units were identified in 41 districts with high intensity of support. Third, the 123 unsupported units were identified in 43 districts with low intensity of support.

The first matching was provided for the supported and unsupported units in the area of high support intensity. With respect to propensity score matching (PSM-DiD method), in total, 12 variables related to unit structure which were considered critical for comparability of economic performance were selected for use in matching process.

Although only 1 variable proved statistically significant at 5% level after Logit regression, dropping the variables with lower significance levels caused a loss of balancing properties in one or more blocks. Similarly, adding of higher order covariates caused the loss of balancing properties. Therefore, the original specification of Logit function was preferred.

For the treated units, control units and total for each of iterated five blocks the computed z-value does not exceed the critical value for the 5% confidence interval.

The common support option has been selected. This restriction implies that the test of the balancing property is performed only on the observations whose propensity score belongs to the intersection of the propensity scores in both groups. With the given specification the balancing property was satisfied.

Matching with the nearest neighbor method was selected based upon the t-test results.

The results of the matching supported units and unsupported units in the area of high intensity of support are shown in Table 3.

The ATT effect on the employment of supported units in the area of high intensity of programme support evaluated by PSM-DiD method is positive at 0.39 AWU per unit. It means that unsupported units in this area are affected negatively in terms of employment. Using the simple difference-in-differences estimator without matching would lead to an erroneous assumption that the effect on supported units is negative at 0.39 AWU.

Table 3
Average changes in employment of supported (T=1) and non-supported (T=0) units of Axis3 measures in the area of high intensity of support

	Employment (AWU)		
	2007	2013	DiD (2014-2007)
Unmatched supported units in high intensity region (P=1) (96)	3.04	3.72	0.68
Unmatched unsupported units in high intensity region (P=0) (61)	0.27	1.34	1.07
Total Ø (157)	1.96	2.80	0.83
Difference (1-0)	2.76	2.37	-0.39
Difference (1-Ø)	1.07	0.92	-0.15
Matched supported units in high intensity region (M=1) (96)	3.04	3.72	0.68
Matched unsupported units in high intensity region (M=0) (61)	0.98	1.26	0.29
ATT	2.06	2.45	0.39

The second matching was provided for the supported units in the area of high support intensity and the unsupported units in the area of low support intensity. With respect to propensity score matching (PSM-DiD method), in total, 10 variables related to unit structure which were considered critical for comparability of economic performance were selected for use in matching process.

Although only 2 and 4 variables proved statistically significant at 5% and 10% level, respectively, after Logit regression, dropping the variables with lower significance levels caused a loss of balancing properties in one or more blocks. Similarly, adding of higher order covariates caused the loss of balancing properties. Therefore, the original specification of Logit function was preferred.

For the treated units, control units and total for each of iterated five blocks the computed z-value does not exceed the critical value for the 5% confidence interval.

The common support option has been selected. This restriction implies that the test of the balancing property is performed only on the observations whose propensity score belongs to the intersection of the propensity scores in both groups. With the given specification the balancing property was satisfied.

Matching with the radius (R=0.1) method was selected based upon the t-test results.

The results of the matching supported units in the area of high intensity of support to unsupported units in the area of low intensity of support are shown in Table 4.

The ATT effect on employment of supported units in the area of high intensity of programme support evaluated by PSM-DiD method is positive at 0.32 AWU per unit. It means that unsupported units in this area are affected negatively in terms of employment. Using the simple difference-in-differences estimator without matching would lead to an erroneous assumption that the effect on supported units is positive at 0.23 AWU.

Table 4
Average changes in employment of supported (T=1) units in the area with high level of support and non-supported (T=0) units in the area of low level of support of Axis3 measures

	Employment (AWU)		
	2007	2013	DiD (2014-2007)
Unmatched supported units in high intensity region (P=1) (61)	3.04	3.72	0.68
Unmatched non-supported units in low intensity region (P=0) (23)	0.32	0.78	0.45
Total Ø (84)	2.33	2.95	0.62
Difference (1-0)	2.71	2.94	0.23
Difference (1-Ø)	0.71	0.77	0.06
Matched supported units in high intensity region (M=1) (58)	0.80	1.70	0.90
Matched non-supported units in low intensity region (M=0) (23)	0.44	1.01	0.58
ATT	0.36	0.68	0.32

The estimated displacement effect on AWU of supported units is calculated as a difference between ATT effects for the first and second matching. The estimated effect is negative at 0.07 AWU. The employment situation in unsupported farms located in the areas with high intensity of support is slightly deteriorating relative to unsupported farms in the areas with low intensity of support.

The estimated displacement effect at the axis level (Axis3) is calculated by multiplying the calculated difference in ATT to the total number of unsupported enterprises in areas with low intensity of programme support. The number of such enterprises amounts to a 13,721. The calculated displacement effect at the axis level (Axis3) is negative at 968 AWU. It means the programme support in regions with high intensity of programme support has negatively affected the employment in non-supported units in direct neighborhood of supported units.

The estimated displacement effect at the programme level is calculated as the aggregate of the effects calculated ar the axis level. Total net impact of the programme on employment considering the previously estimated direct impact at sector level (policy intervention focus area) is shown in Table 5.

Table 5
Total programme net impact on employment (AWU)

	Direct impact	Displacement effects	Net impact
Farm modernization	-2705	2795	2369
Forestry&environment	1144		
Food processing	771		
Subsistency farming	364		
Rural diversification	1055	-968	251
Rural tourism	82		
Rural communities	82		
Total	793	1827	2620

The net programme effects calculated in the previous research on the employment at the national level amount to 793 AWU. Taking the displacement effects into account increases the net effects up to 2620 AWU.

IV. CONCLUSIONS

Use of „naïve" estimators in evaluation of programme effects on economic variables without matching can lead to the erroneous overestimation or underestimation of unplanned indirect effects on changes in employment attributed solely to the programme. Propensity score matching has to be considered a more suitable method in establishing a sound counterfactual.

The previously calculated direct programme impact on the changes in employment can not be considered as a correct result without the estimation of displacement effects that are unintended, and, in cases, can substantially change the final estimation.

The displacement effects can be either positive or negative. As the study shows, the indirect and unintended impacts of the programme support on non-participants can be rather substantial and comparable to direct intended impacts.

The size and sign of the impact varies depending upon the activities enclosed in the measures of programme axis. As Axis1 support mainly focuses on farm modernization, the employment would shift to non-supported farms in the close neighborhood of these supported farms. In turn, Axis3 support with the focus on diversification in the areas other than agriculture can provide job opportunities to neighboring farmers.

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REFERENCES

[1] S. Becker and A. Ichino, "Estimation of average treatment effects based on propensity scores," The Stata Journal. 2, pp. 358-377, 2002.

[2] L. Calmfors, "Active Labour Market Policy and Unemployment: A Framework for the Analysis of Crucial Design Features," OECD Economic Studies, 1994, 22, pp. 8-47.

[3] R. Dehejia and S. Wahba, "Propensity score-matching methods for nonexperimental causal studies," Review of Economics and Statistics, 84, pp. 151-161, DOI: 10.3386/w6829, 2002.

[4] J.J. Heckman, H. Ichimura, J. Smith, and P. Todd, "Characterizing selection bias using experimental data," Econometrica. 66(5), pp. 1017-1098. DOI: 10.2307/2999630, 1998.

[5] P.W. Holland, "Statistics and causal inference (with discussion)," Journal of the American Statistical Association, 81, pp. 945-970, DOI: 10.2307/2289064, 1986.

[6] G.W. Imbens, "Nonparametric estimation of average treatment effects under exogeneity: A review," The Review of Economics and Statistics. 86, pp. 4-29, DOI: 10.1162/003465304323023651, 2004.

[7] N. Mantel and W. Haenszel, "Statistical aspects of the analysis of data from retrospective studies of disease," Journal of the National Cancer Institute, 22(4), pp. 719-748, DOI: 10.1093/jnci/22.4.719, 1959.

[8] J. Michalek, "Quantitative tools for ex-post evaluation of EU RD programmes," in Advanced-Eval. Working Paper Series, University of Kiel, April 2007. http://www.advanced-eval.eu.

[9] PCM, "Ex-post evaluation of the SAPARD programme in the Slovak Republic. Final Report," in P.C.M. Group, December 2007.

[10] A. Pufahl, and Ch. Weiss, "Evaluating the effects of farm programs: results from propensity score matching," in Department of Economics Working Paper Series 113, Wien: Vienna University of Economics and Business Administration, 2007.

[11] P.R. Rosenbaum and D.B. Rubin, "The central role of propensity score in observational studies for causal effects," Biometrika, 70, 41- 55, DOI: 10.1093/biomet/70.1.41, 1983.

[12] P.R. Rosenbaum, *Observational Studies.* New York: Springer, 2nd edition, 2002.

[13] A. Roy, "Some thoughts on the distribution of earnings," Oxford Economic Papers, 3, pp. 135-146, 1951.

[14] D.B. Rubin, "Estimating causal effects of treatments in randomized and nonrandomized studies," Journal of Educational Psychology, 66, pp. 688-701. DOI: 10.1037/h0037350, 1974.

[15] J. Smith, "A Critical Survey of Empirical Methods for Evaluating Active Labor Market Policies," Schweiz, Zeitschrift für Volkswirtschaft und Statistik, 2000, 136, pp. 1-22.

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MULTIPLIER EFFECTS OF LATVIAN RURAL DEVELOPMENT PROGRAMME 2007-2013

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Abstract. The core question to be answered in periodic evaluations of EU Member States Rural Development Programme (RDP) specific policy interventions is whether the stated objectives are accomplished by particular intervention (support or „treatment" provided to programme participants). Programme effects should normally be expressed in "net" terms, which means after subtracting the effects that cannot be attributed to the intervention, and by taking into account indirect effects (deadweight, leverage, displacement, substitution and multipliers). The level of the estimation of indirect effects (micro or macro level) depends on the size of the interventions and country specific issues. In the ex-post evaluation of the Latvian Rural Development programme 2007-2013, deadweight effects, leverage effects and multipliers are estimated at the individual measure (micro) level, while substitution and displacement effects are aggregated over the sets of measures. Multiplier effect is a secondary effect resulting from increased income and consumption generated by the public intervention. Multiplier effects are cumulative and take into account the fact that a part of the income generated is spent again and generates other income, and so on in several successive cycles. In each cycle, the multiplier effect diminishes due to purchases outside the territory. The existing study provides an assessment of the multiplier coefficients (multipliers) for the economic growth in terms of Gross Value Added and for the employment creation in terms of Annual Working Units. The research results show that total estimated programme secondary cumulative impacts on economic growth and employment over the entire economy are significant and positive.

Keywords: policy evaluation, input-output analysis, secondary cumulative impact, multipliers, multiplier effects.

I. INTRODUCTION

The core question to be answered in periodic evaluations of EU Member States Rural Development Programme (RDP) specific policy interventions is whether the stated objectives are accomplished by particular intervention (support or „treatment" provided to programme participants). Programme effects should normally be expressed in "net" terms, which means after subtracting the effects that cannot be attributed to the intervention, and by taking into account indirect effects (deadweight, leverage, displacement, substitution and multipliers). The level of the estimation of indirect effects (micro or macro level) depends on the size of the interventions and country specific issues. In the ex-post evaluation of the Latvian Rural Development programme 2007-2013, deadweight effects, leverage effects and multipliers are estimated at the individual measure (micro) level, while substitution and displacement effects are aggregated over the sets of measures. Multiplier effect is a secondary effect resulting from increased income and consumption generated by the public intervention. Multiplier effects are cumulative and take into account the fact that a part of the income generated is spent again and generates other income, and so on in several successive cycles. In each cycle, the multiplier effect diminishes due to purchases outside the territory. Correctly estimating programme multiplier effects is a rather difficult issue. The possible methodological approaches proposed in the evaluation guidelines by European Evaluation Network for Rural Development [1] are the following: regional Social Accounting Matrix (SAM), regional Input - Output models (Input-Output tables) or general propensity score based models.

The use of Input-Output (I/O) tables in empirical analyses has notably increased recently. Input-Output (I/O) multipliers and multiplier effects can be used to assess the national economic impacts from an activity, such as investments under the framework of Rural Development Programmes. Multipliers are derived from a national I/O table or matrix which is a representation of national or regional economic accounting that records the way industries both trade with one another and produce for consumption and investments. The flows of products and services are registered, simultaneously by origin and by destination. The use of I/O multipliers for impact assessment of policy interventions rests on the fact that the direct effects of the investments in a specific sector of the economy (agriculture, forestry, food processing or public services) are followed by

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indirect and induced effects. These two types of effects are observed respectively because purchasing links with other industries in the national level exist and employees who work in the value chain spend their incomes on domestic goods and services.

II. MATERIALS AND METHODS

Input-output (I/O) analysis has been developed by Leontief who has applied the I/O model on the U.S. economy [3] - [5]. Two main I/O techniques are impact analysis and the projection (or imputation) of primary inputs [9], [6]. Impact analysis, which is the most traditional I/O technique, studies the impact of a changing final demand on the production of economic sectors. The second technique concerns the projection of primary inputs on final demand. Although traditionally, only the inputs of labour and capital were analysed, later other types of inputs were also taken into account. Both I/O techniques mentioned require the calculation of so-called Leontief multipliers. The impact estimates derived from I/O analysis represent activity within a single year. Thus, the economic impact assessment is mostly used as a one shot assessment. The I/O multipliers and multiplier effects are commonly assumed stable for up to six years after the initial calculation of the I/O table. If the data are available enabling the initialization of the impact assessment each year, the different scenarios can be analyzed. However, usually I/O tables are available with time gaps 36 months after the year selected for the analysis. The method has further limitations. The assessment pertains only to economic impacts and it does not address the environmental, social or cultural issues. The errors in terms of estimation of the direct impacts are added up and contribute to the uncertainty in the final results. Even though it cannot be clearly measured, presenting the results in terms of ranges of values (rough confidence intervals) rather than a single figure can help to underline the inherent uncertainty of an economic impact analysis. A sensitivity analysis can also help. It might also be interesting to first present the direct effects in terms of spending or change in final demand (supposedly highlighted in the simulation model) and the multipliers; to then show the broader impact (including the indirect and induced effects) while explaining the differences and underlying uncertainties with respect to each step of the method. This will help shed light on the importance of broadening the perspective, away from considering the simple direct impacts of one measure. At the same time, it will provide a good picture of the assessment.

Basic principles of Input-Output methodology and calculation of Input-Output multipliers

The I/O methodology has been applied in the analysis of various industry sectors. Nevertheless, predominantly research focuses on tourism and related economy sectors. In Scotland, initially suggested approach of Stynes [11] was further developed by Wilson [13]. In the Scottish Firth of Clyde tourism case study, the evaluation of the secondary effects of sailing expenditure in the Firth was based on output multipliers. Key economic sectors that are mainly impacted by the recreational boating activities were identified representing relevant categories of spending, such as Recreational, cultural and sporting activities or Tourism (hotels, catering and pubs), Supporting and auxiliary transport activities, Retail. The direct effects were then multiplied up to derive the total economic effects of spending and thus capture the secondary economic effects of tourism activity. A similar approach is used in the analysis of Romanian Hotels and Restaurants Sector with respect to tourism [11].

An I/O matrix is a representation of national economic accounting that records the way industries trade with one another and produce (flows of products and services). Those flows are registered in a matrix, simultaneously by origin and by destination [8]. The matrix illustrates the relationship between producers and consumers as well as interdependencies of industries for a given year. The I/O table is also called transactions matrix. The transactions matrix is divided into several sections. The section called the domestic intermediate matrix is a square matrix where the rows represent the outputs (suppliers) and the columns the destination of inputs (users). All the cells of the domestic intermediate matrix show the flows between sectors. Another section of the transactions matrix is called domestic investment matrix. It accounts for the supplies of goods that are not consumed by domestic industries. The rows represent sectors and the columns include such categories as Consumption expenditure, Gross Fixed Capital Formation, Changes in inventories, Direct purchases abroad by residents (imports), Direct purchases by non-residents (exports), Exports (cross border) and Imports (cross border). The columns in the third section of the transactions matrix correspond to the sectors with rows representing Taxes less subsidies on intermediate and final products, Total intermediate and final expenditure at purchasers' prices, Value added, Output, Labour compensation, Other value added, Taxes less subsidies on production, Consumption of fixed capital and Net operating surplus and mixed income. The initial monetary values in the domestic intermediate matrix can be converted into ratios by dividing each cell of the domestic intermediate matrix by its column total (output at basic prices). The square matrix obtained is called technical coefficients matrix (or the A matrix). The technical coefficients show the rate at which inputs are transformed into outputs. When the technical coefficients have been calculated, an identity matrix (or the I matrix) needs to be constructed. It is a square matrix with the same dimensions as the direct requirements matrix. The

type I Leontief inverse matrix shows how much of each industry's output is needed, in terms of direct and indirect requirements to produce one unit of a given industry's output. Type I Leontief inverse matrix is calculated using the formula:

$$L = (I - A)^{-1}, \quad (1)$$

where

L - Leontief Inverse matrix,

I - Identity matrix,

A - Direct Requirements matrix.

The type II Leontief inverse matrix shows the induced requirements (in terms of industry's output) of a production of one unit of a given industry's output. Its purpose is to take into account, besides the direct and indirect requirements included in the type I inverse matrix, the flows of money in and out of households and the effect of these flows on industries. The type II inverse matrix is derived in the same way as the type I inverse matrix. But since it is necessary to include households in the analysis we treat them as an additional industry by adding an extra row and column into the Direct Requirements matrix for "compensation of employees" and "final consumption expenditure by households" coefficients respectively. The formal notation for the Direct Requirements matrix is modified as follows:

$$A = \begin{bmatrix} A_{II} & A_{IH} \\ A_{HI} & A_{HH} \end{bmatrix}, \quad (2)$$

where

$(A_{II})_{ij}$ - square matrix representing the amount of industry i required per unit of industry j (Direct Requirements matrix in the type I inverse matrix),

$(A_{IH})_i$ - vector representing the amount of industry i required per unit of total household income from all sources,

$(A_{HI})_j$ - vector representing the income paid to households per unit of output of industry i (compensation of employees divided by the total output of the industry),

(A_{HH}) - single cell representing the household expenditure per unit of exogenous household income (this cell is set to zero value).

Previous research shows that the use of the "Total use at purchasers' prices" as the denominator when calculating household expenditure coefficients would tend to overestimate the induced effects of changes in the economy by artificially inflating the effect of earned income in generating further rounds of household spending as the sum of the household income vector components would equal 1. Not all household expenditure results from "Income from employment" paid to households as certain amount of household purchases is bought with unearned income (property income, inheritance, pensions and payments received from public welfare). A number of studies suggest the total household income provided by National Statistics offices should be used as the denominator when calculating household expenditure coefficients. The Type II Direct Requirements matrix is also called Augmented Direct Requirements matrix. There are seven types of multipliers and multiplier effects that can be calculated after the type I (or type II) inverse matrices have been derived: output, income, GVA and employment multipliers and income, GVA and employment multiplier effects. The multipliers and multiplier effects should be selected upon the purpose of the research and availability of input data for the calculations. For multipliers, the estimation of direct and indirect impacts on selected variable throughout the whole economy is generated by multiplying a change in final demand (direct impact) by Type I output multiplier. The estimation of direct, indirect and induced impacts on selected variable throughout the whole economy is generated by multiplying a change in final demand (direct impact) by Type II output multiplier. For effects, direct and indirect impacts are generated by using Type I Leontief inverse matrix, while using Type II Leontief inverse matrix also include induced effects in the economy. The research objectives suggest type I and type II income, GVA and employment multipliers should be derived.

Income multiplier

The Type I and II income multipliers for the industry sector j are calculated as follows:

$$(I_{mult})_j = \sum_i \frac{v_i L_{ij}}{v_j}, \quad (3)$$

where

L - Leontief inverse matrix,

v - vector representing the ratio of Income from Employment in the sector to total output of the sector. The Type I and II income multipliers show the increase in income from employment throughout the whole economy that results from a change of one currency unit (€1) of income from employment in the industry sector j.

GVA multiplier

The Type I and II GVA multipliers are calculated as follows:

$$(G_{mult})_j = \sum_i \frac{g_i L_{ij}}{g_j}, \quad (4)$$

where

L - Leontief inverse matrix,

g - vector referring to the ratio of GVA to total output for the sector.

The GVA multipliers show the increase in GVA throughout the whole economy that results from a change of one currency unit (€1) of GVA in the industry sector j.

Employment multiplier

The employment multiplier is calculated as follows:

$$(E_{mult})_j = \sum_i \frac{w_i L_{ij}}{w_j}, \quad (5)$$

where

L - Leontief inverse matrix,

w - vector referring to Full Time Employment (FTE) per one currency unit (€1) of total output for the industry sector.

The employment multipliers show the total increases in employment throughout the whole economy which result from an increase in final demand which is enough to create one additional FTE in the industry sector j.

Consistency testing the Leontief tables and multipliers

The consistency of the Leontief tables and multipliers is tested by calibration, matrix cell value comparison and ratio of income multipliers. The term "calibration" is used to describe the process whereby the Leontief Inverses are checked by calculating the matrix product of the Leontief and the vector of final demands. The outcome of this calculation (if the Leontief's are correct) is to recreate the base year gross outputs at basic prices. It should be apparent that, as the type II Leontief is equivalent to the type I Leontief but also includes induced (or household spending) effects, each and every cell in the type II matrix should be of equal or greater value to its type I equivalent. An extra check is carried out on the income multipliers. Dividing the type I income multiplier for each industry by the corresponding type II value should lead to a constant ratio across all industries.

The method has a few rather important shortcomings. I/O models assume that technological or economic relationships are fixed over time and do not respond to price or cost changes. The method does not reflect possible changes in regional productive structure as it always uses the same input-output table. In cases, it proves to be even more of a drawback if the available input-output table offers data corresponding to a year some way back in time.

III. RESULTS AND DISCUSSION

The data necessary for deriving the multipliers for Latvia were retrieved from the latest set of OECD harmonised national Input-Output Tables database which presents matrices of inter-industrial flows of goods and services either produced domestically or imported in current prices (USD million), covering the years 1995 to 2011 [9]. The OECD database of harmonised national tables takes the industry vs. industry approach covering all sectors of the economy. Considering the period of the policy intervention from 2007 to 2013 the study was based upon the 2009 tables.

As the period of the policy interventions analyzed begins in 2007, the use of I/O table for 2009 is justified by a commonly accepted 6 year period of stability of multipliers. Use of the latest I/O table available for the year 2011 would cover only the ending of the interventions. However, the impact of the global financial crisis from 2008 on could not be reflected in the analysis. Thus, applying the proposed model, problems with timeliness of the key data raises questions regarding the validity of the results.

The standardized tables cover 34 industry sectors. As for the sector "Private households with employed persons" the corresponding rows and columns in the tables are set to zero values, only remaining 33 sectors are included in the matrices. First, the technical coefficients matrix is developed by dividing every cell in totals table to the corresponding sector's labour compensation. Then "I-A" matrix is calculated by subtracting technical coefficients matrix from an identity matrix with 33 rows and 33 columns. The type I Leontief inverse matrix is an inverse matrix of the "I-A" matrix. Second, the column of share of sector consumption expenditures in total consumption expenditures and the row of share of the labour compensation in total output are added to the totals table. The cell in the intersection of the 34th row and 34th column is set to zero. The total consumption expenditures for the Latvia in 2009 are provided by National Statistics office. Then "I-A" matrix is calculated by subtracting enlarged technical coefficients matrix from an identity matrix with 34 rows and 34 columns. The type II Leontief inverse matrix is an inverse matrix of the "I-A" matrix. Third, the vectors of coefficients are calculated. The vector *v* is calculated by dividing labor compensation to industry output in every sector. The vector *g* is calculated by dividing gross value added to industry output in every sector. The vector *w* is calculated by dividing full time employment to industry output in every sector. Finally, the income, gross value added and employment Type I and Type II multipliers are calculated using formulae 3, 4 and 5. After the calculation of the Type I and Type II multipliers, the consistency has been checked. Dividing the type I income multiplier for each industry by the corresponding type II value provides a constant ratio across all industries at 0.2364. As preliminary research shows, this ratio for developed countries fluctuates around the value of 0.8, e.g., 0.86 for The Netherlands in 2001. This points to a rather high share of unearned (possibly, undeclared and untaxed) income in Latvian household expenditures, thus making the use of the type II multipliers unreliable. The calculating of the matrix product of the Leontief and the vector of final demand is expected to recreate the base year gross outputs at basic prices. However, for some sectors the differences are rather marked. This can be explained by compiling the information on final demand variables from various sources. The final demand is calculated by extracting Imports (cross border) and Direct purchases abroad by residents (imports) from sum of Consumption expenditure, Gross Fixed Capital Formation, Direct purchases by non-residents (exports), Exports (cross border). This suggests the calculated values of multipliers should be treated cautiously. For research

purposes, only industry sectors and multipliers with relevance to policy intervention should be considered. The overall objectives of the Latvian Rural Development Programme are focused on agriculture, forestry, food processing, rural tourism and local communities in terms of economic growth and employment creation. The indicators calculated previously for economic growth and employment creation are gross value added and full time employment, respectively. Thus, the corresponding industry sectors from I/O tables should be analyzed by using gross value added and employment multipliers. As for the economic growth, the previously estimated programme direct impacts are multiplied by respective gross value added multipliers to calculate the total secondary impact (Table 1). As some of the programme measures are targeted towards a number of sectors, the calculation of multipliers in that case is impossible. The multiplier value for these sectors is set to one assuming no secondary cumulative impact. Similarly, multiplier values are not applicable for the whole economy. The total estimated programme secondary cumulative impact on economic growth when accounting for multipliers exceeds the previously estimated direct impact more than three times. As all the multipliers are positive, the secondary respective impacts in all the sectors are positive, too. With respect to sectoral level, investments in food processing are the providing the most marked secondary cumulative impact on GVA, followed by agriculture and tourism (hotels and restaurants).

Table 1
Total secondary cumulative impact of the rural development Programme on economic growth (EUR million)

Industry sector	Direct impact	Multiplier	Total secondary impact
Agriculture, hunting, forestry& fishing	147.7	2.9091	428.3
Food products, beverages& tobacco	90.2	4.0954	369.8
Hotels and restaurants	2.4	2.2948	5.5
Other community, social and personal services	26.3	1.9643	52.6
Other sectors	30.5	1.0000	30.5
Total	297.1	n.a	886.8

Table 2
Total secondary cumulative impact of the rural development programme on employment (AWU)

Industry sector	Direct impact	Multiplier	Total secondary impact
Agriculture, hunting, forestry& fishing	-1197	1.9910	-2383
Food products, beverages& tobacco	771	3.4451	2656
Hotels and restaurants	82	1.4973	123
Other community, social and personal services	82	1.0000	82
Other sectors	1055	1.0000	1055
Total	793	n.a	1533

Similarly, the previously estimated programme direct impacts on employment are multiplied by respective employment multipliers to calculate the total secondary impact (Table 2).

The total estimated programme secondary cumulative impact on employment when accounting for multipliers exceeds the previously estimated direct impact almost two times. While the negative direct impact on employment in agriculture and forestry has almost doubled over the entire economy when multipliers are taken into account, the positive secondary cumulative impact in food processing more than offsets this.

IV. CONCLUSIONS

The total estimated programme secondary cumulative impact on economic growth (Gross Value Added) exceeds the previously estimated direct impact more than three times.

With respect to sectoral level, investments in food processing are the providing the most marked secondary cumulative impact on GVA, followed by agriculture and tourism (hotels and restaurants). The total estimated programme secondary cumulative impact on employment (Annual Working Units) exceeds the previously estimated direct impact almost two times. With respect to sectoral level, investments in food processing are the providing the most marked secondary cumulative impact on AWU, followed by agriculture and tourism (hotels and restaurants). In general, policy interventions of Rural Development Programme provide significant positive secondary cumulative impact on economic growth and employment creation.

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REFERENCES

[1] EENRD, "Capturing the success of your RDP: Guidelines for the Ex post evaluation of 2007-2013 RDPs," June 2014.
[2] J. D'Hernoncourt, M. Cordier, and D. Hadley, "Input-Output Multipliers - Specification sheet and supporting material," in Spicosa Project Report, Université Libre de Bruxelles - CEESE, Brussels, 2011.
[3] W. Leontief, *The structure of American economy, 1919-1929: an empirical application of equilibrium analysis.* Harvard University Press, 1941.
[4] W. Leontief, *Studies in the Structure of the American Economy: Theoretical and Empirical Explorations in Input-output Analysis Harvard Economic Research Project.* Oxford University Press, 1953.
[5] W. Leontief, *Input-Output Economics.* 2nd ed., New York: Oxford University Press, 1986.
[6] P.J.A. Konijn, "The make and use of commodities by industries; on the compilation of input-output data from the national accounts," Faculty of Public Administration and Public Policy, University of Twente, Enschede, 1994.
[7] R.E. Miller and P.D. Blair, *Input-Output Analysis: Foundations and Extensions.* Prentice Hall, 1985.
[8] OECD, "Input - output analysis in an increasingly globalised world: applications of OECD's harmonized international

tables," in STI/Working paper 2006/7. [Online]. Available: http://www.oecd.org/dataoecd/6/34/37349386.pdf. [Accessed January 12, 2017].

[9] OECD Input - Output Tables. [Online]. Available: http://www.oecd.org/trade/input-outputtables.htm. [Accessed January 12, 2017].

[10] J. Oosterhaven, *Interregional input-output analysis and Dutch regional policy problems.* Gower, 1981.

[11] D.J. Stynes, "Approaches to Estimating the Economic Impacts of Tourism: Some Examples," Michigan State University, 1999.

[12] C. Surugiu, "The economic impact of tourism. An input-output analysis," Romanian Journal of Economics 29 (2), pp. 142-161, 2009.

[13] M. Wilson, *Sailing in the Clyde economic impact study,* Scottish Enterprise Ayrshire, Glasgow, 2006.

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Competitiveness of the Fishery Sector in Latvia

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Abstract. ***The aim of the research is to evaluate the competitiveness of Fishery Sector in Latvia. Based on the author developed Model of the Factors influencing Competitiveness of the Fisheries Sector Cluster and methodology of the Index of Fishery Sector Competitiveness the authors determined the competitiveness level of Fishery Sector in Latvia and identified spheres influencing competitiveness: facilitating and promising spheres as well as procrastinatory and stagnating spheres, moreover the possibilities of further development were established. The author has developed the evaluation methodology of the Fishery Sector Competitiveness that can be used in any country in the Fishery Sector for the evaluation of competitiveness. The elaborated methodology for evaluation of competitiveness may assist the institutions involved in the Fisheries' policy formation to work more successfully and improve the common policy in the Fisheries sector.***

Keywords: competitiveness, fishery, index, model.

I. INTRODUCTION

In the development of Latvia's economy fishery, which has been one of the most ancient people's activities, has always had a significant importance, especially in development of the coastal areas of the Baltic Sea and the Gulf of Riga. In Latvia, fishery has not only ancient history and traditions, but also an internal self-development potential. Using the support opportunities provided by the EU funding instruments and participating in formation of the Common Fisheries Policy, wide possibilities of facilitating competitiveness and growth reveal to the Latvian fishery sector.

The length of the Latvian border is 1 836 km and the coastline is 494 km log or 27%, which is 0,7% of the total EU coastline of 66 000 km [3]. The territorial waters of the Baltic Sea, up to 12 sea miles from the coastline, also the economic area and continental shelf of the area of 28 thousand km^2 are under the state jurisdiction [1].

Fishing opportunities and catch quotas in the Baltic Sea and the Gulf of Riga are available to Latvia, based on long-term environmental and fish resource study at the national and international level. According to the cross-border agreements concluded by Latvia, there are opportunities of fishing also in the economic areas of other countries and regions covered by the international conventions [6].

High-seas fisheries take place in the areas confirmed by the Northwest Atlantic Fisheries Organization (NAFO), Northeast Atlantic Fisheries Commission (NEAFC) and Fishery Committee for the Eastern Central Atlantic (NEAFC) [3].

In 2015, Latvian fishing fleet consisted of 686 fishing vessels with the total engine power of 43.30 thousand kW and total gross tonnage of 24.68 thousand (GT). The fishing fleet included 7 high-seas vessels, 68 ships, fishing in the Baltic Sea beyond the foreshore in the gulf, and coastal small volume fishing boats. The total catch in 2015 was 81.31 thousand tons. In the national territorial waters mostly the catch consisted of sprat, Baltic pilchard and cod, in turn, in high-seas – mostly scad, sardine, round sardinella and mackerel.

Environmental pollution, inimical spawning conditions as well as intensive fishing and other factors have negative impact on the fish stock, as a result the number of catch quotas and the amount of fish available in the Baltic Sea reduces, resulting in negative influence on the operation of fishery and fish processing companies, simultaneously increasing the role of the aquaculture sector in acquisition of alternative fish resources [6].

Several studies show that the Baltic Sea, which according to the World Wide Fund for Nature is one of the youngest seas and one of the largest bodies of brackish waters, is one of the most polluted seas in the world [13], not only due to the consequences of fishery activity, but also other factors (such as waste waters, rubbish, munition lying on the sea floor after World War II and chemicals it contains, etc.). The Baltic Sea is almost entirely closed; it is comparatively shallow (average depth 55 km) and rarely freezes up. During severe winters mainly the Gulf of Riga, which is the shallowest of the big gulfs in the Baltic Sea (its average depth is 26 m), freezes up and thus limits the fishing activities. Considering the unique ecosystem of the Baltic Sea determined by its special geographical and hydromorphological conditions [3] one must sustainably manage it.

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The Common Fisheries Policy of the EU strives to ensure ecologically sustainable fisheries activities over a long term and fisheries management corresponding to the objective of ensuring benefits in economic, social and employment spheres, facilitating availability of food [4]. The overall objective of the Common Fisheries Policy is to ensure that fishing and aquaculture activities contribute to the creation of environmental conditions capable of being sustained long-term which are necessary for economic and social development. Moreover, it should foster increased productivity, a fair standard of living for the people employed in the fisheries sector and stable markets, and it should ensure the availability of resources and that products reach consumers at reasonable prices [5].

Facilitation of competitiveness has become one of the major objectives in the development strategy of companies, branches and countries [12]. Taking into account the dependence of fishery on the fishing opportunities, coordinated at the EU level corresponding to the principles of sustainability, and increase in global rivalry in the world markets, strengthening of fishery's competitiveness plays a significant role. Evaluation of competitiveness provides an opportunity to judge impartially and allows understanding the need in structural reforms and choice of priorities better.

Research aim – to evaluate the competitiveness of the fishery sector in Latvia. To reach the aim, the following work tasks were set: 1) to elaborate the methodology for competitiveness of the fishery sector; 2) to evaluate the competitiveness of the fishery sector in Latvia, identifying the spheres ensuring competitiveness.

The novelty of the research – developed evaluation methodology of the Fishery Sector Competitiveness that can be may assist the institutions involved in the fisheries' policy-making to work more successfully and improve the common policy in the fisheries sector.

The qualitative and quantitative research methods were used in the study, including the general scientific research methods, statistical research methods, mathematical methods and sociological research methods. Microsoft Excel was used in the processing and analysis of the study results.

II. MATERIALS AND METHODS

According to the Model of the Factors Influencing Competitiveness of the Fisheries Sector Cluster elaborated by the author one can identify factors influencing the competitiveness of the fisheries sector, and they are: various internal and external social, economic, political, natural and cultural environmental factors (including random events) and the ability to adapt them, as well as formation of mutual interaction and cooperation forms and relationship among affiliated companies and support infrastructure institutions (Fig. 1).

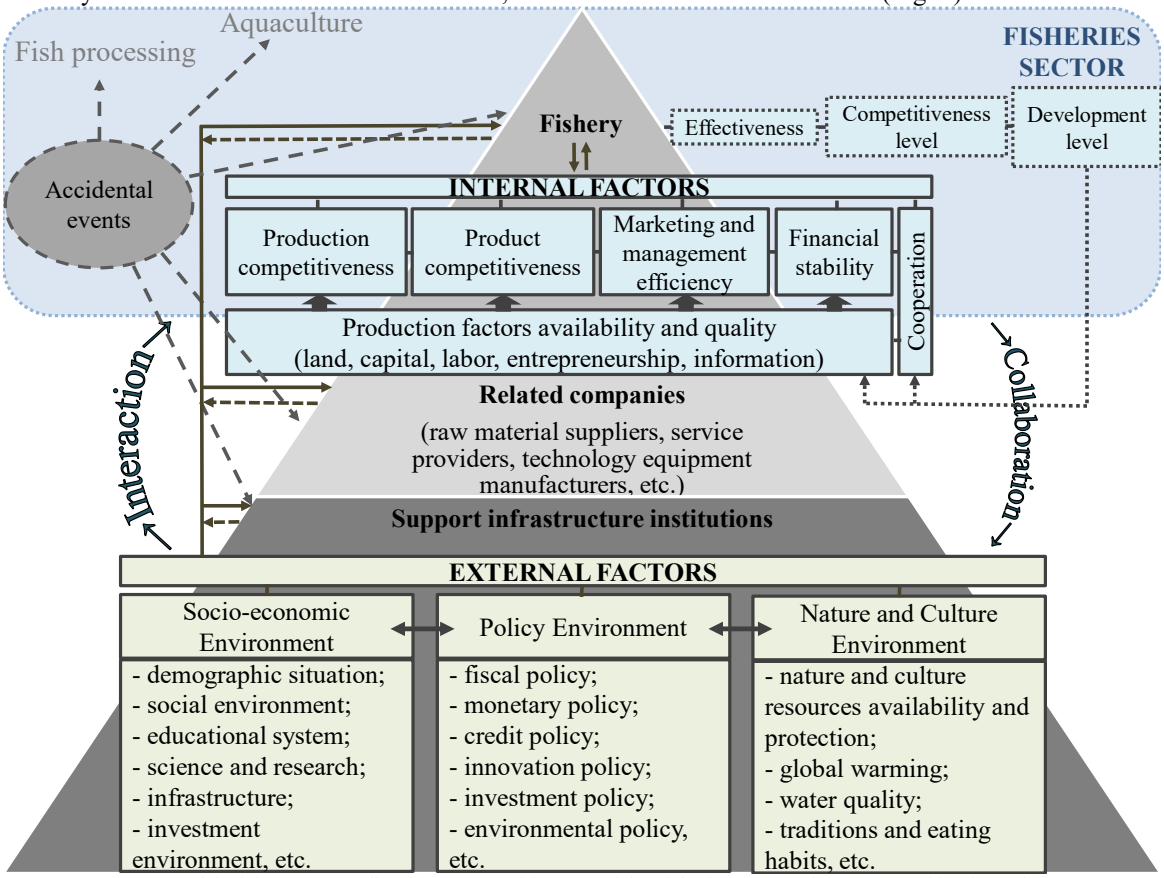

Fig. 1. Model of the Factors Influencing Competitiveness of the Fisheries Sector Cluster [created by the author]

To evaluate competitiveness of Latvia's fishery sector at the level of microeconomics, the author elaborated the Fishery Sector Competitiveness Index (Fig. 2).

The development of the Index is based on the Model of the Factors Influencing Competitiveness of the Fisheries Sector Cluster elaborated by the author.

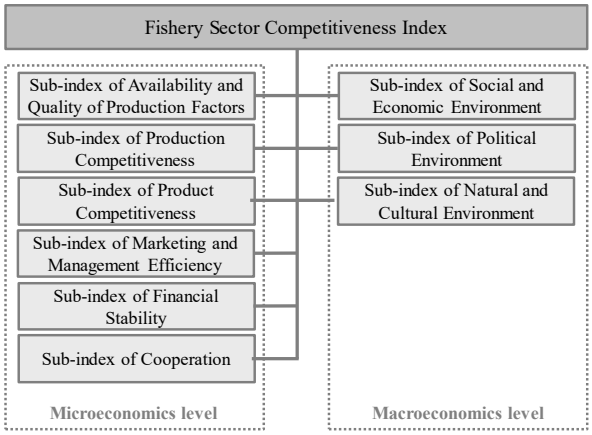

Fig. 2. Fishery Sector Competitiveness Index [created by the author]

Calculation of the Fishery Sector Competitiveness Index at the level of microeconomics is based on 6 sub-indexes in terms of functions from their relative proportions and normalized values of indicators of the factors influencing the competitiveness (1).

$$SI = \alpha\left(I_1^{nv} + I_2^{nv} + I_3^{nv} + ... + I_n^{nv}\right) \quad (1)$$

where: SI - Sub-indexes, α - relative scales, $I_1^{nv} ... I_n^{nv}$ - indicators with the normalized values.

All in all, the author selected 22 indicators [7] and more than 35 sub-indicators as well as used several additional indicators, the choice of which was determined by the main conditions for indicators selection, elaborated by the author [9], to evaluate competitiveness. The author performed normalization of the indicators on the basis of min-max algorithm values from -5 to 5.

The Index of the Fishery Sector Competitiveness is a tool for assessing the fishery competitiveness, which allows identified facilitating and promising spheres as well as procrastinatory and stagnating spheres influencing competitiveness.

The Index of the Fishery Sector Competitiveness can be used as a basis for the development of a specific strategy and the implementation of a proper investment policy (Table 1).

Table I
The promotion strategies of the competitiveness [created by the author]

Competitiveness	Strategy type			
	Penetration strategy	Enlargement strategy	Development strategy	Improvement strategy
$C_{L(-0<)}; G_{P(0\leq)}$	✓	-	-	-
$C_{L(-0<)}; G_{P(>0)}$	-	✓	-	-
$C_{L(>0)}; G_{P(0\leq)}$	-	-	✓	-
$C_{L(>0)}; G_{P(>0)}$	-	-	-	✓

where: C_L – competitiveness level, G_P – growth pace.

Penetration strategy foremostly provides for implementation of measures to strengthen spheres procrastinating competitiveness, where cooperation plays a significant role. Enlargement strategy foremostly provides for implementation of measures to strengthen spheres stagnating competitiveness. In turn, development strategy provides for implementation of measures to strengthen spheres promising competitiveness. Only improvement strategy provides for implementation of measures to strengthen spheres promising competitiveness.

The evaluation methodology of the Fishery Sector Competitiveness developed by the author can be used to evaluate competitiveness of the fishery sector of any country. The elaborated methodology for evaluation of competitiveness may assist the institutions involved in the Fisheries' policy formation to work more successfully and improve the common policy in the Fisheries sector.

III. RESULTS AND DISCUSSION

The competitiveness of the fishery sector in Latvia during the period from 2005 to 2014 is evaluated as medium-high (1.59) (Fig. 3).

In this period the competitiveness of the fishery sector in Latvia increased by 108%: from 1.00 in 2005 to 2.07 in 2014.

The fishery sector as any other sector of the economy has its own spheres that influence competitiveness – facilitating and procrastinatory spheres as well as promising and stagnating spheres, ensuring the competitiveness of the sector and its further development potential.

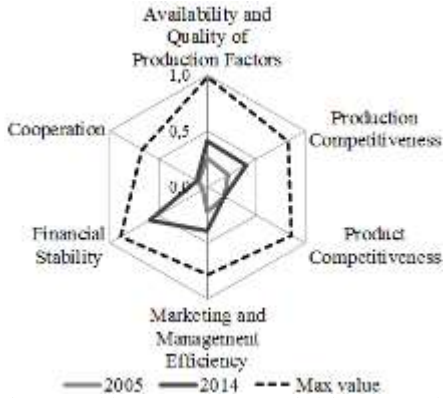

Fig. 3. The competitiveness assessment of Fishery Sector in Latvia according by the spheres in 2005 and 2014 (value of sub-indexes) [calculated and create by the author according to 2, 10, 11]

The facilitating spheres of the fishery sector competitiveness are the financial stability, the marketing and management efficiency, the availability and quality of production factors, the production competitiveness as well as the cooperation. Although product competitiveness in the fishery sector may be evaluated as average high, currently it is in stagnation and a transitional stage between the facilitating and promising sphere (Fig. 4).

There was an average high level of competitiveness also in cooperation, in turn, high level of competitiveness – in availability and quality of production factors, production competitiveness, marketing and management efficiency as well as in financial stability. Fishery sector has no spheres procrastinatory and stagnating the competitiveness.

The companies that operate in the fishery sector in Latvia and the representatives of the institutions involved in the fisheries sector policy-making and implementation believe that the growth of the sector competitiveness can be promoted by the implementation of a number of interrelated and subordinated measures (Fig. 5).

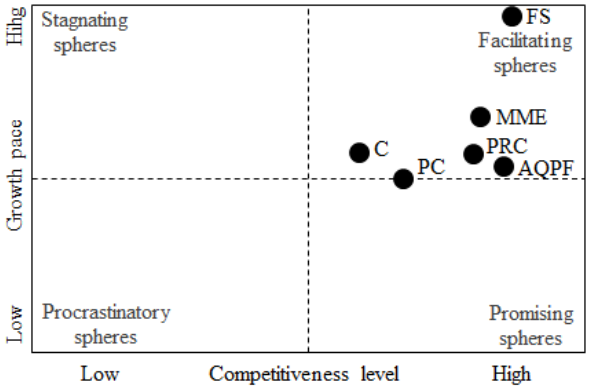

Fig. 4. The ensuring spheres of the competitiveness of Fishery Sector in Latvia [calculated and create by the author according to 2, 10, 11]

where: $AQPF$ - Availability and Quality of Production Factors, PRC - Production Competitiveness, PC - Product Competitiveness, MME - Marketing and Management Efficiency, FS - Financial Stability, C – Cooperation.

The competitiveness of the fishery sector in Latvia can be promoted by an efficient and rational use of EU financial instruments and support options provided by the state, making a cost optimization, as well as manufacturing innovative products of good quality with a high added value and creating a strong cooperation (particularly coastal fishery). According to the opinion of the companies and the representatives of the institutions involved in the fisheries sector policy-making and implementation the competitiveness of the fishery sector in Latvia can be also promoted by the other measures.

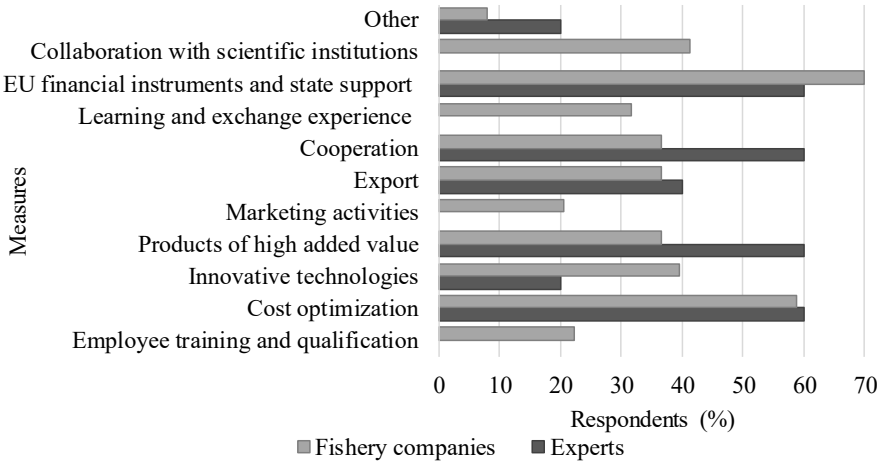

Fig. 5. The promoting measures the competitiveness of Fishery Sector in Latvia (respondents, %) [calculated and create by the author according to 8]

Although the measures proposed by the fishery companies and the representatives of the institutions involved in the fisheries sector policy-making and implementation are focused on promotion the competitiveness of the fishery sector in Latvia and they are considered useful, however, the author

believes that the promoting measures should be structured and implemented according to the chosen development strategy and investment policy. There are several types of strategies, however, in the opinion of the author, to facilitate the competitiveness of the fishery sector in Latvia a strategy of corresponding approach should be developed.

For Latvia's fishery sector all the spheres are spheres facilitating competitiveness (except product competitiveness), consequently to contribute to the sector's competitiveness it is recommended to implement the improvement strategy. In the framework of development strategy one should foremostly implement measures to strengthen spheres facilitating competitiveness in the fishery sector, and only then – to strengthen the other its spheres.

IV. CONCLUSION

In the development of the Latvia's economy fishery has always had a great importance. It has not only ancient history and traditions, but also an internal self-development potential, where using the support opportunities provided by the EU funding instruments and participating in formation of the Common Fisheries Policy of the EU wide opportunities of enhancing competitiveness open to the Latvia's fishery sector.

Currently the competitiveness of Latvia's fishery sector may be evaluated as average high, which is to a great extent ensured by financial stability, marketing and management efficiency, availability and quality of production factors, production competitiveness and cooperation. To facilitate the competitiveness of Latvia's fishery sector the author recommends implementing the improvement strategy.

REFERENCES

[1] Agriculture Ministry, "Ricibas programma zivsaimniecibas attīstībai 2014. – 2020. gadam (Operational Programme for Development of Fisheries 2014-2020)," CCI 2014LV14MFOP001, p. 138, 2014 (In Latvian).

[2] Central Statistical Bureau database, 2017. [Online]. Available: http://data.csb.gov.lv/pxweb/lv/?rxid=cdcb978c-22b0-416a-aacc-aa650d3e2ce0 [Accesed: January 03, 2017] (restricted access data).

[3] European Commission, "Eiropas Jūrlietu un zivsaimniecības fonds Latvijā (European Maritime and Fisheries Fund in Latvia)," p. 4, 2014 (In Latvian).

[4] European Parliament and Council, "European Parliament and Council Regulation (EU) No. 1380/2013 on the Common Fisheries Policy, amending Council Regulations (EC) No 1954/2003 and (EC) No 1224/2009 and repealing Council Regulations (EC) No 2371/2002 and (EC) No 639/2004 and Council Decision 2004/585/EC," Official Journal of the EU, L 354, pp. 22-61, 28.12.2013.

[5] European Parliament and Council, "European Parliament and Council Regulation (EU) No. 508/2014 on the European Maritime and Fisheries Fund and repealing Council Regulations (EC) No 2328/2003, (EC) No 861/2006, (EC) No 1198/2006 and (EC) No 791/2007 and Regulation (EU) No 1255/2011 of the European Parliament and of the Council," Official Journal of the EU, L 149, pp. 1-66, 20.05.2014.

[6] Finance Ministry, "Single Programming Document for Latvia. Objective 1 Programme 2004 – 2006," p. 365, 2003.

[7] I. Biukšāne, "Index of the Fisheries Sector Cluster Competitiveness: Internal factors," SGEM2016 Conference Proceedings, Book II, vol. 4, pp. 347-354, doi: 10.5593/SGEMSOCIAL2016/B24/S07.046, 2016.

[8] I. Biukšāne, "The results of the Interviews and the Questionnaire given by the representatives of the institutions involved in the Latvian fisheries sector policy-making and implementation and the fishery sector companies' survey results (18.03.2016. - 13.04.2016.)" (restricted access data).

[9] I. Biukšāne, I. Judrupa, "Evaluation of competitiveness of the fisheries sector cluster," International Scientific Conference "Research for Rural Development 2016" Proceedings, vol. 2, pp. 238-245, 2016.

[10] Latvian Fisheries integrated control and information system "LFICIS" database, 2017. [Online]. Available: https://lzikis.zm.gov.lv/Account/LogOn [Accesed: January 03, 2017] (restricted access data).

[11] Producer organizations, "Latvian producer organizations data", 2017 (restricted access data).

[12] R. Škapars, Ē. Šumilo, *Latvijas ekonomikas un sabiedrības pārstrukturizācijas ietekme uz uzņēmējdarbības konkurētspēju un iedzīvotāju dzīves kvalitāti (Impact of Latvian Economy and Society Restructuring on the Competitiveness of Companies and life Quality of the Population).* Rīga: LU Akadēmiskais apgāds, 2006, p. 339 (In Latvian).

[13] World Wide Fund for Nature, "Clean Baltic within Reach? How can a new chemical policy contribute to the protection of the Baltic Sea?," p. 4, 2005.

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Environmental Communication in Latvian Municipal Newsletters

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Abstract. The present study reviews environment-related articles in official newsletters issued by municipalities in Latvia. It evaluates the themes and contents associated with environment in order to evaluate the performance of newsletters as providers of relevant information to the population. Official publications of four Latvian municipalities-Mazsalaca, Jūrmala, Krāslava, and Kandava—were analyzed. Common themes included nature and its protection, history of the place, social and cultural events, quality of life and performance of the municipality. A widespread approach of engaging the local population is to hold contests and competitions. However, it is uncertain if the response rate help raising the civic participation level significantly. The official newsletters are willing to publish environment-related public relations materials prepared by other institutions of companies, without exhibiting consistent editorial policy of their own. The implications of the continued publication of these newsletters as competitors to the regional independent newspapers are also discussed.

Keywords: municipal newsletters, municipal newspapers, journalism, environmental communication, municipal communication.

I. INTRODUCTION

One of the tasks of an administration is to keep the stakeholders informed about the topicalities and policies under its supervision. This principle applies to municipal governance, too. The local population is a key stakeholder, and their awareness about their environment and activities of the municipality is crucial to the accountable and effective implementation of these policies.

A communication channel favored by municipalities in Latvia is official newsletters—a print outlet, which in most cases is being distributed for free straight to the mailboxes of all inhabitants [1]. Recently, such practices of publishing have come under fire in Latvia. Media experts have pointed out that these official newsletters attempt to emulate local newspapers and unfairly compete with them in the media market without fulfilling the role of a journalistic outlet. Rather than independently evaluating the work of the local government, these official newsletters serve as a public relations instrument aimed at presenting the municipal council in a positive light.

A recent initiative to restrict the ability of municipalities to pass their official newsletters for mass media in the sense of the "Law on the press and other mass media" has been struck down by the parliament of Latvia [2]. This means that in the near future the Latvian municipalities will continue the previous endeavors of what has been described as providing self-approved and uncritical view on the current events and workings to their voters [3]. As such, this communication practice invites closer evaluation of the messages the municipalities compose and the approaches they take to pass them down to the local inhabitants.

Since official newsletters are issued by municipalities, it is to be expected that their contents reflect the judgement of the municipality regarding which topics and themes should be covered and how. In this study, I analyze how the municipalities cover the environment in their newsletters. The term "environment" here is understood in a broad sense, which includes nature, cultural and historical heritage, safety, and quality of life. The aim of this paper is to evaluate how the municipalities through the environment-related topics reflect on the topicalities of the populated area and how they present the opportunities to participate in the shaping of the environment to their audience.

Communication about the environment is one of the ways in which municipalities can present themselves as an attractive place to live, work, and rest. However, the challenge these newsletters face is to live up to standards—if not to those of independent media, then at least to those of public relations in the positive sense of the term. Rather than simply influencing the perceptions of the municipality among the population, municipal public relations denote *communication* between the local government and the citizens "in the interest of an informed public opinion" [4].

Since municipal newsletters compete with the independent outlets in the media market, it is

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important to evaluate the diversity and thoroughness of these newsletters. The absence of such qualities reduces the justification for municipalities to operate in the media business even further.

II. METHODOLOGY

Newsletters of four municipalities in Latvia—Mazsalaca, Krāslava, Kandava, and Jūrmala—were reviewed. The municipalities were selected to reflect the diversity of areas in terms of size of territory and population, availably of natural and cultural resources, and location.

This study examines the most common environment-related themes in the municipal newsletter. Rather than defining relevant codes based on the previous theoretical assumptions, the paper seeks patterns during the review of the data and presents insights based on them. As such, this approach is influenced by the core ideas of the grounded theory [5].

Four municipal newsletters were analyzed. "Jūrmalas pašvaldības informatīvais biļetens" (The newsletter of Jūrmala municipality), which in 2016 was renamed "Jūrmalas avīze" (Jūrmala newspaper), contains 16 pages is issued twice a month; "Kandavas novada vēstnesis" (Kandava municipality herald) has 16 pages and is issued once a month; "Krāslavas vēstis" (Krāslava tidings) is issued twice a month and contains eight pages; and "Mazsalacas novada ziņas" (Mazsalca municipality news) is published once a month and has eight pages.

In the sample, I included the issues from 2015 and 2016.

III. RESULTS

A number of common environment-related topics and publishing practices were identified during the examination of articles. Tis subsection provides and overview of them.

Nature and the protection of nature

Nature is an important resource that can be linked to a number of other aspects that describe the conditions in the particular area and the quality of life.

While the newsletters do touch upon such themes from time to time, articles in this category tend to cover relatively narrow aspects of the protection of nature and are being published as a reaction to specific events or behaviors by the population. Little attention is devoted to raising awareness of the importance of nature or detailing the current state of the issue in the area.

Newsletters readily publish articles on the annual joint work activities "Lielā talka," which take place each spring in Latvia. The aim of "Lielā talka" is to involve other people in tidying up littered territories—this non-governmental initiative was started in 2008 and now has become a steady tradition maintained by local coordinators in many territories in Latvia [6]. The politicians of municipalities also take part in the work, presumably as a publicity stunt, and newsletters report on what has been achieved during the joint work and what the superiors of the municipality did.

Few articles include a call to action for readers regarding other activities related to the protection of the environment. Additionally, newsletters generally lack proactive attempt to discourage undesirable or hazardous human behavior, even in cases when such a behavior is seasonal in nature. An example here is burning of last year's grass in spring—a dangerous and harmful "tradition" of clearing up a territory in which grass has not been cut the year before. Municipal newsletters report that incineration is taking place and that it poses a danger to both nature and property. However, little attention is being paid to this practice before it breaks out—although it is to be expected that at least to some extent the burning will occur each year and thus it is important to inform people about the costs and other disadvantages of this Latvian practice in advance.

All in all, the studied newsletters pay relatively small attention to provision of information about nature, its significance and the need to protect it. Furthermore, little effort is made to address the readers proactively and ask them to do or abstain from doing certain things that harm the nature.

Cultural environment, education, and society

All of the reviewed newsletters cover current events in the territory—news from schools, cultural or sports events; occasionally feature stories and interviews with notable people take up a large part of their pages. Examples of such articles are those that inform about marine-themed exhibitions in Jūrmala [7], a storytelling evening on love in Mazsalaca library [8], or the 130th anniversary of Zante primary school in Kandava municipality [9]. This kind of information is arguably relatively easy to obtain—cultural events and various school activities usually take place regularly, with or without a direct a participation from the municipality.

Simultaneously such reports are particularly useful for the image-building of the municipality. They construct a general perception about the vibrant social and cultural life of the place, and the readers will get a sense that their place or residence is not an isolated and abandoned territory where nothing happens.

History and the present

History plays a significant role in shaping the perceptions of an inhabited territory and promoting the identification of the population with it [10]. Knowing how their town, parish, or district has developed through the time, may foster the

development of the sense of belonging and increase the awareness of the environment.

The reviewed newsletters differ greatly in the way they cover such themes. "Mazsalacas novada ziņas" publishes a column "Mana nama stāsts" (The story of my house), which extensively and in detailed manner describes the history of particular buildings in the municipality. "Kandavas novada vēstnesis" on a regularly provides local historian Agris Dzenis' stories on different places and people related to the municipality.

The other two municipalities take a more passive approach. They may cover commemorations of historic events that take place in the territory, but in many cases, such events simultaneously serve as a photo opportunity for local politicians. For example, in 2015, Krāslava newsletter reported on the commemoration of the liberation of Latgale in 1920 [11]—however, the article seemed to pay more attention to the fact that among the guests of the event were the Latvian minister of Defense and representatives of the Polish embassy than to the analysis of the historical events. While the presence of dignitaries does act as a marker of significance, it is important not to lose focus on other important roles that commemoration, remembrance, and other history-related themes have in societies.

The quality of life and the performance of the municipality

The concept of environment also relates to the living conditions in the particular municipality. The newsletters typically put great emphasis on the positive contributions the municipality councils provide to the territory, such as various improvements, renovations, innovations, attraction on investment, and the like. Examples of the coverage of such aspects are articles about the successful implementation of the project for the development of water management in Jūrmala [12]; the column of the chairman of the Kandava municipality, in which he explains how the municipality council intends to solve some of the practical problems, such as excessive dust on country roads [13]; or plans to demolish an abandoned and dangerous building in Krāslava [14].

It was to be expected that the leadership of a municipality would attempt to present themselves as attentive to the needs of the population and constantly making things better. In this regard, somewhat more telling are reflections on the current situation in the municipality, including acknowledgement of various deficiencies—or the lack thereof.

The newsletters usually are reluctant to take such an approach, and their role as the mouthpieces of municipal councils prevents them from evaluating critically the work of the municipality. Articles that discuss the living conditions, societal problems, or measure political sentiment among the local population are virtually inexistent. However, sometimes these outlets are able at least mention the problems and challenges the local population face and provide useful information that might help the audience to evaluate the situation in a realistic manner.

A rare example of this is from Krāslava. One of the Latvian towns in which SEB bank recently closed its branch, thus for the time being Krāslava was left without a single bank office in the town. A number inhabitants reportedly had taken the news as an ominous sign—today a bank office is closed, tomorrow other services might follow, including the post office and bus terminal. Krāslavas vēstis reacted to these rumors and attempted to counter them [15].

The involvement of audience

Apart from the most prominent environment-related topics in the newsletters, another theme became apparent—the way these outlets speak to the audience and what efforts they put into encouraging them to take part in shaping of their own environment and contribute to it. Addressing the population can be seen as a recognition—a reciprocal relationship that holds a potential to raise civic engagement [16].

Articles that encourage active participation of the readers in environmental issues instead or merely providing information are quite rare. Such an approach mostly can be observed in articles that cover the issues of nature and ecology—for example, it manifests itself through the calls not to burn the last year's grass [17], an issue discussed previously, or appeals not dispose trash outside the designated places.

However, municipalities do try to involve people, usually through various contests. Among such contests announced in the newsletters were an idea competition for a new environmental object for newly-weds [18], photo contest in which participants are urged to present a place dear to them [19], project tenders for landscaping activities [20], to name a few. Usually it is not clear how popular such competitions are and how many submissions the organizers receive. However, Krāslava municipality reported that it received six submissions to the idea contest for the newly-weds' environmental object [21]. Given that this town has more than 9000 inhabitants and the competition was described in a multiple issues of the newsletter, it is not a large number.

Such contests as a way to invite the civic involvement involve a considerable risk that they are appealing mostly to the part of the population that already is socially engaged—and this segment might be a minority. To reach out to a wider public, the municipalities should provide more diverse opportunities of participation, which does not necessarily involve submission of competition materials to the municipality.

Authors of the publications

Typically, the articles published in the municipal newsletters are written by authors who work for the municipality. However, a number of environment-related articles come from external sources. Publications on the protection of nature in many cases have been based on press releases from, for example, the waste management company "ZAAO," which urges people to sort waste for recycling or describes the achievements of the company [22]; the Latvian Ministry of Agriculture, which informed about the hunting of wild animals that cause damage to farms and forests [23]; or used paper collection competition held by the waste management society "Piejūra" [24].

Newsletters also publish externally prepared public relations materials on other topics, such as cultural events [25], but the difference is that press releases written by commercial companies or governmental institutions usually are not uniquely targeted at the audience of the particular newsletter. These are published in newsletters of other municipalities and unrelated media outlets, too.

Such a practice illustrates a pattern of utilizing information submitted by other organizations and companies, rather than formulating and executing the newsletter's agenda based on its own editorial principles. Thus, instead of reflecting the conscious attention the municipality might want to pay towards environmental issues, such articles frequently are the result of public relations and publicity efforts by other parties. Such an approach leaves segments of environmental communication to drift on its own, instead of being directed by the environmental policy of the municipality.

IV. CONCLUSIONS

The newsletters of four municipalities—Mazsalaca, Kandava, Krāslava, and Jūrmala—do cover numerous environment-related topics. At the same time, these media outlets generally leave much to be desired in terms of their ability or willingness to address the urgent issues that the local population faces in their diversity. The fact that these newsletters cover activities of the very same institutions that are responsible for these outlets means that only issues and interpretations favorable towards the municipality are printed.

Municipal newsletters provide information about the natural, historical, cultural, and social environment of the inhabited place, but the publications do not suggest the existence of consistent editorial policies that underlie their selection and execution of themes. Articles on the protection of nature are published sporadically and usually retroactively. Many other environment-related themes gain prominence mostly in case if something good has happened or is about to happen—water management system reconstructed, dangerous building torn down, dust on roads reduced. Shortcomings or deficiencies usually are only acknowledged if the municipality simultaneously is not able to promise solutions to them. The newspapers are willing to present successes in various fields of municipal activities, but the few articles discuss challenges the municipality faces are more of exception.

A stable thematic direction is cultural and social life, though, and some newsletters also pay considerable attention to history. Nonetheless, history, as well as the depiction of social and cultural events is themes through which municipal newsletters can emulate independent regional newspapers the closest. These topics are also covered by these newspapers, which traditionally have played an important role in shaping the local cultural identity, while at the same time being part of it [26]. Thus, municipal newsletters also claim a role in shaping local identity, albeit in a more restricted way.

The inconsistency of editorial policy toward environment-related topics is also evident in the authorship of the articles. Usually publications are written by the newsletter staff and/or public relations people of the municipality. However, it is not uncommon, especially regarding topics related to the natural protection and safety from various hazards, that these newsletters publish materials prepared by other institutions or companies. Such a practice creates an impression that the newsletter is very open to outside contributions that allow them to fill the space of the paper with relatively little effort.

Thus, the findings once again bring into focus the function of municipal newsletters as public relations instruments, rather than real journalistic media, which are bound by such principles as impartiality, editorial autonomy, immediacy, and providing public service to the society [27]. The distinction between independent local newspapers and municipal newsletters admittedly is not always clear-cut: the newsletters do also publish valuable and timely content, and some of the articles referred to in this paper illustrate this. It is also possible that a nominally independent media outlet reports on the activities of a municipality in an uncritical manner [28]. However, readers of municipal newsletters should be aware of the limitations this media genre has so that they do not confuse an imitation of a journalistic outlet with a genuine one.

Since the Latvian parliament has rejected the recent proposals to restrict the rules of publication for these newsletters [2], it is to be expected that the current practice will continue in the future. Under such conditions, one can only—naïvely—hope that the municipal leaders in Latvia themselves are capable of redefining the purpose of their official outlets from that of publicity instrument to providing the population with more relevant and well-considered information on their natural, cultural, and living environment.

V.ACKNOWLEDGMENTS

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REFERENCES

[1] Petrova, A. (2016). State gets to work on municipal newspapers. Public broadcasting of Latvia. 13.10.2016. http://www.lsm.lv/en/article/societ/society/state-gets-to-work-on-municipal-newspapers.a205271/

[2] BNS/The Baltic Times. Saeima rejects proposal to ban municipalities from funding mass media. The Baltic Times. 2017.02.02. http://www.baltictimes.com/saeima_rejects_proposal_to_ban_municipalities_from_funding_mass_media/

[3] Andersone, I. Latvia: Discussions about municipal newsletters and media independence. European Centre for press and media freedom. 2016. https://ecpmf.eu/news/legal/archive/latvia-discussions-about-municipal-newsletters-and-media-independence

[4] Wheeler, P. D. Municipal public relations. The American Journal of Economics and Sociology, 15(3), 1956. pp. 315–320.

[5] Glaser, B. G., Strauss, A. L. The discovery of grounded theory: Strategies for qualitative research. New Brunswick: Aldine Transaction, 2006.

[6] Talkas.lv. Talkas ideja. http://www.talkas.lv/?page=558

[7] Jūrmalas pašvaldības Sabiedrisko attiecību nodaļa. Vairāk jūras tematikai veltītu izstāžu. Jūrmalas avīze. 2016.07.07. http://news.lv/Jurmalas-Avize/2016/07/07

[8] Apsīte, L. (2016). Mīlestības stāsti bibliotēkā. Mazsalacas novada ziņas, 2. 2016. 2. lpp.

[9] Kandavas novada vēstnesis. Zantes skolai – 130. Kandavas novada vēstnesis, 126(10). 2015, 1. lpp.

[10] Friedman, J. The past in the future: history and the politics of identity. American Anthropologist, 94(4). 1992, pp. 837–859.

[11] Škutāne, E. Pasākums par godu kritušajiem poļu karavīriem. Krāslavas vēstis, 1. 2015, 4. lpp.

[12] Zaķe, A. Sekmīgi īstenota Jūrmalas ūdenssaimniecības attīstības projekta trešā kārta, Jūrmalas avīze, 2016.07.07.

[13] Štoferts, N. Novada svētki. Kandavas novada vēstnesis, 134(6). 2016, 2. lpp.

[14] Krāslavas vēstis. Bijušās viesnīcas ēka tiks demontēta. Krāslavas vēstis, 276(11). 2016, 4. lpp.

[15] Škutāne, E. "Dariet, ko spējat, ar to, kas jums ir, tieši tur, kur esat!" Krāslavas vēstis, 2. 2015, 4. lpp.

[16] Divay, G., & Micheau, M. Recognizing citizens in municipal management: An exploratory study based on a content analysis of municipal websites in the province of Quebec. International Review of Administrative Sciences. 2016.

[17] Cepurīte, E. Sausās zāles dedzināšana ir bīstama cilvēkam un kaitē videi. Jūrmalas pašvaldības informatīvais biļetens, 83(48). 2015.

[18] Krāslavas vēstis. Jauns vides objekts kāziniekiem Krāslavas pils kompleksā. Krāslavas vēstis, 3. 2015, 4. lpp.

[19] Kandavas novada vēstnesis. Piedalies fotokonkursā „Ar mīlestību savā novadā". Kandavas novada vēstnesis, 118(2). 2015, 10–11. lpp.

[20] Jūrmalas pilsētas dome. Iedzīvotāju iniciatīvas projekti. Jurmala.lv. 2015. http://www.jurmala.lv/page/1851

[21] Kozačuka, T. Tuvākajā laikā pils kompleksu rotās skaista "Mīlas kariete". Krāslavas vēstis, 252(7). 2015, 4. lpp.

[22] Leimane, Z. Dzīvot ietaupot un videi draudzīgi. Mazsalacas novada vēstis, 12. 2016, 2. lpp.

[23] Kalniņa, V. Par savvaļas medījamo dzīvnieku postījumiem. Krāslavas vēstis, 13. 2016, 2. lpp.

[24] Atkritumu apsaimniekošanas sabiedrība "Piejūra". Aicina piedalīties makulatūras vākšanas konkursā. Kandavas novada vēstnesis, 10. 2016. 12. lpp.

[25] Krogzeme-Mosgorda, B. & Pokratniece, K. Latviešu folkloras krātuves izbraukuma seminārs, Mazsalacas novada vēstis, 4. 2016, 2. lpp.

[26] Zelče, V. (2006). Lokālā prese — kopienas informācijas vides veidotāja. Grām.: I. Brikše, Informācijas vide Latvijā: 21. gs. sākums. Rīga: Zinātne, 2006. 144–166. lpp.

[27] Kovach, B. & Rosenstiel, T. The elements of journalism. New York: Crown Publishers, 2001.

[28] Kupčs, E. (2015). Pašvaldību "avīzes" – domju slavināšana un izklaides raksti, zaudēta demokrātija nākotnē. Latvijas sabiedriskie mediji. 2015.11.30. http://www.lsm.lv/lv/raksts/zinju-analiize/zinas/pasvaldibu-avizes--domju-slavinasana-un-izklaides-raksti-zaudeta-demokratija-nakotne.a157269/

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Melting Temperature Behavior of Different Energy Crop Ashes

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Abstract. For solid fuels ash melting temperature is recommended to be higher than 1000°C, so that it can be used in automated furnaces; therefore-promising energy crops are investigated as renewable energy source. This paper presents the results of tests on melting temperature of different energy crop ashes.The field trial was carried out in the study farm of the Latvia University of Agriculture "Pēterlauki" (56°53'N, 23°71'E) in the sod calcareous soils characterized by pH KCl 6.7, P 52 mg kg^{-1}, K 128 mg kg^{-1}, organic matter content from 21 to 25 g kg^{-1} in the soil. Energy crops analysed: reed canary grass (Phalaris arundinacea L.), birch (Betula pendula Roth.), osier (Salix spp.), grey alder (Alnus incana (L.) Moench), poplar (Populus tremula L.), hybrid aspen (Populus tremuloides x Populus tremula). Results indicate that the ash melting temperature (D, St, Ht, Ft) for the wood energy crops were higher than for the studied grass energy crops and their mixture. Ash melting temperature in all phases over 1200°C was observed for such poplar and hybrid aspen mixture proportions: 3 parts of wood and 1 part of reed canary grass, or 1 part of wood and 1 part of reed canary grass.

Keywords: ash melting temperature, reed canary grass, birch, osier, grey alder, poplar, hybrid aspen.

I. INTRODUCTION

Biomass ashes have a relatively low ash melting temperature - deformation temperature (Dt) is usually in the range of 750 to 1000 ° C, compared with coal, which Dt exceeds 1000ºC, as ash chemical and mineralogical composition is very different [1]. Ash melting point of straw is 850 – 1100°C but of coal 1150 - 1500 °C [2].

It is important to consider what kind of pellets will be used to heat the heating boiler. For wood pellets the ash percentage is 0.5 - 1.5%, for straw pellets it is 5 to 10%. Straw pellets have got a very low ash melting point; therefore, a slag layer is formed in the combustion chamber, which, hardens while cooling down and takes up space. If the melting point is below 1000°C, then particles begin to sinter and the distribution of particles becomes unpredictable.

Ash melting point, defining all four of its standardized values, varies in a very wide range, even within one biomass group; however, on average the deformation temperature is about 1200 ° C, which allows to use this fuel for the household and industrial boilers [3]. An important indicator for solid biofuel is the ash melting point for security, burning technology and sediment formation.

Aim of the research: to find out the ash melting point of different energy crops and mixtures thereof in support of energy crop breeding efficiency.

II. MATERIALS AND METHODS

Reed canary grass (*Phalaris arundinacea* L.) was used in the study as grass energy crop. Reed canary grass (RCG) experimental installation conditions: sowing- the third decade of April, place- the study farm of the Latvia University of Agriculture "Pēterlauki" (56°53'N, 23°71'E), soil- in the sod calcareous soils characterized by pH KCl 6.7, P 52 mg kg-1, K 128 mg kg^{-1}, organic matter content from 21 to 25 g kg^{-1} in the soil, additional fertilizer- ammonium nitrate, harvest time- October, flowering phase- mid-June.

From each fertilizer variable three samples, were taken from an area of reed canary grass (16 m^2); which were weighed ± 0.01kg. The samples were used to determine the amount of dry matter. The harvested dry matter was established, by drying the samples in a temperature of 105°C until a constant mass remained (ISO 6496). The results were then calculated for a hectare (t ha^{-1}).

The following wood biomass was used for pellet mixture formation: birch (*Betula pendula* Roth.) form naturally recovered birch sapling hylocomiosa forest type in Baldone district of Zemgale forestry, osier (*Salix* spp.) - variety 'Thor' from Marupe plantation, gray alder (*Alnus incana* (L.) Moench), aspen (*Populus tremula* L.) and hybrid aspen (*Populus tremuloides x Populus tremula*), which were provided in the form of dry wood powder by Latvian State Forest Research Institute “Silava”.

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Laboratory analysis - the ash melting point was determined according to the standards: LVS CEN/TS 15370-1, EN ISO 17225-1. The study compares five types of pellets, whose composition was as follows: 100% wood (w), 100% reed canary grass (RCG) 25% w / 75% RCG 50% w / 50% RCG 75% w / 25 % RCG.

The results were statistically processed using descriptive and variable statistics, correlation analysis with Microsoft Excel for windows 2000 and the SPSS [4].

III. RESULTS AND DISCUSSION

The ash melting point, which determines energy crop quality, is an important indicator that characterizes ash. It has four phases: DT - initial temperature of deformation, ST - melting point, HT - Hemispherical temperature, FT - the flow temperature when the melted ash flows over the surface [3]. One of the most important phases is DT because it usually has one of the lowest ash melting phase temperatures.

Also, this study shows that reed canary grass, birch, osier, grey alder, poplar, hybrid aspen DT is over 1200°C (Fig. 1). In contrast, the reed canary grass mixtures, whose DT is over 1200°C, consist of poplar and hybrid aspen. The recommended proportions are as follows: 3 parts of wood and 1 part of reed canary grass, or 1 part of wood and 1 part of reed canary grass.

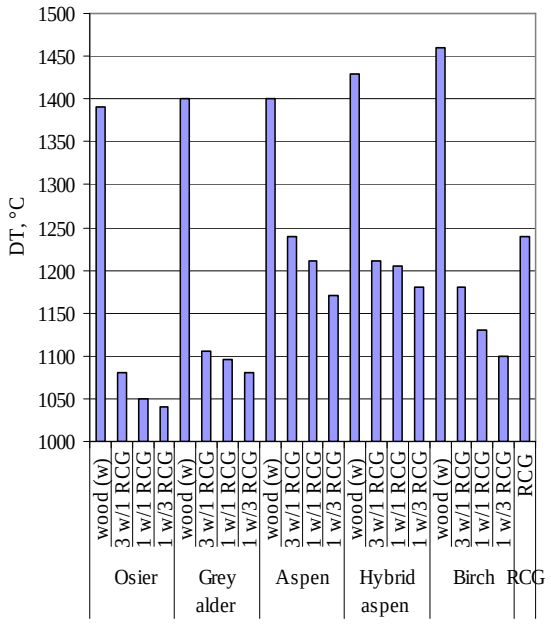

Fig. 1. Deformation temperature (DT) of various energy crops and their mixtures: w- the particular species of wood, RCG – reed canary grass

Initial melting temperature of ash ST over 1200 °C is observed for reed canary grass, birch, osier, grey older, hybrid aspen un RCG mixtures with poplar and hybrid aspen (Fig 2). An osier and hybrid aspen monoculture plantation is a new way to produce woody biofuel in Latvia. When compared RCG mixtures with osier and hybrid aspen biomass, then hybrid aspen biomass is better for mixtures. Observing ash Hemispherical temperature HT and the flow temperature FT over 1200° C, it is evident that reed canary grass, birch, osier, grey alder, poplar, hybrid aspen and some of RCG mixtures with poplar and hybrid aspen, birch, gray alder are suitable (Fig. 3, Fig. 4).

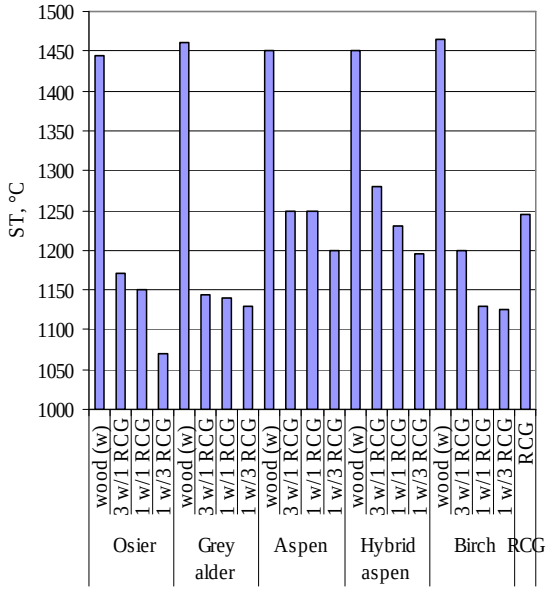

Fig. 2. Initial melting temperature (ST) of different energy crops and their mixtures: w- the particular species of wood, RCG – reed canary grass

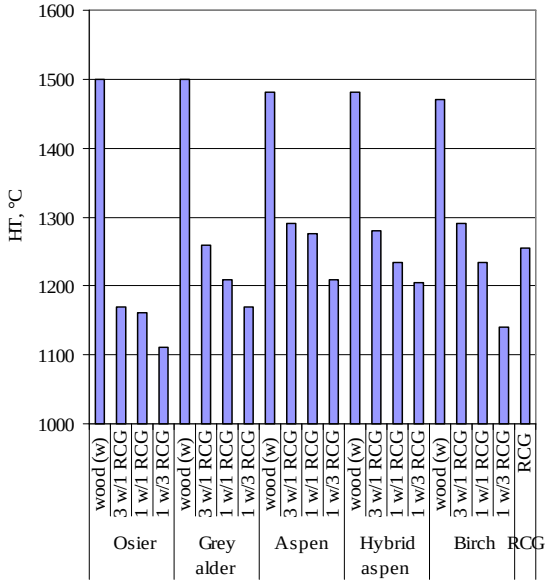

Fig. 3. Hemispherical temperature (HT) for different energy crops and their mixtures: w- the particular species of wood, RCG – reed canary grass

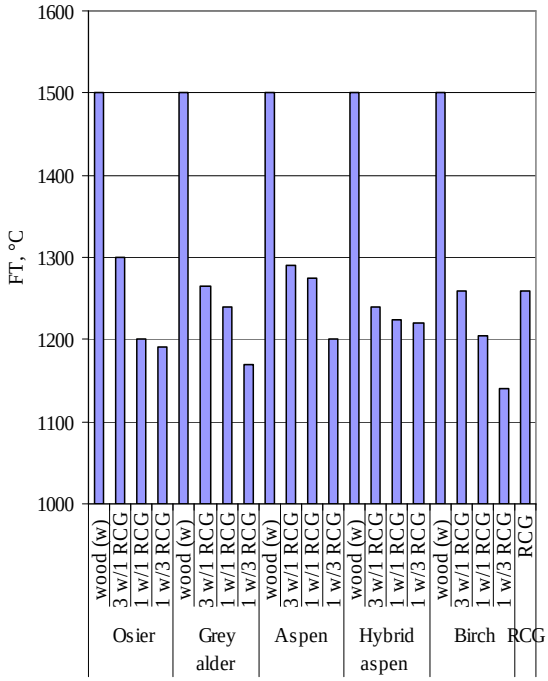

Fig. 4. The flow temperature (FT) for different energy crops and their mixtures: w- the particular species of wood, RCG – reed canary grass

In turn, a lower (< 1300 °C) ash melting temperature means that during the combustion of these materials attention should be paid to proper combustion mode to avoid mechanism damage. Accordingly, the alkali metal, phosphorus, chlorine, silica and calcium presence is a determining factors for the ash melting temperature [5], [6]. Reduction of melting temperature is most commonly associated with potassium oxide content increase [3]. Differences in ash melting temperatures within samples of the same plant species, researchers explain by the chemical composition of plants or individual elements, which under the influence of high temperature result in certain chemical reactions [7].

To find out potential relationships of chemical composition of reed canary grass biomass and ash melting temperatures element analysis of biomass was performed. For the reed canary grass dry matter the ash melting deformation temperature forms a negative linear correlation with alkaline and alkaline earth metals K, Na, Ca ($r = -0.59$, $P < 0.001$, $r = -0.42$; $P < 0.05$, $r = -0.55$, $P < 0.001$, $n = 36$) but a positive linear connection is formed with S ($r = 0.57$, $n = 36$, $P < 0.001$) with phytotoxic elements As, Cd, Pb ($r = 0.73$, $r = 0.63$, $r = 0.55$, $n = 36$, $P < 0.001$). Similar correlations have been also noted for St, Ht and Ft.

The research on the reed canary grass yield showed a substantial negative correlation with the ash melting temperature; an positive correlation with carbon, calcium, potassium and sodium in the dry matter, and with the highest calorific yield; a negative correlation with ash content, sulphur content in the dry matter.

For the sustainable production of biofuel it is necessary to use local resources, for example growing of perennial grasses. To facilitate the introduction and to promote environmental protection and energy conservation programmes it will be necessary to utilize the fallow farmland which is not not used for crops or cattle at present. In 2013 it has been noted that Latvia has 342 084.29 ha of utilized farmland (LIZ) (312 604.00 ha in 2011) suitable for growing of energy crops [8].

IV. CONCLUSIONS

Ash melting temperature over 1200°C was observed for reed canary grass, birch, osier, grey alder, poplar, and hybrid aspen.

The ash melting temperature in all phases over 1200°C was observed for the following poplar and hybrid aspen mixture proportions: 3 parts of wood and 1 part of reed canary grass, as well as for 1 part of wood and 1 part of reed canary grass.

Further research is needed to find the optimal energy crop mixture proportion, where the ash melting temperature would be over 1200° C.

REFERENCES

[1] L. Baxter and, J. Koppejan Biomass-coal co-combustion: opportunity for affordable renewable energy. Fuel, vol. 84, 2005, pp. 1295 – 1302.

[2] E. Kronbergs Biomasas konversija enerģijas un mēslojuma ieguvei. Scientific and practical conference**:** Mehanizācijas un energetikas problēmas lauksaimniecība. April 11-12, 1996, Jelgava, Latvia, pp. 31 – 34

[3] J. Kalnačs, V. Grehovs, D. Grigale, A. Murašovs, and A. Orupe. Koksnes un augu pelnu sastāvs un īpašības, videi labvēlīgas utilizācijas iespējas (Wood and plants ashes content and properties, environment freandly utilisation possibilities). International conference: Eco-Balt. May 15- 16, 2008, Rīga, Latvia, pp. 69.

[4] I. Arhipova and S. Bāliņa. Statistika ekonomikā (Statistics in economy). Datorzinību centrs, Rīga, 2003. 352 p.

[5] A. Maciejewska A., Veringa H., Sanders J., Peteves S. D. (2006) *Co-firing of biomass with coal: constraints and role of biomass pre-treatment.* Luxemburg: Office for Official Publications of the European Communities. 100 p.

[6] N. Magasiner, M. van Alphen, M. Inkson, and B. Misplon. Characterising Fuels for Biomass – Coal Fired Cogeneration. International sugar journal, vol. 104, 2002, no. 1242, pp. 251 – 267.

[7] A. Kaķītis, M. Šmits and I. Belicka. Suitability of crop varieties for energy production. Proceedings of the 8th International Scientific Conference "Engineering for Rural Development", May 28 – 29 2009, Jelgava, Latvia, pp. 188 – 193.

[8] Lauku atbalsta dienests, [Online]. Available: http://www.lad.gov.lv/lv/par-mums/aktualitates-un-pazinojumi/dec-2013/zinami-liz-apsekosanas-rezultati/ [Accessed: Aug. 8, 2014]

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Modelling of Tracer Transport in the White Sea

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Abstract. We consider advection of floating passive tracer in the White Sea using a hydrodynamical model of sea circulation JASMINE. Simulations show that the Onezhskiy Bay is a hydrodynamical trap for tracers: concentration there decrease more slowly. Typical times needed to remove concentrated tracer completely from bays are estimated. General scheme of tracer advection is described.

Keywords: tracer transport, numerical advection, pollution, hydrodynamical trap, White Sea, JASMINE.

I. INTRODUCTION

The White sea is interesting from a number of points of view. It completely belongs to Russian national waters and is an important object for mariculture, fishery, tourism. Also the White Sea is the gateway to the Arctic, because here the Northern Sea Route begins, an important transport system of Russia that connects Europe and Asia by sea.

The White Sea is a unique hydrodynamical object due to strong currents with stable pattern, high tides, high level of available potential energy; also sea bottom configuration influences significantly on the sea dynamics because the sea is shallow. The Sea can be considered as a model of the Arctic [1] and is a convenient model basin for developing and testing numerical models, software, equipment, and algorithms. Small size and depth, high current velocity, strong level oscillations are a serious challenge to numerical stability of mathematical models and algorithms: time step needs to be small due to the Courant stability condition. Therefore some models suitable for oceans or the Global Ocean are hardly useful for the White Sea. On the other hand, relatively stable pattern of circulation due to strong tides implies low dependence of the Sea state on initial distributions: this facilitates modelling significantly.

The White sea is relatively close to the Atlantic Ocean, belongs to the Arctic basin, this sea is small (600 km from the Kanin Nos cape to the river Kem' mouth), shallow (mean and maximal depth are 67 m and 340 m, respectively). Tidal motion dominates in the sea, though wind currents are also important. The coastline is highly indented. In Summer the Sea is free of ice. River discharge, which is 4% of the Sea volume per year, is quite important. This implies lower salinity of the Sea compared to the neighbour Barents Sea. Subbasins, coasts, and rivers of the White Sea are shown in Fig. 1.

Fig 1. The White Sea. Coasts, subbasins, rivers

Although a large amount of data has been accumulated [2], the distribution is highly heterogeneous both in space and in time; this makes choosing precise boundary conditions and model verification serious challenges.

In this paper we pretend to answer the following questions:

1. How does initially concentrated in a single grid node tracer propagates?

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2. Does a pollution in some region of the Sea disappear from the Sea after some time? What are typical times needed for that?
3. What regions are cleared faster than others, for given initial concentration of pollutant? Are there regions that are cleared faster than others for wide range of initial conditions?
4. Are there hydrodynamical traps in the White Sea, i.e., regions that need more time to be cleared from tracers compared to other regions?
5. What are the roles of wind and tidal motions in tracer advection?

To answer these questions we use numerical modelling. Experiments in this area hardly can be performed and amount of data on this subject is low [3, 4]. One more aim of this article is to offer some observable phenomena that can be proved to exist in future expeditions.

II. MATERIALS AND METHODS

Numerical software complex *JASMINE* is based on the Finite-Element Model of the Arctic Ocean [5]. It allows to evaluate state of the Sea, including sea ice. The early version of the model participated in model intercomparison projects (*AOMIP*, now the Forum for Arctic Ocean Modeling and Observational Synthesis (*FAMOS*), http://web.whoi.edu/famos) and was adapted for the White Sea [6]. The model is described in detail in [7]. External forcing includes atmospheric data from open sources (*NCEP*), run-off of five main rivers (Northern Dvina, Onega, Kem', Kovda, and Mezen'), M_2 tide induced from the Barents Sea. Tide and wind are the most important for our purposes. Boundary values for temperature and salinity on liquid boundaries are monthly mean, provided by expeditions of Northern Water Problems Institute. Horizontal distribution was either 50x50 or 80x80 equidistant points which is equivalent to 8 or 5 km step. Vertical grid consists of 16 levels with smaller step near the surface. Time step is 6 minutes. Tide is described as harmonic oscillation of the outer sea level with phase delay from East to West taken into account. Only the most important M_2 tide is taken into account.

Boundary conditions for scalars in straits (including rivers) are of radiation type if the water goes out and of the third kind if it goes in [8]. Therefore boundary values for all scalar fields, including water temperature, salinity, and all biogeochemical tracers, are necessary. We implicitly assume that the matter disappear in the Barents Sea so that clean water is coming in. This assumption is valid because the Barents Sea is much bigger so that concentration indeed quickly dissipates. However, if we study tracer advection near the sea boundary, the assumption leads to too quick reduction of concentration. For other distributions it works well enough. Boundary condition answers question 2, because any concentration would reduce to arbitrary low values after sufficiently long time. However, typical time of this process is still unknown.

The transport scheme of scalars is based on the Taylor-Galerkin two-layer method [9], with the flux correction transport (*FCT*) according to [10]. This scheme guarantees non-negative solution in a case of the right choice of the "mass diffusivity" parameter in low-order time scheme [10]. Being computationally expensive, the *FCT* approach nevertheless conserves the second order of spatial approximation for smooth solutions and dumps nonphysical oscillations in high-gradient regions.

The open boundary condition for velocity and sea level is the generalized Flather condition [11], with specified M2 tidal component for level (assuming relatively low tidal currents in the Barents Sea), and quazi-geostrophic low-frequency velocities, calculated using observed monthly temperature, salinity, wind stress and sea level. The open boundary is located in the Gorlo. At solid boundaries and at the bottom there are zero fluxes for scalars and quadratic drag for momentum.

Advection is the most time-consuming numerical procedure; therefore it is done in parallel using the MPI paradigm on the cluster of the Karelian Research Centre (http://cluster.krc.karelia.ru).

III. RESULTS AND DISCUSSION

Transport of floating and three-dimensional tracers

Wind, tidal, and other currents are able to transfer tracers. Tracer can be two-dimensional: matter of positive buoyancy distributed over the sea surface; three-dimensional: zero-buoyancy matter distributed in the bulk of the sea; sinking tracer: matter heavier than water; variable-buoyancy tracer with density similar to that of water so thermohaline density fluctuations yield vertical accelerations of either sign. In this article we consider, mostly, two-dimensional tracers. An example is sea-ice (only the drift velocity field can differ from the current surface velocity). By density of a tracer we mean that of dry matter which influences only on buoyancy; concentration is amount of matter of mass per unit water volume. Mathematical description of transport deals only with concentration. A source/sink is any process that increases/decreases concentration in a volume provided that there is no flux through its boundary. River mouths can be considered as sources or sinks (e.g., of salinity), propagation or death of planktonic organisms, chemical reactions, flux of matter from atmosphere to the sea surface of from the sea bottom into the water, different physical sources.

By *floating tracer* here we understand a two-dimensional scalar field of an abstract matter that does not influence on other fields, such as velocity, temperature or salinity, etc, and is influenced only by two-dimensional field of horizontal current velocity.

So the sea state is independent on the tracer which changes only due to transport and sources or sinks. Of course, these assumptions simplify the real situation; however, they look reasonable provided that concentrations are not too high and time span of numerical experiment is not too big. Later we are planning to take into account tracer capture and transport by floating sea-ice, interchange with atmosphere, change of sea water transparency because of the tracer, and so on.

An important example of a tracer is oil films on sea surface. A large class of pseudo-two-dimensional tracers is phytoplankton that lives in the relatively thin euphotic layer. Ichthyoplankton also can be considered as a tracer in areas with strong currents where larvae are not able to resist currents.

Transport of floating tracers differs from that of three-dimensional ones, mostly by dynamism.

Transport in the White sea

Typical pattern of currents in the White Sea was described by Timonov [12] and Derugin [13] and later was improved in [14, 15, 16]. This pattern is formed by tidal quazi-geostrophical circulation. Dominating M2 tidal wave comes from the Barents sea creating high-energy motion in the Voronka, quick currents of changing direction in narrow shallow Gorlo, and quazi-geostrophical circulation in the Bassein and bays of the White sea. Semenov [6] showed that period of this circulation is close to that of the tidal wave, which makes this pattern quazi-geostrophical.

Wind currents are also important. As the Sea is small and shallow, wind is able to create level gradient and change the circulation pattern significantly. Influence of wind currents on transport of the floating tracers is more important compared to three-dimensional ones.

Main components of stable surface circulation pattern of the White Sea is:

- bi-directional current in the Gorlo, which is closer to the right (with respect to current velocity) coast;
- cyclonic rotation in the Bassein;
- eddies in bays;
- chaotic motion in the Voronka;
- currents along Onezhskiy, Letniy, and Zimniy coasts. It is reasonable to guess that these currents are able to take matter from the Onezhskiy Bay to the Dvinskiy Bay and then to Gorlo and to the Barents Sea.

Tracer advection paths agree with typical patterns of sea currents, though it is much disturbed by wind. Tracer initially concentrated in a grid node at the surface spread over the sea up to relatively homogeneous distribution (with less concentration in tops of bays). 3D tracer is dispersed more propagating also to the sea bulk and is less influenced by wind.

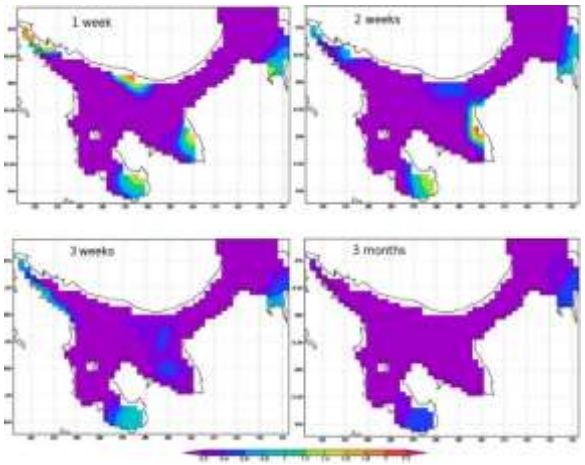

Fig 2. Tracer dynamics

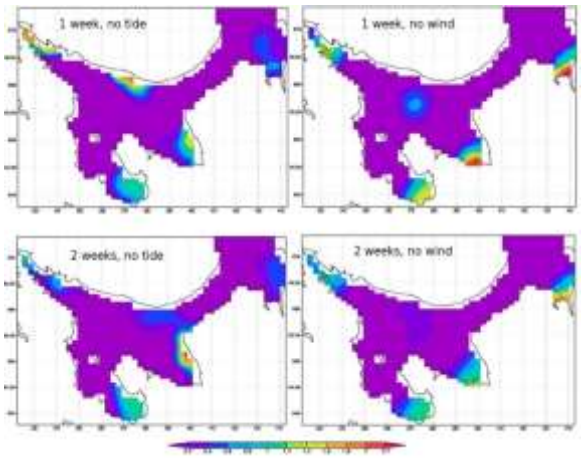

Fig 3. Pure tracer dynamics: wind only and tide only

Let us define sea clean-up by reducing of the concentration 100 times compared to the initial field. Then the Sea is cleaned up of a homogeneous slick covering all surface after 42 months. With no wind (with only tidal circulation) this time is still less than 48 months. With no tide wind currents also clean up the Sea by 42 months. It is interesting that most area of the Sea is cleaned up after 24 months; the rest of the time is needed to clean up the Onezhskiy Bay. Slick on the surface of this bay needs the same amount of time than the whole Sea to be cleaned up. This and other numerical experiments show that the top of the Onezhskiy Bay is a hydrodynamical trap: concentration of matter (both floating and three-dimensional) there reduces much more slowly compared to any other region. Tracer concentrated in one grid node in the top of the Bay needs 6 months to be cleaned up; on the other hand, not more than 3 months are needed to clean up similar tracers from other regions (top of the Kandalakshskiy Bay), while for the Dvinskiy and Mezenskiy Bays, the Gorlo, and the Bassein this time is at most 2 months or less, see Fig. 2. In this figure we show surface concentration of four tracers initially concentrated in a single grid cell

in tops of Bays. Left to right, time passed is 1,2,3 weeks and 3 months. Trapped matter is clearly seen.

Matter can enter the Dvinskiy Bay but is not able to leave it: so the term “trap” is valid. There have been no (up to our knowledge) observations that confirm or reject this phenomenon. A consequence of matter caption is pollution of water of the top part of the Bay, because floating litter can be considered a tracer. The Bay indeed is quite polluted; however, this can be also explained by function of Onega and Belomorsk harbours. The mouth of the Onega River can capture pollutants due to shallowness and kennels [17]. Another supporting fact is results of ichthyological observations of larvae of the White Sea herring: in the summer of 2016 they concentrated near the Uhta Bay and were almost absent to the north of it (data of the joint expedition of Oceanology Institute and Northern Water Problems Institute).

Numerical experiments also show that tidal currents take tracers from to the top of the Mezenskiy Bay. Even with no wind, tracer initially concentrated in the Onezhskiy or Dvinskiy Bay concentrates in the Mezenskiy Bay. If a tracer was initially concentrated in this Bay, it leaves it after about 2 months; however, this is rather long because the Bay is near the inter-sea boundary and matter disappears after crossing it. Such behaviour agrees with typical pattern of the White Sea currents, though there are no direct observations of matter transport to the Mezenskiy Bay. Permanently high concentration of dissolved matter in the Bay (optics.ocean.ru) implicitly supports this conclusion.

General pattern of tracer transport is as follows. First the concentrated tracer distributes over the sea surface; then concentration decreases in the Kandalakshskiy and Dvinskiy Bays. The matter is dissipated and carried out of the Sea; however, concentration in the Onezhskiy and the Mezenskiy Bays, as well as near the Terskiy Coast, remains rather high (in these bays it remains higher than in the neighbour parts of the Sea up to complete dissipation). Wind is able to carry the spot into the Kandalakshskiy or Dvinskiy Bay for a short time.

We compared tracer transport in realistic conditions (tide and wind) and that with one of the factors absent (Fig. 3). This figure compares no-wind and no-tide dynamics, while realistic dynamics is in Fig. 2. Wind is very important for floating tracers and is able to change the pattern significantly; however, it is also important for 3D tracers (influence of wind and tide are comparable). For example, evolution of 3D tracer initially concentrated in a single grid node in the Dvinskiy Bay is similar for a long time (up to rather uniform distribution)for these three types of dynamics: realistic, pure wind, or pure tidal. General pattern of floating tracer transport described above changes little if there is no tide, though pure tidal transport preserves pattern in general.

Tracers are diluted by river discharge, more if wind is absent.

IV. CONCLUSION

We considered advection of passive tracers (focusing on floating ones) due to tidal and wind currents by numerical simulations. The Onezhskiy and Mezenskiy Bays are shown to be hydrodynamical traps: they take more time to clear from tracers compared to neighbour regions. They capture matter just due to special circulation patterns and bathymetry. Typical times needed to clear up the Sea and different bays were estimated and shown to be tightly dependent on that for the traps. These times are less than half a year for the Sea in total and the Onezhskiy Bay and less than a few months for other regions. The Kandalakshskiy and Dvinskiy Bays are cleared up more quickly (though the top of the Kandalakshskiy Bay need 3 months to clear up, which is more than that for other Bays excluding the Onezhskiy). This is also true for both purely wind and purely tidal dynamics. Wind was shown to be more important for floating tracers than tide, though qualitative pattern is provided by both mechanisms.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] Filatov N. N., Terzhevik A.Yu., Druzhinin P.V. Belomor'e — region dlya resheniya aktual'nykh problem Arktiki [Belomorie is the region of the Arctic challenges solving]. Arktika: Ekologiya i ekonomika [Arctic: ecology and economy]. 2011. No. 2. P. 90-101.

[2] Tolstikov A. V., Filatov N. N., Zdorovennov R. E. Beloe more i ego vodosbor. [Certificate of official registration of the database "The White Sea and its watershed"]. No. 2010620435 ot 16.08.2010 g.

[3] Klevanniy K. A. Modelirovaniye dlinnovolnovih processov v geophizicheskoy gidrodinamike [Simulation of long-wave processes in geophysical hydrodynamics] // Thesis of Dr. of phys. and math. sciences on a specialty of oceanography. S-Petersburg. 1999. 314 p.

[4] Zdorovennov R. E., Lifshic V. H., Fuks V. R. Prilivniye dvizheniya i perenos primesi v estuarii reki Onegi [Tidal movements and transport of impurities in the estuary of the Onega River] // Oceanologiya [Oceanology]. 2001. V. 41. No 5. P. 680-685.

[5] Yakovlev N. G. Vossproizvedeniye krupnomasshtabnogo sostoyaniya vod i morskogo l’d Severnogo Ledovitogo okeana v 1948–2002 gg. Chast’ 1: Chislennaya model’ i srednee sostoyanie [Reproduction of the large-scale state of water and sea ice in the Arctic Ocean from 1948 to 2002. Pt. 1. Numerical model and the average state]. Izvestiya RAN, FAO [Izvestiya, Atmospheric and Oceanic Physics]. 2009. No. 3. P. 1–16.

[6] Chernov I. Numerical Modelling of Large-Scale Dynamics of the White Sea // Universal Journal of Geoscience. 2013. Vol. 1(3), pp. 150-153.

[7] Chernov I. A., Tolstikov A. V., Iakovlev N. G. Kompleksnaya model' Belogo morya: gidrotermodinamika vod i morskogo lda. [Comprehensive model of the White Sea: hydrothermodynamics of water and sea ice]. Trudy KarNC RAN [Transactions of KarRC of RAS]. Seriya

"Matematicheskoye modelirovaniye i inforacionniye tehnologii" [Mathematical Modeling and Information Technologies]. 2016. No. 8. P. 116-128. doi: 10.17076/mat397.

[8] Marchesiello P., McWilliams J.C., Shchepetkin A. Open boundary conditions for long-term integration of regional oceanic models. Ocean Modelling. 2001. Vol. 3. P. 1-20.

[9] Zienkiewicz O.C., Taylor R.L. The finite element method. 5th Ed. Oxford: Butterworth and Heinemann, 2000. Vol. 3: Fluid dymanics. 306 p.

[10] Loehner R., Morgan K., Peraire J., Vahdati M. Finite element flux-corrected transport (FEM-FCT) for the Euler and Navier-Stokes equations. Int. J. Numer. Meth. Fluids. 1987. Vol. 7. P. 1093-1109.

[11] Flather R.A. A tidal model of the northwest European continental Shelf. Memories de la Societe Royale des Sciences de Liege. 1976. Vol. 6, no. 10. P. 141-164.

[12] Timonov V. V. Shema obchey circulyacii vod basseyna Belogo morya i proishozhdenie ego glubinnih vod [The scheme of general circulation of the White Sea and the origin of its deep waters] // Trudi Gos. okenograph. in-ta [Proceedings of the State Oceanographic Institute]. 1947. Vol. 1. P. 118–131. In Russian.

[13] Derugin K. M. Fauna Belogo morya i usloviya ee suchestvovaniya [The fauna of the White Sea and the conditions of its existence] Leningrad.: Izd. Gos. Gidrol. in-ta. [Publishing of The State Hydrological Institute]. 1928. 510 p. In Russian.

[14] Gidrometeorologiya i gidrokhimiya morei SSSR. Vol. II. Beloe more. Iss. 1. Gidrometeorologicheskie usloviya [Hydrometeorology and hydrochemistry of the seas (USSR). Vol. 2. The White Sea. Iss. 1. Hydrometeorological conditions]. Leningrad: Gidrometeoizdat, 1991. 240 p. In Russian.

[15] Semenov E. V. Chislennoe modelirovanie dinamiki Belogo morya i problema monitoringa [Numerical modelling of the White Sea dynamics and monitoring problem]. Izvestiya RAN, FAO [Izvestiya, Atmospheric and Oceanic Physics]. 2004. No. 1. P. 128–141. In Russian.

[16] Zimin A. V., Atadzhanova O. A., Romanenkov D. A. et al. Submezomasshtabniye vihri v Belom more po dannim sputnikovih radiolokacionnih izmereniy [Submezoscale eddies in the White Sea from satellite radar measurements] // Issledovaniye Zemli iz kosmosa [The study of the Earth from space]. 2016. No 1-2. P. 129-135. In Russian.

[17] Lebedev A. A., Andrianov V. V., Neverova N. V., Lukin L. R. Vtorichnoye zagrazneniye nefteproduktami pribrezhnoy zoni Onezhskogo zaliva Belogo morya [Recontamination by oil of coastal area of the Onezhskiy Bay of the White Sea] // Izv. Samarskogo nauch. centra RAN [Proceedings of the Samara Scientific Center of RAS]. 2013. V. 15. No 3(3). P. 927-931. In Russian.

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Analysing Environmental Implications of Anthropogenic Impacts as a Result of Syzran Shale-processing Refinery Work

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Abstract. Extraction and primary processing of natural minerals have a direct human impact on the lithosphere in the following way: the area of excavation and the area covered by rock dumps of overburden and substandard rocks increase; the landscape also changes. This problem occurs on all operated deposits and exists in out-of-operation deposits. This paper performs a critical analysis of environmental implications of anthropogenic impacts as a result of Syzran shale-processing refinery work Rock dumps parameters № 1 of Mine 3 and № 2 of Mine 5/6 of ZAO "Kashpirskaya Mine" are investigated. Rock dumps depth and surface ares, conservation volume and utilization capacity are considered to be landscape modifying parametres. The research demonstrates rock dumps parameters change in the period from 1950 to 2002. The paper evaluates the degree of anthropogenic impact of dumps territories and burnt rocks burials which were formed during the extraction of oil shale at Syzran shale-processing refinery. Those rock dumps resulted in the following transformation and change of the natural system and landscape: curvature of the slopes altered, soil and vegetation cover was dislocated. The only industry capable of reducing ecological tension in the region is building industry.

Keywords: resource output, anthropologic impact, burnt rock dump, construction industry, landscape change.

I. INTRODUCTION

Samara region has various natural minerals reserves for the production of building materials. To begin with, such materials are brick and tile, and expanded-clay and argillous raw materials, the fields of which distributed on the whole region. Besides, there are other mineral resources in the region. Among the major fields with a long history of exploitation: deposits of carbonate rocks - Sokskoe and Troekurovo-Guben; Balasheevskie molding sands; Kashpirskoe oil shale. Among the major fields with a long history of exploitation may be: Sokskoe and Troekurovo-Gubernskoe, Balasheesvkiye molding sand; Kashpirskoye oil shale field. The extraction of natural resources in most cases is being done with surface mining. As the location production the pit area is increased and the pit has much overburden dumps and non-standard raw materials, which leads to an influential change in the landscape. These effects are manifested in all producing fields and stayed in the unexploited fields.

Due to the scale of the Russian Federation, the Samara Region, in particular, the task was monitoring the area occupied by pits and dumps. The area has a lot of vacant land, but landscape changing barrow pits and accumulated dumps, has ecological effect of anthropogenic impacts. A typical example is the area of oil extraction shale OOO "Shahti Kashpirskaya" Syzran petrochemical company based in Shale.

II. EXPERIMENTAL METHODS

When the extraction and processing of natural mineral raw materials, human influence directly on the lithosphere. The degree of human influence is difficult enough to estimate, but there are indicators, that can be measured, estimated, trace the dynamic. Tetnor A.N. [1] It says that anthropogenic impacts include all types of oppressive nature effect produced by the technology and the human directly.

The anthropogenic impacts on the biosphere in the past decade came on the same level with the natural influences, become a guiding force further evolution of ecosystems. This is due not only population growth, but a quantum leap in the development of science and technology.

An analysis of the ecological effects of anthropologic impacts allows them to divide all types on positive and negative. The positive human effects on the biosphere may be the restoration of natural resources, groundwater recharge, and land remediation on the land development of mineral resources.

Negative human effects on the biosphere are manifested in the most different and extensive actions: deforestation over large areas, salinization and desertification, depletion of fresh water, the destruction of natural landscapes.

Many human effects are made on purpose; there is the technical transformation and destruction of

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natural systems and landscapes, to achieve the goals In the process of natural resources extraction. By the nature, the depth and distribution areas, the anthropogenic impacts time actions [2-5] may be different.

When extraction of mineral resources with surface mining first of all, there is an infringement of the soil cover in the developed area of the field due to remove, pollution, bury and destruction of soil. The area of disturbed soil with the further development of deposits is increasing. A similar situation may be with the construction (drifting of building pits, trenches for communications, road construction).

The next stage is extraction of mineral resources where overburden removes, and they are also stored around the pit. As the development of pits - the number of pits is increasing while they are produced. The negative consequences at this stage include reducing the area of fertile land, and subsequently the landscape changes.

In the future, sub-standard difference of mineral raw materials may be added to the overburden. Each field has its own situation, which depends on many factors: geological features, square pits, production capacity (availability of access roads and approaches to the development of new lands).

Technogetic impact in this case is a change in structure of the complex geodynamic its components or linkages between them. This may be a change in any of geological factors or process conditions of flow. Besides the terrain disturbance there may be changing the slope of the curvature, the composition and the build of massive rocks.

In the future, there will be a violation of the hydrological, hydrogeological and hydrodynamic conditions, which led to the modification or destruction of the biochemical cycles.

There are a lot of negative impacts in extractions of mineral resources by underground method. A typical example of shale extraction is Syzran petrochemical company based in Shale.

Oil shales are common minerals. The structure of combustible organic substances (up to 70%) in limestone or mud mineral mass is a part of them. Shales can be used as fuel, and the most valuable direction is a chemical feedstock.

One of the largest oil shale fields in the Volga is Kashpirskoe near Syzran. Value Volga shale is their shallow occurrence, facilitates the production, and in particular the composition of the organic part.

For the first time, Kashpirskoye oil shale field in the scientific papers referred to the XVIII century. During the nineteenth century, geologists have repeatedly offered to expand extraction of oil shale in the village Kashpir. But in practice, these proposals have been implemented since 1917. At this time, the question of building a shale company near Syzran Shale was opened.

Oil shale extraction was carried out by underground method, first of all, from pits and adits and futher- in closed mines by drilling and blasting method.

The Mine № 1 was founded in 1932 to provide raw materials and fuel for Syzran Shale company which was built in the same year, which specializes in thermal processing of oil shale. As the report shows [6], the company was built next to the Kashpirskim shale field.

The mine № 5/6 put out the operation in 1950 and the mine № 3 is in 1959. In 1967, after working reserves, mine № 1 was closed, and in 1991 the mine the №5/6 was closed as well.

Oil shale extraction in the Kashpirskoe field lasted more than 80 years until 2003 and was accompanied by the accumulation of waste rock and rock containing not removed during the extraction and subsequent sorting shale. The presence of organic substances in dumps promoted mixed spontaneous combustion [7], which led to the formation of burnt rock.

III. EXPERIMENT

On the instructions of the Ministry of Natural Resources in the Samara region in 2003 - 2004 on the theme "Creating a local source of raw materials based on the construction industry waste dumps and burial audit exploited and unexploited fields of Samara region" was estimated man-made dumps and burial formation of waste shale Syzran company. Published dumps Kashpirskyi fields date was manipulated for analysis since 1950.

According to published data, all waste dumps are not burning, waste dumps № 1 and № 2 are plat, deformation was off.

Survey dumps conducted in 2004 showed [6] that their form in certain areas characterized by a plat (Fig. 1 and 2), there is altitude. Waste dump mine № 1 has the shape of the pit (Fig. 3). The central part is developed and there are the pit heap remains, which look like indiscrete mass of weathering products (Fig. 4).

Fig.1. Rock dump №1

Fig.2. Rock dump №2

Fig.4. Rock dump of mine №1

Fig3. Rock dump of mine №1

As follows from the data, presented in Fig. 5, the done supply of rocks in the dump №1, changed widely. It amounted to 55 thousand м^3 in 1950, it changed from 179 to 260.8 thousand м^3 in the period of stable work (1977-1989). The exception was in 1981, when the supply was 130 thousand м^3.

The decline in production was since 1990. The extraction peak was in 1991. The decay period was from 1992 to 2002.

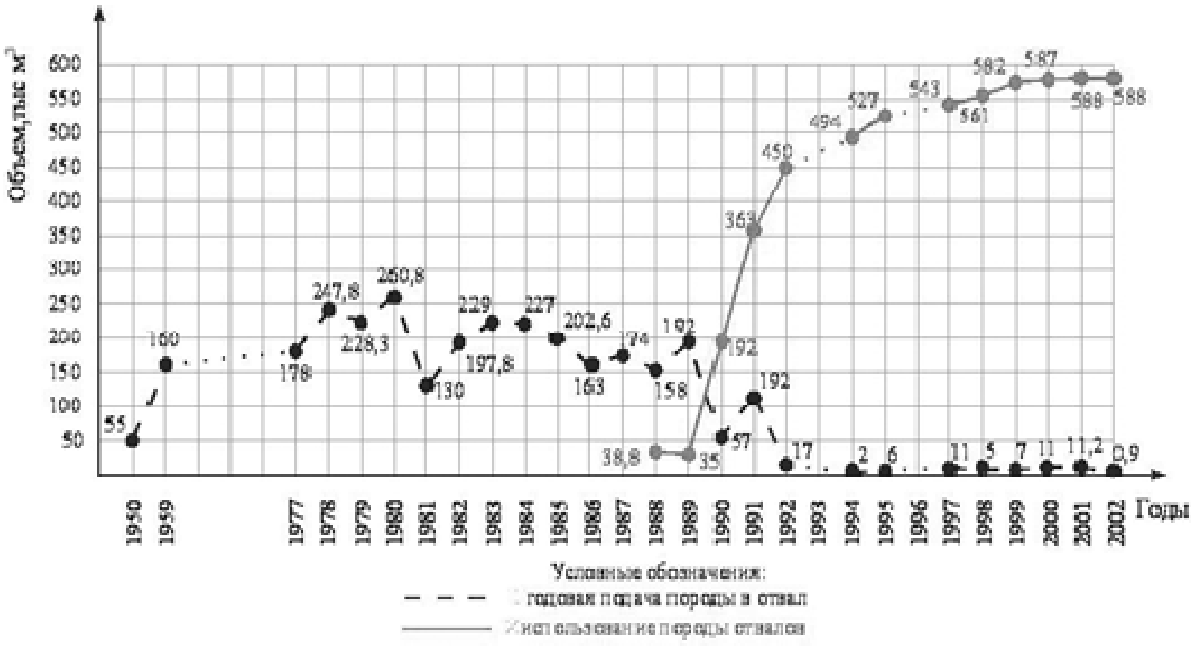

Fig.5. Dynamic of accumulation and usage of pit dump №1
Volume thousand m3, Years, Shorthand: years handling mineral resources into the dump

The volume of use of the breed in the published data has come to represent in 1988. There is an important development in the use (more than 10-fold) from 1990 to 1992 and reached 450 thousand м^3 to 1992. The period from 1992 to 1998 can be characterized as a period of smooth development the volume of use. In the period from 1999 to 2003 volume was using the maximum and stable in the period from 1999 to 2003.

The dump volume №11 was uniformly increased from 1950 to 1989. As we can see from Fig. 6, its volume increased during this period by more than 5 times. The dump volume began to decrease since 1987, due to the start of the planned overburden use. From 1988 to 1994 the volume of the dump varies slightly from 1988 to 1994. The dump area built up from 1984 to 1987, and since 1990 it does not change and amounts to 155,940 м^2.

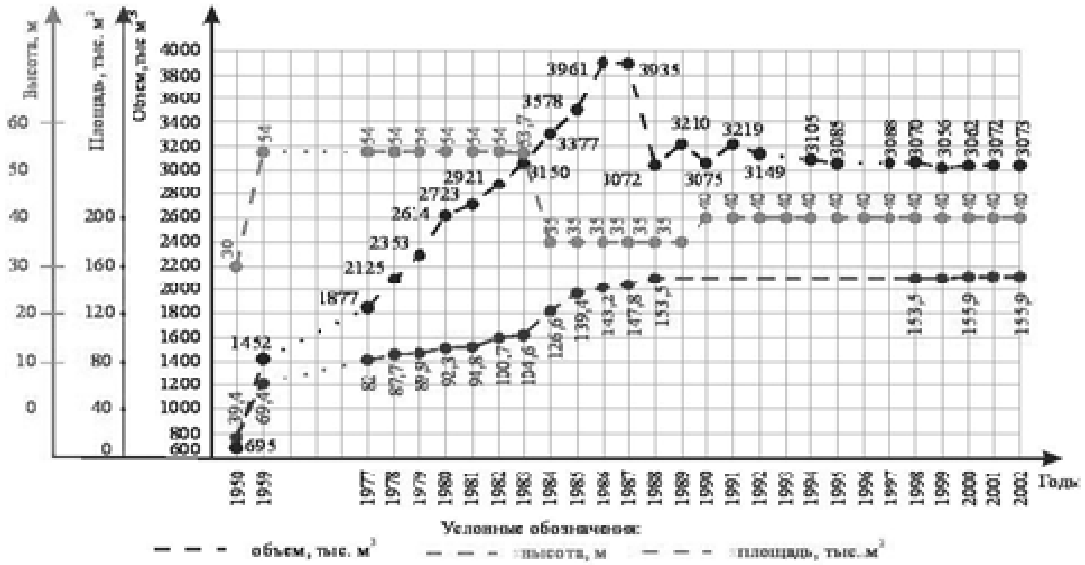

Fig.6. Dynamic of accumulation and usage of pit dump №1
Height m, square thousand m2, Volume thousand m3, Years, Shorthands: Volume thousand m3, height m, square thousand m2.

When the dump was forming, its height has increased on 20 m., but it has not changed for the period from 1950 to 1959. The height of 40 m. appears in the published data since 1990.

The actual height for the dump №1 mine №5/6 is 35 m. The dump is filled to 94%. The use of waste rock is 7.4 м^3, which corresponds to 0.9% of the accumulated volume.

The annual flow in the rock dump, as it follows from the data presented in Fig. 7, was varied over a wide range of 9 to 139.6 thousand м^3.

The dynamic increase in production is typical for 1997-2001. The nature of the accumulation can be characterized as unstable.

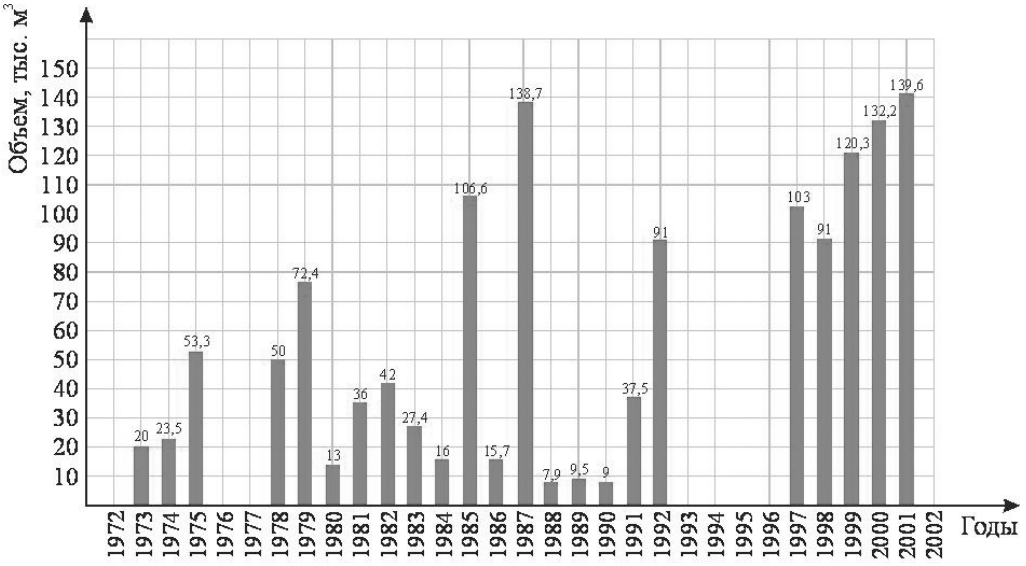

Fig. 7. Character accumulation pit dump №2
Volume thousand m3, Years

IV. DISCUSSING

Due to the economic changes in the country there have been significant changes in the environmental conditions. At the time oil shale company execution work does not process the shale, and uses the accumulated stocks of resin uses for this work.

The important improvement atmosphere state is due to a decrease in emissions of oil shale company, termination of burning waste heaps mine № 3 and № 5/6 (previously backfilled burning rocks ended, new breeds are not available), stopped emissions agloporite company and insulation products company.

Water state pool is also improved, due to a decrease in the level of industrial and household waste pollution, which, in turn, is related to the termination of the mines, agloporite company and thermal insulation products company and the reduction of shale production company.

The reducing negative impact of dumps on resources land is due, primarily, to the mines closure and the lack of income in spontaneously combustible pit waste heaps.

At the same time burned rocks are mineral raw materials [6] akumineironsilicate calcium composition. When resource-saving method approach to the construction resource base industry [7-9] technological education and natural raw materials are the single source of raw materials. The human structures use in the production of various building materials [10-12] solves environmental problems. Outlined transition in the production of building materials to multi-natural and human compounds [13] is possible with computer design of charges. With this approach, burnt rocks become raw material base [6] for the production of a wide range of building materials from the burden.

V.CONSLUSION

1. The squares and volumes of human structures dumps and Syzran petrochemical company based in shale burial was estimated (ZAO "Mine Kashpirskaya").
2. It was found that the mine dumps Kashpirskaya, accumulated over more than 50 years, on-currently dumps do not burn, but they occupy large areas, have changed the landscape, reduce the area of fertile land and have a negative impact on the surrounding area.
3. Using rocks heaps in the construction industry will reduce environmental stress.

REFERENCES

[1] Arustashov A.A., Levakov I.V. Ecologicheskiye osnovi prirodovepolzovaniya. [Ecological basis of nature] Moscow, 2001, 385 p.

[2] Vremenaya metodika opredeleniya economicheskoy effectivnostu osuschestvleniya prirodoochranyaemich meropriyatiy I ozenki aconomicheskogo uscherba, prichinyaemogo narodnomy chozyaiyastvu v resultate zagryaznenya okruzhauschey sredi. [The temporary method of determining the cost-effectiveness of the implementation of environmental protection measures and assess the economic damage caused to the national economy as a result of environmental contamination.] Perm: VNIIOSugol, 1985.

[3] Gavrilov V.P. ecologiya I prirodopolzovaniye: problem nauki I obrazovaniya [Ecology and nature: problems of science and education]. News of the universities (Construction), 8, 1997, pp. 107-111.

[4] Domanin A,B. economica I razionalnoye prirodopolzovaniye na rubeze vekov [Economics and environmental management at the turn of the century]. Moscow university Vestnik. Economics, 3, 2000, pp. 54-59.

[5] Lebedev O,T., Mascheva T. V. Economica regionalnogo prirodopolzovaniya. [Economics of regional nature]. Saint Petersburg, 2001.

[6] Chumachenko N.G., Turnikov N.G., Seykin A.I., Bannova S.E. Vozmoznosti ispolzovaniya gorelich porod v stroitelstve. Ecologiya I promischlennost Rossii [Possibilities of use of burned rocks in construction. Ecology and Industry of Russia] V.19, 11, 2015, pp. 3 – 9.

[7] Chumachenko N.G., Turnikov V.V., Bannova S.E., Kirillov D.V. Perspectivi formirovaniya sirevoy basi stroyindustii s ispolzovaniyem technogennogo sirya is onvalov Kaschpirskogo rudnika Samarskoy oblasti / SGASU. [Prospects of the raw material base construction industry using raw materials from technogenic dumps mine Kashpirskiya Samara Region / SGASU.] Samara, 2006, 225 p.

[8] Chumachenko N.G., Turnikov V.V., Kirillov D.V., Kirillov M.V., Gavrilov A.V. Formirovaniye mestnoy sirevoy basi na osnove othodov stroiyindustii. Stroitelniye materiali, oborudovaniye, technologii XXI veka [Formation of araw materials local source based on the construction industry waste. Building materials, equipment, technologies of XXI century], 1 (96), 2007, pp. 16-18.

[9] Chumachenko N.G. Resursocberegaushiy podhod k sirevoy base stroiyindustrii. Vestnik SGASU. Gradostroitelstvo I arhitectura. [Resource-saving approach to the resource base of the construction industry. Urban construction and architecture], 1, 2011, pp. 112-116.

[10] Khlystov A,I., Zakirova M.N., Shirokov V.A., Isaev D.I., Sedisheva M.U. Ecologicheskiye aspekti utilizazii othodov keramzitnogo proizvodstva v sostavah materialov obshestroitelnogo I spezialnogo naznacheniya. Bashkirskiy himicheskiy zurnal [Environmental aspects of expanded clay production waste recycling in the compositions of materials for general and special purpose. Bashkirskiya chemical journal], book 21, 4, 2014, pp. 116-123.

[11] Khlystov A.I.,Vlasov A.V., Konnov M.V. Primeneniye visokoglinozemistih shlamov v technologicheskih prozessah proizvodstva obzigovih i bezobzigovih ogneuporov. Vestnik Orenburgskogo gosudarstvenogo universiteta. [The use of high-sludge in the production process biurnt and unburned firebrick. Vestnik of the Orenburg State University, 5, 2013, pp. 212-215.

[12] Khlystov A.I., Zakirova M.N., Shirokov V.A. Isaev D.I. Sedisheva M.U. Ecologicheskiye aspekti utilizazii othodov keramzitnogo proizvodstva v sostavah materialov obshestroitelnogo I spezialnogo naznacheniya. Bashkirskiy himicheskiy zurnal [Environmental aspects of expanded clay production waste recycling in the compositions of materials for general and special purpose. Bashkirskiya chemical journal.], book 21, 4, 2014, pp. 116-123.

[13] Chudin A.N. Razrabotka metoda komputernogo proektirovaniya shicht dlya polucheniya iskustvennogo poristogo alumosilikatnogo zapolnitelya: Dis. Kand. Tech.nauk [Chudin A.N. Development of charges method of computer-aided design for artificial porous aluminosilicate filler: Dis ... Cand. tehn. Sciences:]: 05.23.05. SGASU. p. 220.

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Study on the Adsorption Characteristics of Congo Red by Sycamore Bark Activated Carbon

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Abstract. The activated carbon was prepared from sycamore bark by activation of zinc chloride. The absorbing effect of activated carbon on Congo red wastewater is studied. The characteristics of sycamore bark activated carbon were characterized by SEM and BET. The effects of adsorbent dosage, time, and shaking speed on the adsorption properties of Congo red by sycamore bark activated carbon were studied. The isotherm, kinetics, and thermodynamics of adsorption were explored. The results revealed that the activated carbon contain a large apparent mesopores. Adsorption efficiency was increased with enhancing the adsorption dosage and time. The removal rate of Conge red reached to 98.2% under room temperature with adsorbent dosage of 3.0 g/L, adsorption time of 120 min, shaking speed of 60r/min. The adsorption of Congo red on sycamore bark activated carbon was followed Langmuir isotherm model and Lagergren pseudo-second order kinetics model. The adsorption was spontaneous, endothermic, and the entropy was increasing in the adsorption process.

Keywords: sycamore bark activated carbon, Congo red, adsorption kinetics, thermodynamics.

I. INTRODUCTION

Dye wastewater mainly comes from the production of dyes and dye intermediates industry, its deep color, complex composition, poor biodegradability and difficult degradation[1,2]. The actual use of the azo dye is the most common and the most frequently applied, approximately 50%. The precursors and intermediates of azo dyes are carcinogenic, mutagenic and toxicity[3,4,5].Congo red is a typical benzidine azo dye in dyeing and printing industry, mainly for cotton, viscose dyeing and paper industry production [2,3,4,5].Currently Congo red dye wastewater treatment methods are commonly used in adsorption, membrane separation, chemical coagulation, oxidation, biological method [6,7,8].Adsorption method is an effective means of dyeing wastewater treatment, because of its convenient operation, simple process, low cost and good treatment effect have attracted much attention [9,10,11,12].

The preparation of new activated carbon adsorbent with biomass waste as raw material has become a hotspot in recent years[13,14,15,16,17]. Sycamore tree is a common ornamental tree species and garden green road, each year a large number of sycamore bark by the sanitation sector landfill or burning treatment, caused by a huge waste of resources, the combustion of harmful gases can also cause a certain degree of atmospheric pollution. At present, there are few reports on the preparation of activated carbon adsorption materials from the sycamore bark. Sycamore bark raw materials are rich in sources, renewable, inexpensive and environmentally friendly, as a raw material for the preparation of activated carbon adsorbent for the treatment of dye wastewater can reduce pollution and waste utilization, which provides a reference for the treatment of dye wastewater by other activated carbon adsorption. In this study, sycamore bark as raw materials, sycamore bark activated carbon was prepared with zinc chloride, adsorption of Congo red from wastewater, the adsorption properties and mechanism of activated carbon from the sycamorebark to Congo red were studied by means of structural characterization, adsorption conditions and adsorption model.

II. EXPERIMENT

Materials and Reagents

Sycamore bark from the suburbs of Hefei City, wash drying, crushing and sieving standby. The reagents used are $ZnCl_2$,NaOH, HCl and Congo red and soon. The reagents used in the experiment are all analytically pure. Deionized water is used in the experiment.

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Experimental equipment and analytical instruments

FW100 universal grinder, OTF-1200X tube furnace, CP214 analytical balance, UV6000 ultraviolet visible spectrophotometer, DKZ-2thermostat, NAVO2200 nitrogen adsorption specific surface area determinator, SU8000 scanning electron microscope.

Experimental methods

Preparation of sycamore bark activated carbon

Following the method employed in the literature [18,19], take 25 g sycamore bark powder in beaker, adding 50% $ZnCl_2$ solution for 100 mL after mixing evenly impregnated with 12 h, drying at 70℃ for 12 h, stiring irregularly. After drying the sycamore bark and zinc chloride mixture in the quartz boat, then put in a tube furnace. Activation for 50 min under the condition of heating rate of 10r/min, nitrogen atmosphere and temperature of 500℃. The sample to be removed after cooling, successively washed with 3% hydrochloric acid, pure water, 0.5% of NaOH solution each for 30min. Waterwashing to neutral, then filtering and drying to obtain the sycamore bark active carbon samples.

Adsorption experiment

Take a certain amount of sycamore bark activated carbon adsorbent in 250 mL Erlenmeyer flask, adding 100 mL concentration of 100 mg/L Congo red solution, packed in sealed bottles in the constant temperature bath, adsorption in a certain time and temperature, the filtered solution was measured by UV VIS spectrophotometer at 497 nm. The removal rate of Et (%) and adsorption capacity Qt (mg/g) were calculated.

$$E_t = (C_0 - C_t)/C_0 \times 100\% \quad (1)$$

$$Q_t = (C_0 - C_t)V/W \quad (2)$$

In the formula, C_0 is the initial concentration of Congo red (mg/L),C_t is the residual concentration of Congo red adsorption (mg/L) after t time, W is the quality of sycamore bark activated carbon (g), Q_t is the adsorption amount of t time (mg/g), V is the solution volume (L).

Isothermal adsorption experiment

Preparation of different initial concentrations (150~350 mg/L) of the Congo red solution of 100 mL, adding 0.3 g of sycamore bark activated carbon, oscillation adsorption for 4h respectively at 293, 303 and 313 K in constant temperature water bath, filtered, the residual red Congo concentration was measured.

Kinetics of adsorption experiments

In a series of 250mL conical flask were added to a concentration of 100 mg/L Congo red solution 100 mL and 0.3 g of sycamore bark activated carbon, at different temperatures (283, 293 and 303 K) in the constant temperature water bath, with 60r/min oscillating adsorption for a certain period of time, filtered, the residual red Congo concentration was measured.

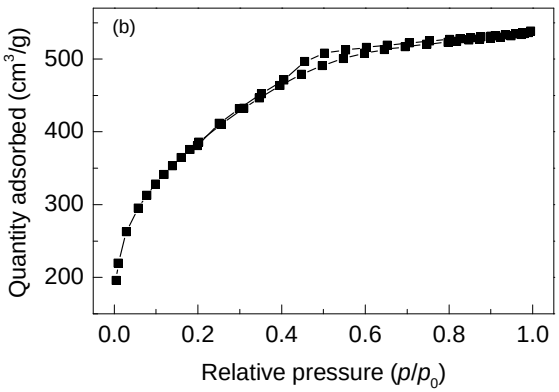
III. RESULTS AND DISCUSSIONS

The characterization of sycamore bark activated carbon

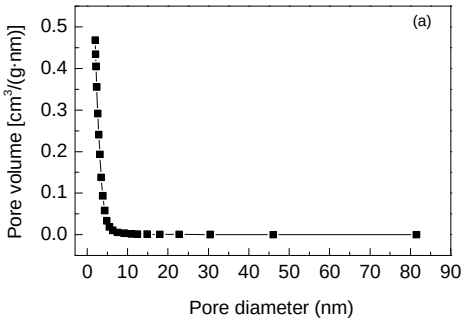
The adsorption generally occurred in the surface of adsorbent, the specific surface area and pore structure of adsorbent are one of the important factors affecting the adsorption performance [20].The pore structure of activated carbon was characterized by nitrogen adsorption, the nitrogen adsorption desorption isotherms under 77K are shown in Figure 1(a).It can be seen from the figure that the nitrogen adsorption isotherms belong to the I type in the IUPC classification [19]. At the beginning of adsorption , nitrogen adsorption reached 200 cm3/g, the results indicated that the activated carbon had a certain pore diameter less than 1 nm[21].In the relative pressure near 0.1, adsorption isotherms rise rapidly, the relative pressure is greater than 0.3, the adsorption isotherm increased slowly, showed that a large number of porous structure exist in activated carbon. The adsorption desorption isotherms have fine desorption hysteresis loop, may be due to nitrogen in the capillary condensation in the hole, the results showed that the activated carbon has a certain number and shape of mesopores.

According to the BET formula, the total specific surface area of sycamore bark activated carbon was 1393 m2/g. BJH method was used to calculate the pore size distribution, the results are shown in Figure 1(b). From the map it can be seen that the most hole diameter below 10 nm. The pore diameter of 2~5 nm is the main hole. The pore volume is 0.623 m3/g by BJH method, among which the micropores are 7.2% and the mesopores are 91.6%. It can be seen that the distribution of activated carbon pore diameter is concentrated in the mesopore.

The morphology and structure of activated carbon were studied by scanning electron microscope, The results as shown in Figure 2.It can be seen that sycamore bark activated carbon in various shapes and sizes, uneven surface, structure of fluffy, sporadic bumps, irregular porous structure faults.



(a)



(b)

Fig.1. Nitrogen adsorption–desorption isotherms and pore distribution of sycamore bark activated carbon

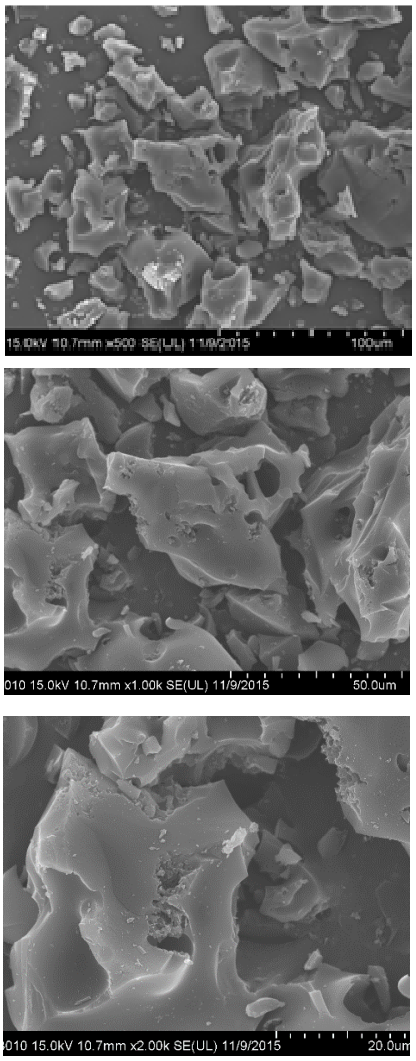


Fig.2. SEM images of sycamore bark activated carbon

Effect of dosage on the removal rate of Congo red.

Take 100 mg/L Congo red solution of 100 mL, plus different doses of the sycamore bark activated carbon, Adsorption of 180 min at room temperature and 60 r/min, figure 3 is different dosage effect of the sycamore bark activated carbon on the removal of Congo red in water. From the map it can be seen that the dosage of 1, 2, 2.5 g/L，The removal rate of Congo red was 49.5%, 85.1%, 94.1%respectively, the removal rate of sycamore barkactive carbon with dosage increasing，This may be due to the increase in the total amount of adsorbent, the adsorption of the total surface area and functional groups increased, the removal rate of Congo red increased.

When the dosage was 3 g/L, the removal rate of Congo red was up to 98.6%, and the removal rate was not increased. The results showed that the solution of Congo red was completely removed by adsorption.

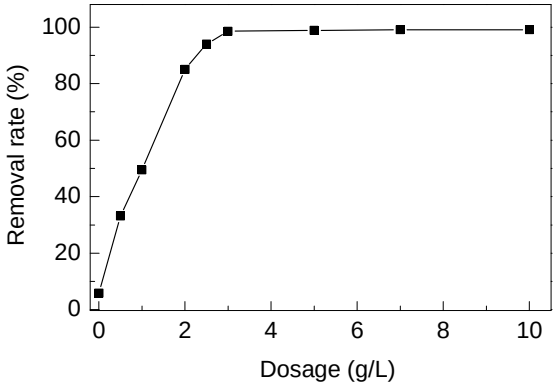


Fig.3. Effect of amount of adsorbent on removal of congo red

Effect of adsorption time on removal rate of Congo red

Take 100 mg/L Congo red solution of 100 mL, adding 3 g/L of sycamore bark activated carbon, adsorption of certain time at room temperature and 60 r/min, the removal effect of Congo red is shown in Figure 4.

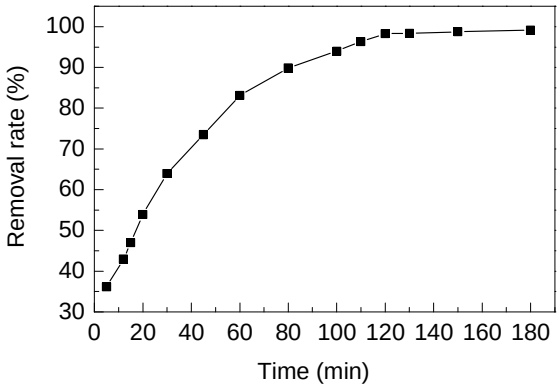


Fig.4. Effect of adsorption time on removal of Congo red

It can be seen from the figure that the first 40 min adsorption is very fast, belonging to the rapid adsorption phase, may the sycamore bark activated carbon adsorbent surface contains a large number of active sites. It can quickly adsorb Congo red in water, and the concentration of Congo red is higher at the beginning of adsorption, also increased the adsorption mass transfer force，Congo red removal rate increasing rapidly. With the increase of adsorption time, a large number of Congored was adsorbed on the surface ofadsorbent, active sites can be provided decrease gradually, at the same time, Congo red

solution concentration decreased, the mass transfer driving force is reduced, the adsorption rate decreased, removal rate tends to be slow, enter the slow adsorption stage. After 120 min of adsorption adsorption gradually reached equilibrium, the removal rate tended to be stable. The equilibrium time of adsorption is 120 min.

Effect of oscillation intensity on removal rate of Congo red

Take 100 mg/L Congo red solution of 100 mL, adding 3 g/L of sycamore bark activated carbon, adsorption of 60 and 120 min at room temperature under different oscillation intensities. The effect of oscillation intensity on the removal rate of Congo red is shown in Figure 5. From the map it can be seen that as the oscillation intensity increases, the removal rate of Congo red rise. The adsorption time is 120 min, the oscillation intensity 60 r/min removal rate reached 98.4%, continue to increase the intensity of oscillation, the removal rate of Congo red remains unchanged, at this time may have reached the adsorption equilibrium. Under the same oscillation intensity, the removal efficiency of Congo red at adsorption of 60 min was significantly less than 120 min.

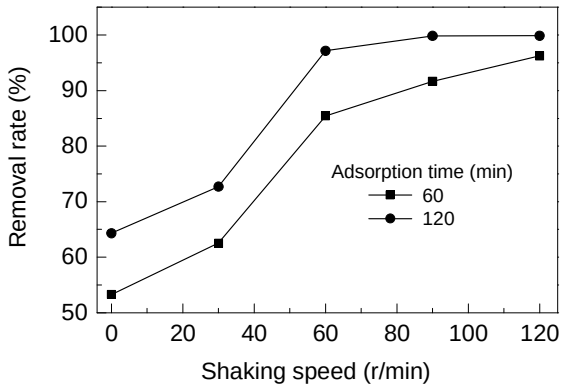


Fig.5. Effect of shaking speed on the removal of Congo red

Analysis of isothermal adsorption model

The most commonly used two adsorption isotherm models are Langmuir isotherm equation and Freundlich isotherm adsorption equation [22,23].

Langmuir Model：

$$C_e/Q_e = C_e/Q_{max} + 1/Q_{max}K_L \quad (3)$$

Freundlich Model：

$$\ln Q_e = \ln C_e/n + \ln K_f \quad (4)$$

In the formula, C_e is the adsorption equilibrium concentration (mg/L) of Congo red solution, Q_{max} is the maximum adsorption capacity(mg/g), Q_e is the equilibrium adsorption capacity(mg/g), K_L is the Langmuir equilibrium constant，N is a dimensionless factor related to adsorption strength, K_f is the Freundlich adsorption equilibrium constant.

Langmuir adsorption isotherm equation and Freundlich adsorption isotherm equation were fitted to sycamore bark of activated carbon on Congo red，the results are shown in Figure 6 and table 1.

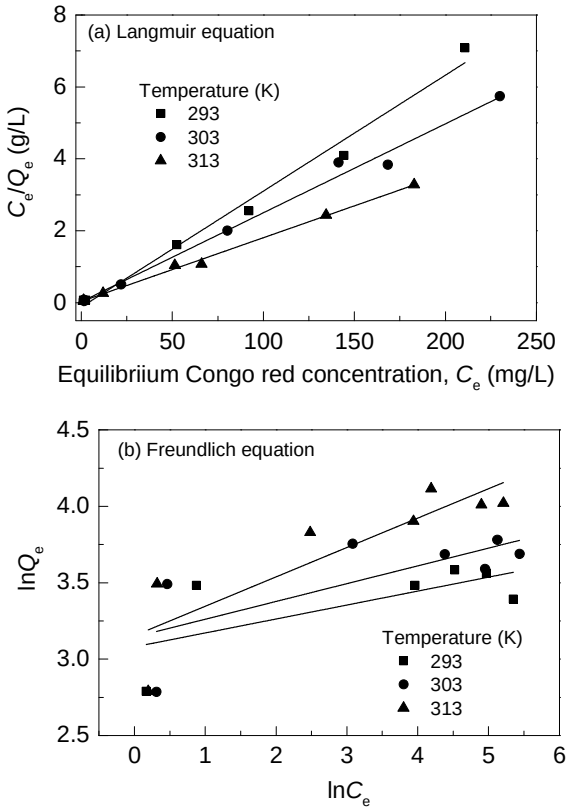


Fig.6. Adsorption of Congo red with sycamore bark activated by Langmuir and Freundlich isotherm equation

As can be seen from Figure 6 and table 1, the adsorption of Congo red by the sycamore barkactivated carbon at different temperatures is in accordance with the Langmuir equation. The correlation coefficients R2were greater than 0.983, The linear fitting is better. When the temperature rises from 293 K to 313 K, the maximum adsorption capacity Q_{max} of sycamore bark activated carbon of Congo red rose from 34.30 mg/g to 56.43 mg/g，the results showed that the increase of temperature was favorable to the adsorption of Congo red by the sycamore barkactivated carbon. The adsorption is an endothermic process.

Table 1
Isotherm model parameters of Congo red adsorption on sycamore bark activated carbon

Temperature(K)	Langmuir equation			Freundlich equation		
	K_L(L/mg)	Q_{max}(mg/g)	R_L^2	K_f(mg/g)	n^{-1}	R_F^2
293	0.986	34.30	0.983	21.56	0.097	0.53
303	0.871	40.44	0.990	23.21	0.116	0.54
313	0.499	56.43	0.997	23.42	0.192	0.76

The Freundlich model coefficients n^{-1} <0.5, showed that the adsorption ofsycamore barkactivated carbon of Congo red is easy adsorption process[4], Sycamore barkactivated carbon has good adsorption properties and can be used as adsorbents for removal of Congo red.

Analysis of the adsorption kinetics model

The adsorption kinetics can be used to describe the adsorption rate of solid adsorbents，revealing the adsorption mechanism，the relationship between the structure of the adsorbent and the adsorption performance can also be analyzed based on the kinetic model and the adsorption process [24,25,26].

The adsorption kinetics process was simulated by Lagergren pseudo first order kinetics model and pseudo two order kinetics model[27].

Lagergren pseudo first order kinetic model:

$$\ln(Q_e - Q_t) = \ln Q_e - K_{1t} \quad (5)$$

Quasi two level kinetic model of Lagergren:

$$t/Q_t = 1/(K_2 Q_e^{\ 2}) + t/Q_e \quad (6)$$

In the formula, K_1 is the first order rate constant(min^{-1})， K_2 is a quasi two order rate constant[g/(mg·min)].

As can be seen from table 2, the equilibrium adsorption capacity $Q_{e,\ cal}$ calculated by the pseudo first order kinetic model is different from the measured adsorption capacity $Q_{e,exp}$. The quasi two level dynamic model of $R_2^2 \geq 0.987$，The calculated value of equilibrium adsorption $Q_{e,cal}$ is close to the measured adsorption capacity $Q_{e,exp,}$ showed that the adsorption data fit well with the pseudo two order kinetics model, the relevance of better.K2 increased with the increasing of temperature, showed that the increase of temperature was beneficial to the adsorption of Congo red by thesycamore bark activated carbon.

Table 2
Kinetics modeling parameters of Congo red adsorption with sycamore bark activated carbon

Temperature(K)	$Q_{e,exp}$ (mg/g)	Pseudo-first-order kinetic model			Pseudo-second-order kinetic model		
		K_1(min^{-1})	$Q_{e,cal}$(mg/L)	R_1^2	K_2 [g/(mg·min)]	$Q_{e,cal}$(mg/g)	R_2^2
283	21.77	0.008	24.32	0.944	0.079	22.51	0.987
293	32.9	0.024	34.31	0.947	0.095	29.97	0.988
303	33.1	0.015	40.44	0.946	0.113	35.13	0.998

Analysis of adsorption thermodynamics model

The thermodynamic properties of the adsorption process can be characterized by thermodynamic parameters, standard Gibbs free energy change (ΔG0, kJ/mol), standard reaction enthalpy change (ΔH0, kJ/mol) and standard reaction entropy [ΔS0,kJ/(mol·K)] [23]. The thermodynamic parameters of the adsorption of Congo red by the sycamore bark activated carbon can be calculated by the following equation [4,28]:

$$\Delta G_0 = \Delta H_0 - T\Delta\Delta_0 \quad (7)$$

$$\ln(Q_e/C_e) = \Delta S_0/R - \Delta H_0/RT \quad (8)$$

In the formula, T is the temperature, R is the ideal gas constant [8.314 J/(mol·K)].

The adsorption data of Congo red by the sycamore barkactivated carbon were plotted with 293, 303 and 313 Kby ln (Qe/Ce) to obtain ΔH^0 and ΔS^0, and the results are shown in Table 3. From the table we can see that sycamore bark activated carbon adsorption enthalpy of adsorption of Congo red variable Delta ΔH^0 is positive, indicated that the adsorption process is endothermic reaction, Increasing temperature is favorable to the reaction[23]. The adsorption energy free energy change ΔG^0 at different temperatures is negative, indicating that the adsorption was a spontaneous process. The ΔS^0 of adsorption process of sycamore bark activated carbon on Congo red is greater than 0, indicating that the adsorption is a entropy production process, the adsorption spontaneous is increased with temperature [28].

Table 3
Thermodynamic parameters for congo red adsorption with sycamore bark activated carbon

Temperature(K)	ΔG^0(kJ/mol)	ΔH^0(kJ/mol)	ΔS^0[kJ/(mol·K)]	R^2
293	–6.40			
303	–7.75	33.16	0.135	0.998
313	–9.10			

IV. CONCLUSION

The activated carbon from the sycamore bark was prepared by the activation of zinc chloride, the adsorption of Congo red was studied, the conclusions as following:

(1) the content of sycamore bark activated carbon is high, the shape of the pore is various, the structure of the void is developed, and the specific surface area is up to 1393 m^2/g.

(2) Increasing the amount of adsorbent can enhance the adsorption of Congo red. The adsorption reached equilibrium within 120 min. The removal rate of Congo red was up to 98.2% under the condition of room temperature, dosage of 3 g/L, adsorption time of 120 min and oscillation intensity of 60 r/min,

(3) The adsorption of Congo red on sycamore bark activated carbon was followed Langmuir isotherm model and Lagergren pseudo-second order kinetics model. The adsorption was spontaneous, endothermic, and the entropy were increasing in the adsorption process.

REFERENCES

[1] Xie Z M, Chen Z, Dai YZ. Preparation of Sepiolite Complex Sorbent and Its Treatment Properties for Dyeing Wastewater. Environmental Science and Technology 32. 2009, pp, 130–133(in Chinese).

[2] Jiang BQ, Xiao ZQ.Preparation of Copper Oxide Loaded Activated Carbon by Waste Sawdust for Acid Red GR Wastewater Treatment. Adv. Mater. Res., 2011,pp, 356/360:395–398.

[3] Hu J, Zhang J, Wang C P, et al. Adsorption Mechanism of Modified Wheat Shell Husk for Conge Red from Aqueous Solutions. New Chemical Meterials 43. 2015, pp, 163–172(in Chinese).

[4] Yu M Q, Yang J B, Lin J Q, et al. Adsorption of Congo Red Dye by Modified Honeycomb Coal Burnt Cinder. The Chinese Journal of Process Engineering 16. 2016,pp, 110–114(in Chinese).

[5] Wei X L, Feng L L, Yang Q, et al. Adsorption of Conge Red from Aqueous Solution by Modified Cotton Shell. Chinese Journal of Environmental Engineering 10. 2016, pp, 29–34(in Chinese).

[6] Ren N Q, Zhou X J, Guo W Q,et al. A Review on Treatment Methods of Dye Wastewater. Journal of Chemical Industry and Engineering 64. 2013,pp, 84–94(in Chinese).

[7] Xue F L, Zhang Y Q. Research Progress of Dye Wastewater Disposal Technology. Water Sciences and Engineering Technology. 2007, pp, 26–29(in Chinese).

[8] Nirav PR, Prapti US, Nisha KS. Adsorptive Amputation of Hazardous Azo Dye Congo Red from Wastewater: A Critical Review. Environ. Sci.Pollut. Res. 23. 2016, pp, 14810–14853.

[9] Zhou M, Zhu S F, Liu S B, et al. Adsorption of Dye Wastewater by Banana Peel Powder Immobilized by Sodium Alginate. Techniques and Equipment for Environmental Pollution Control 7. 2013, pp, 2208–2212(in Chinese).

[10] Asha S, Virarahavan T. Decolorization of Dye Wastewater by Biosorbents: A Review. J. Environ. Manage. 91. 2010, pp, 1915–1929.

[11] Luo P, Xu Y C, Zhang H. Adsorption Property of Active Carbon onto Dyeing Wastewater. Dyeing and Finishing. 2016, pp, 14–20(in Chinese).

[12] Meng F P,Yi H C. Application of Different Adsorbents on Dyeing Wasterwater Treatment. Materials Review 23. 2009, pp, 69–73(in Chinese).

[13] Wei X L, Yu Z M, Wu K, et al. Preparation of Activated Carbon from Dewatered Sludge by Chemical Activation with KOH. Applied Chemical Industry 43. 2015, pp, 463–469(in Chinese).

[14] Munagapati VS, Kim DS. Adsorption of Anionic Azo Dye Congo Red from Aqueous Solution by Cationic Modified Orange Peel Power. J. Mol. Liq., 220. 2016,pp,540–548.

[15] Zhang R, Ge Y. Adsorption of Cationic Dye by Surfactant-modified Activated Carbon. Techniques and Equipment for Environmental Pollution Control 7. 2013, pp, 2233–2238(in Chinese).

[16] He Z J, Lu Y Q, Zhang H, et al. Congo Red Adsorption from Wastewater by Activated Carbon of Pomelo Peel.Journal of Guilin University of Technology 35. 2015, pp, 147–151(in Chinese).

[17] Zhao E L, Wang M L, Fan J F. Adsorption of Congo Red by Peanut Shells. Journal of Ecology and Rural Environment 26. 2010, pp, 372–375(in Chinese).

[18] Feng L L, Wei X L,Zhang N, et al. Preparation and Characterization of Activated Carbon from Sycamore Bark by Zinc Chloride. Journal of Fuyang Normal University (Natural Science) 33. 2016, pp, 41–45(in Chinese).

[19] Yu Z M, Wei X L, Lou M S, et al. Preparation and Characterization of Activated Carbon from Bio-char by Chemical Activation with $ZnCl_2$. Chemical Industry and Engineering Progress 33. 2014, pp, 3318–3323(in Chinese).

[20] Yao H, Zhang S C, Shen Y, et al. Preparation and Characterization of Sludge Activated Carbon. Techniques and Equipment for Environmental Pollution Control 6. 2012, pp, 2138–2142(in Chinese).

[21] Wang L L, Long L J, Chen X P, et al. Characterization of Mesoporous Activated Carbon from Camellia Oleifera Shell and Study on Its Porous Structure. Journal of Chemical Engineering of Chinese Universities 27. 2013, pp, 297–303(in Chinese).

[22] Nautiyal P, Subramanian KA, Dastidar MG. Adsorptive Removal of Dye Using Biochar Derived from Residual Algae after in-situ Transesterification: Alternate Use of Waste of Biodiesel Industry. J. Environ. Manage. 182. 2016, pp, 187–197.

[23] Wu Y, Luo H J, Wang H. Adsorption Properties of Modified Sawdust for Conge Red Removal from Wastewater. Acta Scientiae Circumstantiae 34. 2014, pp, 1680–1688(in Chinese).

[24] Liu L, Liu J, Li H, et al. Equilibrium, Kinetic, and Thermodynamic Studies of Lead(II) Biosorptionon Sesame Leaf. Bioresour. Technol. 7. 2012, pp, 3555–3572.

[25] Wei X L, Bao X Y, Wu k, et al. Adsorption of Cr(VI) from Aqueous Solution by Modified Cotton Shell. Technology of Water Treatment 42. 2016, pp, 36–47(in Chinese).

[26] Huang X D, Lou B Y. Study on the Adsorption of cetyltrimethylAmmonium Bromide from Aqueous Solutions with Durian Shell. Journal of Jinggangshan University(Natural Sciences Edition). 2013, pp, 22–27(in Chinese).

[27] Rao TM, Rao VV B. Biosorption of Congo Red from Aqueous Solution by Crab Shell Residue: A Comprehensive Study. SpringerPlus 5. 2016, pp, 537–551.

[28] Liu J, Zhu Q X, Tan X W, et al. Adsorption of Methyl Orange on Modified Activated Carbon. The Chinese Journal of Process Engineering 16. 2016, pp, 223–227(in Chinese).

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Creation of Reed Cadastres

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Abstract. In Latvia the total renewable energy resource volume has not been fully evaluated. Reed exploitation for energy output has not been developed on a large scale. One of the factors for this is the lack of information about to reed resource spread and characteristics. Therefore, there arises the need for a united inventory system – the formation of a reed cadaster. The study contains information on basic principles of reed cadastre creation and research methodologies.

The reed cadaster is a list of the reed researches which contains information about the reed areas in Latvia, the volume and locations, the legal status, possibilities for exploitation, as well as the biomass qualities, in each specific water reservoir. For each water reservoir, which is included in the reed cadaster, a certificate and chart have been produced. Information about the reed locations in each specific lake have been shown on the cadaster chart; the boundaries of the water reservoir, the boundaries of the reed plants and areas, the natural habitat protected area boundaries, the district boundaries, as well as the access roads. The data for reed characteristics and accessible volumes is compiled in the water reservoir cadaster passport. Development for reed exploitation in the conditions of Latvia is dependent on the location, accessible volumes and existing infrastructure. Reeds are a long term renewable energy resource, with the spread of reeds increasing every year.

Keywords: common reed, reed biomass, renewable energy resource, common reed cadaster.

I. INTRODUCTION

Up to this point in time the energy potential resource of the biomass of water plants has not been taken into account in Latvia. The exploitation of these plants as an energy resource would create new jobs, reduce the use of fossil energy resources, as well as solving a variety of environmental protection problems. One of the plants, which could be made use of in the Latvian conditions for energy purposes, is the reed plant *(Phragmites australis (Cav.) Trin. Ex. Steud.*) growing in natural and artificial water reservoirs. [1,2,3].

Studies carried out by foreign scientists also indicate that reeds can be used as a raw material for fuel generation. [4,5]. Basing on information from the Database of Latvian Lakes, there are 17 lakes and artificial bodies in Latvia whose surface exceeds 1000 ha. [6]. Overall, reeds from more than 2000 Latvian lakes can be used to generate energy. [7]. Latvian lakes have to face eutrophication that has a negative impact on lake biotopes and decreases biological diversity in these lakes; besides, residues of decaying water plants promote emission of gases causing the greenhouse effect. Lake eutrophication is also well-known in other parts of the world. [8]. Reed is one of the most common water plants growing in almost all water bodies in Latvia. Currently, they are being used in small amounts for construction needs, but, due to the increase in prices of fossil energy resources and to the pollution caused by the use of fossil resources, the interest in using local biomass in energy supply is growing. Thus, the issue of rational use of reed resources is becoming more topical.

In Latvia the total renewable energy resource volume has not been fully evaluated, the potential of each energy source and accessability for the long – term in the respective regions. To exploit any of the resources in the long – term in an efficient and justifiable way, it is necessary to evaluate the accessible volumes and qualitative parameters [9].

Thus far, there have not been complex studies on reeds in Latvia, there have only been some studies of specific reed samples to examine their characteristic features and possibilities of biomass pre-treatment. Using reeds for generation of thermal energy in larger volume is not a well-developed practice. One of factors causing this problem is lack of information on distribution of reed resources and their characteristics. Therefore, there is a need to create a unified reed recording system, i.e. reed cadastre. Reed cadastre is a list of reed resources including information on reed-covered areas in Latvia, their volumes and locations, legal status, possibilities of use, as well as characteristics of the biomass in each specific water body. Data included in reed cadastre would allow planning works necessary for reed extraction and forecasting the quantity and quality of the respective raw material. The aim of the research is to study reed distribution and characteristic parameters of this plant, establish criteria for the cadastre of reed resources and create a cadastre of Kvapanu Ponds, as well as to give recommendations for further development of the reed cadastre.

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II. MATERIALS AND METHODS

Cadastre contains the main data related to the use of reed growths. Each water body included in the reed cadastre has its own passport and reed cadastral map. The following aspects are shown in the reed cadastral map: borders of the water body, borders and areas of reed growths, borders of SACs (*Special Areas of Conservation*), borders of administrative areas, and access roads. Reed cadastral passport contains the main parameters and features characterising the respective reed growth. This study analyses the main parameters characterising each reed growth to be included into the reed cadastre and provides methods to establish them.

Level of the lake's overgrowth A_{lake} in %, shows the size of the part of the total area of the respective water body overgrown with reeds:

$$A_{lake} = \frac{S_{reed}}{S_{lake}}, [\%], \quad (1)$$

where S_{reed} is the total area of reeds in each lake;
S_{lake} is the lake surface area.

To detect the reed-covered area (S_{reed}), it is possible to use GPS devices [10], by measuring all reed growths, however it is possible in cases when only small areas are to be measured with high precision, because this process is very labour-intensive. Within this study, the reed-covered area was detected using distance-based probing method in the computer program Arc Map 9.2. This method can be also recommended for further creation and development of the reed cadastre. The measuring method is based on analysis of orthophoto images; orthophoto images were analysed without using specific filters. Orthophoto analysis for detection of plant-covered areas in water bodies has also been used by other researchers [11; 4;5;12; 13; 14]. Borders of reed growths are being digitalised and area of the surface of each reed growth in the specific lake or pond farm is being calculated by using the polygon drawing tool in the computer program Arc Map 9.2. (Fig.1.), digitalisation scale is 1:500. The sum of reed growth areas in each lake constitutes the amount of reeds that can be potentially gathered. Reed-covered areas were detected using orthophotos taken from 2005 to 2010.

Fig. 1. Reed growths in the Southern of Kvapanu Ponds

Long-term changes in the total areas of reed growths are shown by dynamics studies. In the respective water body, reed-covered area is being detected in each of the reference year, which allows assessment of reed growth changes. In order to quantify the reed growth changes over time, the following values were introduced: lake overgrowth intensity $I_{overgrowth}$ and increase in reed growths in the water body I_{wb}.

Reed growth increase in the water reservoir I_{wb} is expressed ha *year $^{-1}$ which shows by how many ha in the time period the reed spread has changed on an annual basis in each specific water reservoir:

$$I_{wb} = \frac{S_e - S_s}{n}, \text{ ha *year}^{-1} \quad (2)$$

Where, S_e – Calculated reed area at the year end;
S_s – Calculated reed area at the year start;
n – The number of years in the period analyzed.

Intensity of the lake overgrowing $I_{overgrowth}$, express changes in the reed area, which happen during the course of time in the water reservoir. The lake overgrowing intensity shows by what percentage annual the reed spread expands or contracts over the total area of the water reservoir.

$$I_{owergrowth} = \frac{(S_e - S_s) * 100}{n * S_{lake}}, \%*\text{year}^{-1} \quad (3)$$

Where, S_e – Calculated reed area at the year end;
S_s – Calculated reed area at the year start;
n – The number of years in the period analyzed;
S_{lake} – the lake surface area.

Characterisation of field studies. In each of the lakes examined, the author chose four reed growths that, in respect to their characteristic parameters, visually corresponded to the average level in the respective water body. Two sampling plots were examined in each growth. For each of them, the following parameters showing reed productivity were determined: reed density, average diameter of stems and amount of biomass to be gathered. Each year, reed sampling plots were created within the same growth, which allows comparing parameter changes over years. Winter harvesting of reeds on the ice shows a biomass result. With a direct weighing method in situ the amount of reed biomass was established, which can be extracted from lakes and fishfarms from a 1m square reed growth. In the calculations, the reed sections above ice during the winter are included. Reed harvesting and sample weighing were done in 8 sampling plots (four different plant areas with 2 sampling plots in each) in each of the lakes surveyed Sampling plot area 25m square (figure 2). The obtained results were recalculated to the dry condition. Plots were located in places corresponding to the average overgrowth density, and overgrowth density was determined by monitoring the reed bed. This methodology is also recommended for future maintenance and development of the cadastre.

Fig. 2. Sampling plot for reed biomass measurements in Lubana Lake

Characterisation of laboratory studies.

For each of these samples the following heat technology parameters were established – carbon content in the biomass, the relative moisture content, the lowest combustion temperature, the lignin content in the biomass, evaporable matter in the biomass, ash content, as well as the metal content in the biomass for the following – Copper (Cu), Cadmium (Cd), Nickel (Ni), and Lead (Pb).

Samples for the laboratory experiments were prepared according to the standard method CEN/TS 14780.

Moisture content in the reed biomass was established according to the standard method CEN/TS 14774 – 2.

Ash content was determined by applying the standard method CEN/TS 14775.

Carbon content in the biomass was established with the carbon/sulphur analyzer ELTRA CS – 2000 which works on the principles of chromatographic analysis. The reed biomass thermal capacity was established with a colorimetric thermometer Paar 6772, for a natural moisture content of 10 – 12%.

Lignin content in the reed biomass established by the Classon method [15].

Evaporable matter content established by the following methodology: First weigh the crucible, then the sample for analysis with a mass of 1± 0,1g, the crucibles are covered with a lid and placed in a furnace with tongs with a preset temperature of 600C.

After 7 minutes the crucibles are removed and left to cool in the air. The lids are removed and the crucibles placed in an escalator where the samples cool to room temperature, the crucibles are weighed and the non – evaporable remainder removed. The relevant calculations are made.

To determine the **heavy metal content in the biomass** the mineralization of the samples was carried out using the relevant methodology. The reed biomass was reduced in size by a milling process which produced bits <150 um, which were weighed as a 1,5g dry biomass sample. Then 15ml concentrated $HN0_3$ was added, the sample heated to 95 degrees C over 2hours. The cooled sample was filtered, the filter having been washed with 0,5% $HN0_3$ and diluted with deionized water up to 65ml. The metal content in the solution was established with an optical plasma spectrometer Perkin Elmer optima 2100 DV.

Concentration (C) of heavy metals per 1 kg of reed ashes is calculated using equation 4:

$$C = \frac{C_{el} * V_{sample} * 1000}{m_b}, \text{ mg*kg}^{-1} \quad (4)$$

where C_{el} is concentration of the element, mg*l^{-1};

V_{sample} is volume of the sample after mineralisation, l;

m_b is ash weighting, g.

Content of heavy metals in ash is used to determine maximum five-year doses of ash incorporation into the soil. Maximum acceptable doses of reed ash to be incorporated into one unit of soil area were assessed taking into account sewage sludge incorporation into the soil. Limiting doses were established in line with the requirements of Cabinet Regulation No. 362 of November 1, 2008 "On Utilisation, Monitoring and Control of Sewage Sludge and the Compost thereof" (Table 1).

Table 1
Limit Values Of Annual Heavy Metal Emission Intoagricultural Soils

Nº	Limiting element	Average for a five-year period (g*ha^{-1} per year)	
		sand, loamy sand	loam, clay
1	Cadmium (Cd)	30	35
2	Cooper (Cu)	1000	1200
3	Nickel (Ni)	250	300
4	Lead (Pb)	300	350

All laboratory studies were repeated thrice, the respective error calculations were also carried out, therefore these values are indicated in the reed passport data as an interval. Descriptive statistics and dispersion analysis methods were used for data processing [16; 17]. Images were used to visualise data and correlations.

The amount of the mass obtained was determined at a natural moisture content. Reeds were cut above the ice using a scythe. Reeds, after being cut, were gathered, tied and weighted. The amount of the biomass obtained from the respective sampling plot was recalculated to t*ha^{-1}. For studies of characteristic features, the results obtained were recalculated to a dry state $\mathbf{M_{dry}}$.

Reed height H_{reed} was established with a tape measure in situ. In each of the water reservoir sampling plots the harvested reeds were measured and the mean height established for a 1m square area.

Reed diameter D $_{niedru}$ was established with a slide gauge in situ. In each sampling plot the reed diameter was measured for a 1m square area, when harvested for the biomass result. The diameter was measured 10 cm above the ice. The results were

analyzed to calculate the mean reed diameter in each sampling plot.

Reed density was established in each water reservoir sampling plot with a count of reed stalks for a 1m square area, which were harvested to establish the biomass result. From each sampling plot about 1kg of reed biomass was taken, which was used to establish the parameters of reed heat engineering under laboratory conditions.

Previous studies have revealed that reed stems and leaves have different features and different capacity to accumulate heavy metals. [18]. In our research, reed stems were not separated from leaves, because, when gathering reeds for fuel generation, such separation is complicated and energy intensive, which would make reed procession more expensive. Reed samples gathered from eight sampling plots in each lake were joined together to create the averaged sample. Reed samples were placed in a shelter for storage, no additional drying was performed. Reeds were shredded, and 1 kg of the shredded averaged sample was taken for laboratory studies.

III. RESULTS AND DISCUSSION

The reed cadastre was created as a summary of results of the main researches related to reed growths, which allows using it in further management and studies of reed growths. Each water body included in the reed cadastre needs to have a passport and reed cadastral map. The study resulted in a reed cadastre for 11 biggest reed gathering sites in Latgale region. Studies of reed growths were carried out in Lubana Lake, Gumelis Lake, Raznas lake, Feimanu Lake, Sivera Lake, Luknas Lake, Kvapanu Ponds and Naglu Ponds, as well as in Rusonas Lake, Birzkalna Lake and Cirisa Lake.

Information on reed locations in each specific lake is shown in the reed cadastral map where visualisation of borders of the water body, borders and areas of reed growths, borders of the special area of conservation, borders of regions and access roads (Fig. 3), can help in finding solutions for better logistics of reed use.

Data to be included into the reed cadastral passport were divided into two parts: geographical data of the water body and characteristic parameters of reeds. Geographical data of the water body are the following: CWMD (*Classifier of Water Management Districts*) code and surface area of the water body, as well as average depth and legal status of the water body defined basing on data from the Database of Latvian Lakes. [6]

Characteristic parameters of reeds include calculated reed-covered area, average amount of reed cut above ice in wintertime, potential amount of biomass and amount of biomass actually harvested. (Fig.4).

Areas overgrown with bushes were not added to the total reed areas, while areas covered with cane were taken into account.

Studies carried out by other authors have shown that it is not recommended to cut 100% of all reed-covered areas each year, because it causes changes in the structure of reed growths and may affect negatively populations of organisms living therein [5;19]. Therefore, the amount of reed biomass to be actually obtained is lower than the potential amount of reed biomass that could be theoretically obtained. Besides, to avoid any adverse impact on reed growths and organisms living therein, the maximum amount to be obtained should not exceed 50% of the total amount. [2]. Thus, the biomass amount to be actually obtained was calculated as 50% of the reed amount found in each water body. Total amount of reed biomass to be actually obtained was calculated by multiplying the area covered with reed to be actually used by the amount of biomass obtained from one surface unit in each specific water body.

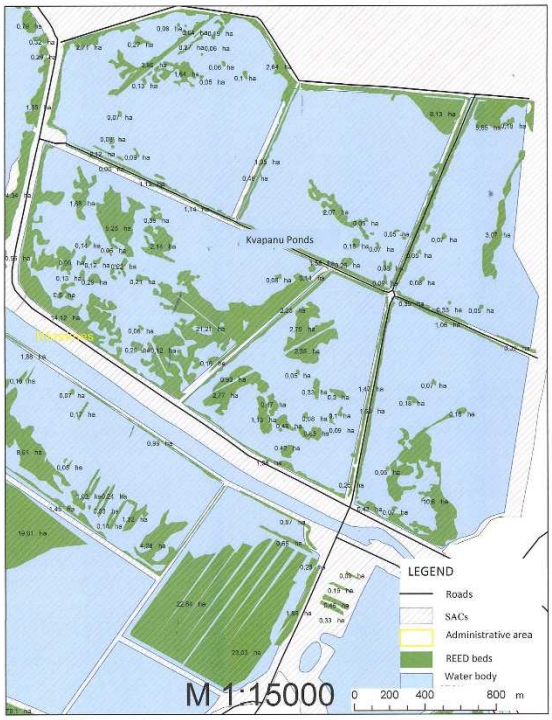

Fig. 3. Cadastral map of reed growths in Kvapanu Ponds

Kvapanu Ponds	
Geographical data of the water body	
CWMD (*Classifier of Water Management Districts*) code	No
Surface area, $\mathbf{S_{lake}}$, [ha]	610
Average depth of the lake, $\mathbf{H_{lake}}$ [m]	0.5
Legal status	Private
Area of conservation	Nature reserve "Wetland of Lubana Lake", territory of Natura 2000.
Characteristic parameters of reeds	
Calculated reed area, $\mathbf{S_{reed}}$,[ha] (in 2008)	160
Distribution of reed areas by administrative territories, %	100 % Rezekne region
Reed-covered area located in Special Areas of Conservation, [ha]	16
Average amount of reeds cut above ice in wintertime, $\mathbf{M_{reed}}$ [t*ha^{-1}] (in 2010-2012)	8.16-8.66
Potential amount biomass (when cutting reed above ice in wintertime), $\mathbf{M_{total}}$,[t] (in 2010-2012)	1305-1385
Amount of biomass actually harvested (when cutting reed above ice in wintertime), $\mathbf{M_{real}}$, [t] (in 2010-2012)	650-690
Overgrowth level in the water body, A_{lake}, [%], (in 2008)	26.2
Increase in reed growths in the water body I_{wb},[ha* year^{-1}], (in 1997-2008)	7.8
Overgrowth intensity in the water body, $I_{overgrowth}$, [%*year^{-1}], (in 1997-2008)	1.3
Average heigh of reeds, H_{reed}, [m] (in 2010-2012)	2.18-2.28
Average diameter of reeds, D_{reed}, [mm]; (in 2010-2012)	7.84-8.24
Average density of reeds, B_{reed}, [stems * m^{-2}]; (in 2010-2012)	55-60
Average ash content, A_d, [%]; (in 2010-2012)	4.3
Average relative humidity, M_{rel},[%] (in 2010-2012)	15.6-17.0
Average lowest heat of combustion, [MJ*kg^{-1}], (in circumstances of natural moisture content) (in 2010-2012)	14.11-14.39
Average carbon content, [%] (in 2010-2012)	40.6-42.8
Average lignin content in biomass, [%] (in 2010-2012)	25-25.67
Average content of volatile substances in biomass, [%] (in 2010-2012)	68.1-68.8
Maximum acceptable five-year dose of reed ash distribution t*ha^{-1}.	Sand, loamy sand – 10.4 Sandy loam, clay – 12.5

Fig.4. Cadastral passport of reeds in Kvapanu Ponds

In Latvia, there is no system performing reed growth monitoring, therefore there are no data on long-term availability of reed resources. Cadastral passport also contains information on the overgrowth level in the water body and increase in reed growths in the water body. The latter shows intensity of reed invasion. These values allow assessing the amounts of reeds as renewable energy sources and their development trends, which helps us foresee their amounts in future. Studies of reed dynamics reveal that every year reed-covered areas in Latvian lakes increase. Thus, it can be concluded that reed is a sustainable resource. To quantify this increase, the cadastral passport contains information on overgrowth intensity in the water body expressed as %*year^{-1}. It can be seen from the Figure 4 that in Kvapanu Ponds this increase amounts to 1.3%*year^{-1} [f] from the total surface area of the water body.

Furthermore, passport data include information on characteristic features of reed growths: average height of reeds, average diameter of reed stems and reed density, which allows conclusions to be drawn as to the overall state of the respective reed growth and which is also necessary in the process of reed harvesting and when choosing and designing technical equipment for primary-processing.

Research results show that average height of reed growths on sampling plots varied between 1.55 and 2.35 m. Average height of reed growths in Kvapanu Ponds amounted to 2.18-2.28 m. Average diameter of reed stems in growths varied from 5.25 to 8.35mm, while in Kvapanu Ponds the average diameter was 7.84-8.24 mm, which is above the average level. Average density of reed growths amounted to 55-60 stems per one m^2 of reed growth.

Reed suitability for energy production is characterised by their thermal features. Reed cadastral passport contains the following features: lowest heat of combustion, carbon content in the biomass, ash content in the reed biomass, relative

moisture content, content of volatile substances in the biomass and lignin content in the biomass. The main indicator to be included into the reed cadastral passport is heat of combustion. For the analysed samples of reed biomass, the lowest heat of combustion varied from 13.57 to 14.70 $MJ*kg^{-1}$. For reeds growing in Kvapanu Ponds, this value was 14.11-14.39 $MJ*kg^{-1}$.

Main factors that can affect the heat of combustion are the content of combustible elements and content of moisture and ash in the biomass. Ash content in the respective samples varies from 2 to 8%. On the average, reeds contain approximately 5% of ash, which is five times more than in wood and is equal to the ash content in straw or canary seed. Ash content depends on individual reed growing conditions in each water body. Ash content in reed biomass is stable within one water body. Main factor affecting the ash content might be the content of various elements in water and silt absorbed by reeds.

Relative moisture content in the respective samples varied from 14.5 to 19.2%. Average moisture content in samples of reed biomass was approximately 16.8%, which shows that reeds may be successfully combusted without previous drying. Almost the same moisture content was found by Estonian researchers: reeds with moisture content not exceeding 20% may be harvested in spring-winter period [5].

Lignin content in plants varies depending upon their type. For wood, it is 19-30%, in fibres of other plants 8-22 %. Lignin content was established using Klasons method [20]. Our study revealed that lignin content was equal to the wood biomass and was higher than in fibres of other plants, which shows that reeds are suitable for granulation and briquetting without adding additional binding agents, therefore this parameter should be included into the reed growth passport.

Content of volatile substances characterises combustion capacity. In the respective samples the content of such substances was high and varied from 64.4-72.8%, which may indicate that reed biomass is a highly flammable fuel.

Studies on canary seed reveal that the time of harvest also affects significantly thermal characteristics of the biomass [21], however harvest time for reeds is limited. Taking into account current technical harvesting equipment, industrial reed gathering requires a thick layer of ice. In order to avoid causing significant changes in reed growths, it is usually possible to harvest reeds only starting from the beginning of February to the end of March, which is also the time when reeds have the best thermal characteristics. Therefore, the impact of the time of harvesting on reed characteristics was not analysed and the recommended time of harvesting was not included into the cadastral passport as an indicator.

Using reeds as a fuel, reed combustion results in ash that can be considered to be a hazardous waste because it contains heavy metals. Studies on possibilities of reed ash utilisation by incorporating it into the soil have helped to determine the maximum acceptable five-year dispersion doses $t*ha^{-1}$ that have been included into the cadastral passport data. For reeds obtained from the Kvapanu Ponds, this value was 10.4 $t*ha^{-1}$ of ash in sand and in loamy sand soils, and 12.5 $t*ha^{-1}$ of ash in sandy loam and clay soils. Although a high level of ash content is typical for reeds, which often causes problems during combustion in wood combustion devices, adapting furnaces to reed combustion would allow successful converting them into energy. Reeds should be used as an additional energy resource, by using it in various technological processes of fuel procession and energy generation, which, in case of necessity, would create a possibility to replace the reed by other types of biomass, e.g. wood, because there are several high risk factors related to the use of reeds: floods in winter, storms and freezing of water bodies during floods, as well as blizzards may seriously damage the reed growths, or, in case of untypically warm winters, ice layer may not be sufficiently thick to ensure industrial harvesting of reeds.

Reeds in the water bodies of Latgale region should be harvested in winter time, by cutting them above ice, because permanent provision of this raw material, by cutting it in summer period, is not possible.

Harvesting of reeds in winter time, i.e. from the beginning of December to the end of April, is the best time to use them for fuel generation, because then the reeds have the best qualities as fuels. During this period, reeds contain the lowest level of chlorine and alkali metals undesirable in combustion devices. Besides, harvesting reeds in winter time reduces emission of CH_4 into the atmosphere. Cutting prevents reed-covered areas from overgrowing, raises reed viability and capacity to absorb nutrients during the next season. Reeds cut in the winter are easy to be converted into energy and they regrow by the next harvesting season [22].

IV. CONCLUSION

Reeds may be used for fuel generation. In Latvia there are more than 2000 lakes and pond farms that can be used to obtain reeds.

Criteria have been drawn up and a cadastre has been created containing information on reed resources in the most important reed harvesting sites in Latgale region. A cadastral map and reed growth passport have been created for each water body.

Cadastral map visualises borders of reed growths, borders of water bodies, areas of growths, borders of administrative territories, access roads and borders of special areas of conservation.

Reed cadastral passport contains geographical data of the water body and characteristic parameters of reeds. Geographical data included in the reed cadastral passport are the following: CWMD (*Classifier of Water Management Districts*) code, name of the water body, surface area of the water body, average depth and legal status.

Characteristic parameters of reeds are the following: reed-covered area, distribution by administrative territories, amount of reeds cut above ice in winter, potential and actual amount of biomass to be obtained, overgrowth level of the water body, reed height, density and average diameter. Besides, reed thermal features were also included: moisture and ash content, heat of combustion, content of lignin and volatile substances, as well as maximum five-year doses of reed ash distribution.

Reed cadastre should be developed and maintained, it can serve as a basis for creation of enterprises related to reed harvesting and processing.

REFERENCES

[1] Čubars E. (2008) Lubānas ezera niedru resursu izvērtējums un to izmantošanas enerģijas ieguvei pamatojums/ *Zinātniskais darbs maģistra grāda ieguvei/* Rēzeknes Augstskola, Inženieru fakultāte. Zin.vad. Gotfrīds Noviks. Rēzekne, 70 lpp.

[2] Enerģētisko augu audzēšana un izmantošana (2007) Adamovičs A.,Agapovs J., Aršanica A. u. c. Valsts SIA „Vides projekti", Rīga, 43-133. lpp.

[3] Kronbergs E., Šmits M. (2009) Cutting properties of common Reed biomass. ***In:*** *8th international scientific conference "Engineering for rural development"*, May 28.-29., Jelgava, Latvia, p.207.

[4] Komulainen M., Simi P.,Hagelberg E., Ikonen I., Lyytinen S. (2008) Reed energy-Posibilities of using the Cammon Reed for energy generation in Southern Finland. ***In:*** *Turku university of applied sciences reports 67*. p.5-75.

[5] Reed up on Reed (2007) Ikkonen I., Roosaluste E., Pitkanen T.at.al. Southwest Finland regional Environment centre, Turku 2007. , p. 5-115.

[6] Latvijas ezeru datubāze (2016)- [tiešsaiste][17.10.2016] Pieejams: http://www.ezeri.lv/database/AdvancedSearch

[7] Kronbergs A., Kronbergs E.,Siraks E., Dalbins J. (2012) Cutting properties of arranged stalk biomass ***In:*** *Proceedings of the International Scientific Conference „Renewable Energy and Energy Efficiency'',* p. 145.

[8] Krolikowska J. (1997) Eutrophication processes in a shallow, macrophyte-dominated lake – species differentiation, biomass and the distribution of submerged macrophytes in Lake Łuknajno (Poland) ***In:*** *Hydrobiologia 342/343*, p. 411–416

[9] Noviks G., Zorins A. (2011) National recomendation report. ***In:*** *Joint European-Latin American Universities Renewable energy Project*, Rēzeknes Augstskola Rēzekne, Latvija p.6-8.

[10] Havens K.J., Berquist H., Priest W.I. (2003) Common reed grass, phragmites australis, expansion into constructed wetlands: are we mortgaging our wetland future? ***In:*** *Estuaries vol.26*. No 2B, p. 417-422.

[11] Maheu-Giroux M., S. Blois S. (2005) Mapping the invasive species Phragmites australis in linear wetland corridors. ***In:*** *Aquatic Botany 83*, p.312.

[12] Ostendorp W., Dienst M., Schmieder K. (2003) Disturbance and rehabilitation of lakeside *Phragmites* reeds following an extreme flood in Lake Constance (Germany) **In:** Hydrobiologia 506–509, p. 687–695.

[13] Hroudova Z., Zakravsky P. (1999) Vegetation dynamics in a fishpond littoral related to human impact. ***In:*** *Hydrobiologia 415*, p.139–145.

[14] Hudon C., Gagnon P., Jean M. (2005) Hidrological factors controlling the spread of common reed (Phragmites australis) in the St. Lowrence river (Quebec, Canada). ***In:*** *Ecoscience 12(3)*, p. 347-357.

[15] Koksnes ķīmijas pamati (2008), Zaķis G., LV Koksnes ķīmijas institūts, 2008, 199 lpp.

[16] Arhipova I., Bāliņa S.(2006) *Statistika ekonomikā. Risinājumi ar SPSS un Microsoft Excel*. 2.izdevums. Rīga: Datorzinību centrs, 352. lpp.

[17] Douglas, C., G. Montgomery and C. Runger (2003) Applied Statistics and Probability for Engineers, Arizona State University 2003, p.140-258

[18] Lasage E., Rousseau D.P.L., Meers E. Et.all. (2007) Accumulation of Metals in the Sediment and Reed Biomass of a Combined Constructed Wetland Treating Domestic Wastewater. **In:** *Water Air Soil Pollut 183*, p.253–264.

[19] Valkama E., Lyytinen S., Koricheva J. (2008) The impact of reed manegment on wildlife: A meta-analitical review of European studies. ***In:*** *Biological conservation 141*, p.371.-373.

[20] Termal properties of green polimers and biocomposites (2005), Hatakeyama T., Hatakeyama H. Hot topics of in thermal Analysis and calorimetry. ***In:*** *ACS symo. Ser.Volume 4*, p.171-215.

[21] Poiša L., Adamovičs A., Platače R., Teirumnieka Ē. (2011(a)) Evaluation of the factors that affect the lignin content in the reed canarygrass (*Phalaris arundinacea* L.) in Latvia. ***In:*** *Proceedings of World renewable energy Congress 2011- Sweden*, 8-13 May 2011, Linkoping Sweden – [tiešsaiste][29.11.2016] pieejams http://www.ep.liu.se/ecp/057/vol1/030/ecp57vol1_030.pdf

[22] Huhta A. (2009) Decorative or outrageous- the significance of the common Reed (*Phragmites australis*) on water quality. *Comments from Turku University of applied sciences 48*, p. 25-27.

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On-line Drinking Water Contamination Event Detection Methods

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Abstract. A task of water supply systems is to provide safe drinking water to every customer, which is a basic human need. Aging of water supply networks and increased precaution of terrorism risks led to re-evaluation of drinking water supply system reliability and vulnerability to accidental and intentional contamination. Contamination of drinking water can cause health, social, psychological and economic issues. During the last decade, early warning systems (EWS) were often used to ensure the safety of drinking water. EWS are driven by conventional sets of drinking water quality sensors, and the collected data are analyzed in real time. For detection of contamination events, numbers of algorithms have been developed. Most of the algorithms are based on statistical analysis or machine learning. The aim of this study was to compare existing methods and to identify the method, which is suitable for contamination detection in drinking water from non-compound specific sensors and requires relatively low computational resource.

A detailed review of 11 different algorithms was presented in the current study with the primary focus on detection probability. Cluster analysis in combination with Mahalanobis distances of feature vectors and Canonical correlation analysis (CCA) approach were selected as the most promising methods for application in a new generation of EWS to detect and classify possible contamination events and agents. While canonical correlation analysis method was the most accurate for detection of contamination events, an advantage of Mahalanobis distances was that it not only detects the contamination events but also could identify the type of contaminant. In this study, we conclude that CCA and Mahalanobis distance methods might be applied for detection of contamination events with relatively high and reliable precision.

Keywords: drinking water quality, early warning systems, online monitoring.

I. INTRODUCTION

Drinking water supply systems (DWSS) are vulnerable to deliberate and accidental contamination events. Contamination events might cause health, social, psychological and economic issues to consumers [1]–[4]. There are numerous drinking water deterioration cases reported in different scientific and technological papers during the past decades. For example, more than 1900 drinking water contamination accidents annually have been recorded in China between 1992 and 2006 [5]. A chemical spill in Elk River West Virginia, the United States in 2014 has influenced more than 300 000 residents by the interruption of drinking water service because of deterioration of drinking water quality [6]. To increase the safety and reliability of drinking water supply system the early warning systems (EWS) have been developed [5]–[7]. The tasks of EWS systems include detection of contamination events during drinking water monitoring and following notification to the responsible institutions. EWS consists of a drinking water quality sensors set, data collection and analysis system and alarm triggering algorithm. Measurements, data collection, analysis and possible alarm triggering is aimed to be done on-line [5]. EWS provide not only the real-time detection of possible contamination event but also could classify the type of contaminant occurred in drinking water supply system.

There are two types of sensors used for drinking water quality monitoring. The first type is non-compound specific sensors or conventional type of sensors (pH, temperature, electrical conductivity, etc.) which are used for routine testing in most of the developed countries. These sensors are relatively straightforward and cheap, easy to maintain and install. The other type of sensors is compound specific sensors which are capable of measuring specific drinking water quality parameters with very high precision and amplitude [8]–[10].

Since EWS should be inexpensive, reliable, easy to maintain and integrate into the network [11], in most of the cases exactly non-compound specific sensors are used in such systems. Usually, there are sets of five to eight sensors installed at each monitoring point. Besides the appropriate combination of the sensors, a key factor for properly working EWS is the detection algorithm [5]. Therefore, mathematical algorithms have been developed through the decades to recognize the contamination events between normal periodic fluctuations of drinking water quality. There are

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various emerging algorithms, which differs in precision, reliability and requirement of computing resources. It is important to choose the most advantageous algorithm regarding these parameters for application in a real scale DWSS. However, no comprehensive studies on the comparison of various proposed algorithms and methods were made to evaluate the applicability for EWS.

The aim of this study was to compare and evaluate available and open code algorithms for detection and classification of contamination events with experimental or artificial data acquired by conventional drinking water quality sensors. To do that a cognitive literature study has been done.

II. CONTAMINATION DETECTION ALGORITHMS

The main part of the EWS is the contamination detection algorithm. Numerous studies have been done to develop and select the most precise event detection algorithm. The accuracy of the event detection method is defined by its ability to place the current measurement of water quality parameters into one of two classes: background – clear and safe water, event – contaminated water [12]. The detection methods during last decades have evolved and expanded from single factor correlation analysis to generic algorithms and artificial neural network analysis. A summary of these methods that were developed and tested in last decades and described in scientific papers is shown in Table 1. However, it should be noted that the methods, based only on the theoretical probability of detection of a potential contamination event, e.g. without any specific sensor installed in DWSS and actual measurements, were not studied in the present review.

Usually, the evaluation of event detection methods was done by assessing the trade-offs between false positive (FP) and false negative (FN) decisions as a function of the detection methods. The adopted received operating characteristic (ROC) curve has been chosen as an evaluation tool [13]. This curve has been used in all evaluated studies. The ROC curve defines the probability of detection (PD) that can be obtained as a function of the corresponding false alarm rate (FAR). FAR is equal to the number of FPs divided by the total number of values that are actually below the detection threshold as in equation (1). The PD is defined as the number of true positives divided by all events that exceed the detection threshold equation (2) [12]. TP represents a true positive detection, TN – true negative. A greater PD means the method is more capable of detecting a real event, while a smaller FPR implies the method is less likely to classify a routine operation as an event. FAR and PD values varies between 0 and 1 [5].

$$PD = \frac{TP}{TP + FN} \quad (1)$$

$$FAR = \frac{FP}{FP + TN} \quad (2)$$

This approach was applied in all observed studies in this paper. Comparison of PD and FAR results, reported in the reviewed papers, is shown in Table 1. The higher is PD, the higher is the probability that the event would be detected in a real contamination situation. Thus responsible organizations could take preventive actions. In contrast, high FAR represent a likelihood of the cases, when the alarm would be triggered wrong. A false alarm could lead to a financial loss and decrease of society confidence in the organization. Thus, an ideal algorithm should have PD value close to 1 and low FAR values. Overall these parameters should be considered by water utilities for integration of EWS into the online monitoring system of drinking water quality.

The type and number of drinking water quality parameters and contamination agents could also affect the results, as shown in the reviewed studies (Table 1). A good example of the impact of the sensor set of detection results is reported for PE method where PD values of 0,76 and 1,00 for nickel and atrazine respectively as contamination agents was reported [5]. Although experimental data sets and real scale data were reported in several studies, some works were based on the artificial data sets with simulated contamination events. It is related to the fact that it is not always feasible to simulate a contamination event experimentally since it requires special facilities and could be unsafe. Therefore, the overall knowledge about the contamination event influence on drinking water quality parameters is limited and actual disturbances to the measurements are unknown [14]. For example, the results of experimental and real scale studies might be affected by sensor calibration, signal noises, signal processing and intensity of data collection [2].

To gain more reliable comparison, PD and FAR values for each method were acquired from multiple studies and data sets and summarized in Table 1. It demonstrates a high variety on contamination detection probability, obtained by different algorithms (Table 1). First generation methods were developed earlier, and have mostly simple algorithms. The highest detection probability (PD) were 0,89, 0,92, 0,587 and FAR of 0,88, 0,82, 0,093 for MED, LPF and ANN (Multivariate time series) methods respectively. Thus high PD values correspond with high FAR, and vice versa, which indicates that either normal signal fluctuations would be assumed for contamination events, or missed. It is explicable with relatively simple algorithms used in MED and LPF methods. Although ANN (Multivariate time series) method is based on artificial neuron network and showed very low FAR, it was not effective for detection contamination events. At this stage, it is unsuitable for drinking water monitoring. However,

there is a great potential for improvement of the approach.

Second generation methods that contain more complicated algorithms shows higher PD, in some cases (CCA, MVE, Canary, SVM, DSM, PE) reaching even 1,00 that means 100% of contamination events will be detected. Though the FAR values of 0,34 and 0,1 for Canary and SVM methods raises doubts on reliability and detection capabilities, PE method has been applied for different types of contamination, and the overall results were ambiguous PD and FAR varied a lot, and were between 0,69 – 1,00 and 0 – 0,87 respectively. PE method can be suggested as an applicable tool in certain conditions. However, the overall usability should be considered. Moreover, the detection of the real scale event was not accurate, resulting with PD = 0,83 and FAR = 0,33. CCA, MVE and DSM methods demonstrated very low FAR values of 0, 0,008 and 0,032 that shows a high potential to be implemented in EWS. It should be emphasized that for methods PE, CCA, DSM experimental data sets have been used leading that those methods have shown a high potential for real scale events. DSM is the only method with relatively high results that has been analyzed for real contaminants.

The results for MD shows not only accurate detection of contamination events but also the correct classification of certain contamination agents. For example, PD of 0,73 - 0,79 means that in the case of DWSS contamination with four different contaminants, three would be identified correctly.

SVM, PE, CCA, MD, and MVE methods approaches allow not only detection of the contamination event, but also the classification of contamination types, detected in a certain event. Still, the studies of classification are only in preliminary phase and numerous experiments with different contaminants, concentrations, flows should be accomplished to develop a working algorithm for this issue.

The methods, which were applied for experimental studies, shows modest results in comparison to methods with artificial data. This could be explained by the diversity of data generated in artificial data sets and additional data distortion in experiments sensors and its properties [6], [15].

Based on PD and FAR values, Canonical correlation analysis (CCA) method provides the most accurate contamination detection. Thus it has a potential to be applied for real DWSS monitoring. Although FAR data are not available for Mahalanobis distance (MD) method, relatively high PD values and its ability to categorize the contamination agents also make this method very promising for EWS.

Table I
Evaluation of Contamination Detection Algorithms

Method	PD	FAR	Data source	Contamination agent	Parameters	Ref.
Multivariate Euclidean distance (MED)	0,52 - 0,89	0,22 - 0,88	exp	Cadmium nitrate	T, pH, NTU, EC, ORP, UV-254, nitrate, phosphate	[16]
Linear prediction filters (LPF)	0,38 - 0,92	0,24 - 0,82	exp	Cadmium nitrate		[16]
Pearson correlation Euclidean distance (PE)	0,97	0,025	exp	Cadmium nitrate		[16]
	0,83	0,33	r	Phenol		[12]
	0,76 - 1,00	0 – 0,1	exp	Herbicides, pesticides, lead nitrate, nickel nitrate, trivalent chromium		[5]
	0,69 - 0,74	0,78 – 0,87	art			[6]
Canonical correlation analysis (CCA)	0,90 - 1	0	exp	Acrylamide		[17]
Minimum ellipsoid classification (MVE)	0,66 - 1	0,05 - 0,08	art	-	T, pH, NTU, EC, TOC, chlorine	[14]
Artificial Neural Networks (ANN) Multivariate time series	0,085 - 0,587	0,001 - 0,093	art	-		[18]
Artificial Neural Networks (ANN) Dynamic thresholds scheme	0,38-0,99	0,04 - 0,15	art	-		[15]
Canary default algorithm	0,63 - 1	0,17 - 0,34	art	-		[2], [14], [19]
Support vector machine (SVM)	0,75 - 1	0,02 - 0,1	art	-		[2]
Mahalanobis distances (MD)	0,73 - 0,79	-	exp	Herbicides, heavy metals, inorganic salts	T, pH, NTU, EC, ORP, UV-254, nitrate, phosphate	[7]
Extended Dempster-Shafer method (DSM)	0,27 - 1	0,006 - 0,032	exp	Potassium ferricyanide, ferric ammonium sulfate	EC, pH, free chlorine, total chlorine, nitrate, sulphate, TOC, COD	[20]

Legend: PD – probability of detection, FAR – false alarm rate, T – temperature, NTU – turbidity, EC – electrical conductivity, ORP – oxidation-reduction potential, UV-245 – ultraviolet light sensor, TOC – Total Organic Carbon, COD – Chemical Oxygen Demand, exp – data acquired in experiments, r – data acquired in real contamination event, art – artificial data sets used

The present review demonstrates the overall comparison between different approaches and algorithms for contamination detection. However, it should be noted that the observed studies were performed within various conditions, used different data sets, types of contaminants and detection sensors, which should be taken into account for selection of contamination detection approach. However, each of studies analyzed in this paper has been aimed to find the best mathematical approach and compare it to previously used algorithms that mean a reliable data and methods comparison in data analysis done by previous authors [7], [12]

III. DISCUSSION

11 algorithms for detection of contamination event of drinking water were compared in this paper. Although the probability of contamination detection varied between different studies, generally all algorithms could reach 0,5 probability coefficient under certain conditions. While PD lower limits below this value were mostly obtained with first generation approaches, PD could even reach 1 with the second generation algorithms. The recent methods showed more precise results than older algorithms, which shows a positive tendency in methods development. Although the methods were capable of detecting the contamination events, some shortages and drawbacks were found.

The methods, based on artificial neural networks, require simultaneous data collection from all sensors that could lead to technical issues in real DWSS conditions [18].

Most of the reviewed studies in the present work concluded that the methods proposed by authors are capable of detecting certain contamination events[2], [5]–[7], [12], [14]–[18], [20]. However, further research is needed to test these methods for conditions, which could influence the accuracy of the methods. For example, it would be important to know how these methods would respond in the real or laboratory scale conditions, with the presence of different types of contaminants, different or changing spreading velocities and contaminant concentrations. Moreover, detection limits for each method should be found in experimental sessions and setups. Detection limits are essential for detection methods because the even low concentration of contamination agents could significantly affect consumers in long term perspective if continuously or periodically appear in the DWSS [17]. Also, the thresholds used in each method should be verified experimentally.

From the reviewed methods, only MD and CCA could classify contamination agents detected in DWSS. Identification of contamination agent is of particular importance for the development of actions and scenarios that should be applied by water utilities during and after the contamination event to ensure the quality of drinking water at consumption point.

None of the methods proposed in the previous studies have addressed the potential contamination of DWSS with biological agents (*Escherichia coli, Pseudomonas aeruginosin*, *Clostridium perfringens*). It is surprising since biological contamination could affect the health of drinking water consumers even more than chemical contamination. Moreover, biological water quality monitoring is obligatory for drinking water and is regulated by the European Union legislation [21]. Furthermore, no investigation on possible correlations between microbiological and physical-chemical parameters of drinking water quality have been done. It clearly shows a need of methods' evaluation for microbiological parameters detection.

Although the results of the second generation detection methods are rather high and precise, the computing resource of running them must be taken into account. Detection and classification of contamination events by using proposed MD and PE methods can reach up to 4 and 9 minutes delay respectively [5], [7] for a single monitoring point with a set of 9 surrogate sensors. For a real scale network, the time and resource needed for compilation of algorithms might increase rapidly. The relation of detection precision, costs of sensors sets and computational resources should be taken into account while developing each of proposed methods for integration in EWS for real DWSS. The methods used for detection of contamination events should be robust, simple and relatively computing resource friendly to ensure the functionality and possibility to implement them in an EWS for real scale system and hydraulic conditions by using fewer sensors. Linking detection tools with a hydraulic modeling would provide a unique next generation monitoring tool for drinking water quality, which could predict possible contaminant distribution in DWSS and identify the contamination point. Within the given situation only Canary default algorithm was tested and implemented in a real scale DWSS by linking it with a real scale hydraulic DWSS models [19].

IV. CONCLUSIONS

During the last decade, many studies on contamination event detection methods for the drinking water supply system were carried out. Numerous methods, based on different approaches including statistical analysis, clustering, and artificial neural networks have been proposed. High detection probability and low false alarm rate are the main parameters to select the algorithms. The ability of classification of different contamination types should also be taken into account. Therefore, CCA and MD methods have been chosen as the most promising methods.

Although the methods have shown good results of detection probability in the reported studies, more tests and experiments in the pilot and real scale

should be done to ensure the stability and functionality in real scale conditions. Additionally, detection of biological contamination should be evaluated.

As the most promising methods CCA and MD were selected.

There is a lack of measurement data and information about real contamination events reported all over the world. More accurate and detailed reports on each event should be done to improve the capabilities of proposed methods.

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REFERENCES

[1] A. Rasekh and K. Brumbelow, "Drinking water distribution systems contamination management to reduce public health impacts and system service interruptions," Environ. Model. Softw., vol. 51, pp. 12–25, 2014.

[2] N. Oliker and A. Ostfeld, "A coupled classification - Evolutionary optimization model for contamination event detection in water distribution systems," Water Res., vol. 51, pp. 234–245, 2014.

[3] the United States Environmental Protection Agency, "Response Protocol Toolbox : Planning for and Responding to Drinking Water Contamination Threats and Incidents," Epa, no. December, 2003.

[4] R. M. Grayman, W.M., Deninger, R.A., Clark, "Vulnerability of water supply to terrorist activities," CE News, vol. 14, pp. 34–38, 2002.

[5] S. Liu, H. Che, K. Smith, and L. Chen, "Contamination event detection using multiple types of conventional water quality sensors in source water," Environ. Sci. Process. Impacts, vol. 16, no. 8, pp. 2028–2038, 2014.

[6] S. Liu, R. Li, K. Smith, and H. Che, "Why conventional detection methods fail in identifying the existence of contamination events," Water Res., vol. 93, no. February, pp. 222–229, 2016.

[7] S. Liu, H. Che, K. Smith, and T. Chang, "A real time method of contaminant classification using conventional water quality sensors," J. Environ. Manage., vol. 154, pp. 13–21, 2015.

[8] C. P. Marshall, S. Leuko, C. M. Coyle, M. R. Walter, B. P. Burns, and B. a Neilan, "Carotenoid analysis of halophilic archaea by resonance Raman spectroscopy," Astrobiology, vol. 7, no. 4, pp. 631–643, 2007.

[9] P. R. Hawkins et al., "A review of analytical methods for assessing the public health risk from microcystin in the aquatic environment," J. Water Supply Res. Technol. - Aqua, vol. 54, no. 8, p. 509 LP-518, Dec. 2005.

[10] J. Jeon, J. H. Kim, B. C. Lee, and S. D. Kim, "Development of a new biomonitoring method to detect the abnormal activity of Daphnia magna using automated Grid Counter device," Sci. Total Environ., vol. 389, no. 2–3, pp. 545–556, 2008.

[11] M. Brussen, "On-line Water Quality Monitoring. Review of Sydney's Current Status and Future Needs. Sydney Water Report," Sydney, 2007.

[12] S. Liu, H. Che, K. Smith, M. Lei, and R. Li, "Performance evaluation for three pollution detection methods using data from a real contamination accident," J. Environ. Manage., vol. 161, pp. 385–391, 2015.

[13] S. A. McKenna, M. Wilson, and K. A. Klise, "Detecting changes in water quality data," J. / Am. Water Work. Assoc., vol. 100, no. 1, pp. 74–85, 2008.

[14] N. Oliker and A. Ostfeld, "Minimum volume ellipsoid classification model for contamination event detection in water distribution systems," in Procedia Engineering, 2014, vol. 70, pp. 1280–1288.

[15] J. Arad, M. Housh, L. Perelman, and A. Ostfeld, "A dynamic thresholds scheme for contaminant event detection in water distribution systems," Water Res., vol. 47, no. 5, pp. 1899–1908, 2013.

[16] S. Liu, K. Smith, and H. Che, "A multivariate based event detection method and performance comparison with two baseline methods," Water Res., vol. 80, no. May, pp. 109–118, 2015.

[17] R. Li, S. Liu, K. Smith, and H. Che, "A canonical correlation analysis based method for contamination event detection in water sources," 12th Int. Conf. Hydroinformatics, no. July, 2016.

[18] L. Perelman, J. Arad, M. Housh, and A. Ostfeld, "Event detection in water distribution systems from multivariate water quality time series.," Environ. Sci. Technol., vol. 46, no. 15, pp. 8212–9, 2012.

[19] D. B. Hart, S. A. Mckenna, U. S. Epa, and N. Homeland, User ' s Manual for CANARY, no. September. Cincinnati: U.S Environmental Protection Agency, 2012.

[20] D. Hou, H. He, P. Huang, G. Zhang, and H. Loaiciga, "Detection of water-quality contamination events based on multi-sensor fusion using an extented Dempster–Shafer method," Meas. Sci. Technol., vol. 24, p. 55801, 2013.

[21] The Council of the European Union, "Council Directive 98/83/EC of 3 November 1998 on the quality of water intended for human consumption," Off. J. Eur. Communities, vol. L330, pp. 32–54, 1998.

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Assessment of Ecological State of the Velikaya River Delta Based on Hydrochemical Indicators and Structure of Phytoplankton

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Abstract. The basis of the existence of freshwater ecosystems is phytoplankton, which produces most of the primary biological production, participates in repair processes and provides a wide range of ecosystem services. The short life cycle and high speed metabolism of microalgae make them ideal objects for ecological monitoring.

The aim of the present study is to research the ecological state of the Velikaya river delta based on the species composition of phytoplankton community and some hydrochemical parameters.

The sample collection for phytoplankton study and physicochemical measurements was carried out in summer 2016 at five stations representing different ecological locations of the Velikaya river delta.

One hundred sixty five species taxa of microalgae belonging to 8 phylums were identified during the research: Bacillariophyta (37%), Chlorophyta (33.9%), Cyanophyta/Cyanobacteria (9.7%), Chrysophyta (6.1%), Euglenophyta (6.1%), Cryptophyta (3%), Dinophyta (3%), Xanthophyta (1.2%).

The values of Shannon index indicate the average complexity of the microalgae communities structure. Values of Margalef index characterize the Velikaya river delta as an area of high species richness. Compared to the previous studies, a significant increase in the level of information diversity is observed, indicating an increase in the number of possible flows of substance and energy in the ecosystem. Dynamics of biogen substances in the water shows a slight increase of their concentrations.

Ecological and geographical analysis proves that absolute dominance of cosmopolitan freshwater forms is typical for the algoflora of the Velikaya river delta. In relation to the pH-reaction inhabitants of neutral and slightly alkaline water dominate. Pantle–Buck saprobity index is applied for water quality assessment, which shows beta-mesosaprobic water quality in the ecosystem. Thus, the water of the Velikaya river delta could be referred to the category of moderately polluted water (class II of water quality). This is confirmed by the data of hydrochemical analysis.

Keywords: phytoplankton, species diversity, ecological monitoring, algae, ecological assessment, Velikaya river delta.

I INTRODUCTION

Nowadays it is difficult to monitor of the structural changes in natural ecosystems, which are the most important providers of ecosystem services and essential elements of existence of human civilization. Nowadays conservation of natural ecosystems is possible only if there is an effective environmental governance program based on integrated ecological monitoring [1, 2]. Local and regional ecosystems play a key role in the interaction with anthropogenic objects as they neutralize various pollutants by natural biochemical processes. Aquatic ecosystems play an essential role providing a wide range of ecosystem services, such as food, clean water, waste treatment, nutrient cycling, carbon accumulation and recreational resources. Due to high metabolism rate and complex structural and functional organization aquatic ecosystems are sensitive to urbanization and climate change [3, 4].

Microalgae communities are vital for aquatic ecosystems. Phytoplankton organisms are important components of aquatic communities because they make the primary ecological production. Phytoplankton communities are first to respond to initial changes in aquatic ecosystems by changing structural and energetic components. That makes them the key objects for studying the energy balance of ecosystems and water quality biomonitoring [5, 6].

I.The Velikaya river delta located 8 km north-west from Pskov is chosen as a model ecosystem. It is a unique natural complex where water masses of the Velikaya river and its catchment area (before it joins in the Lake Peipus) mix and transform. The shape of the delta is almost trianglular, its median length is 4.2 km and width is about 4 km. Its total area is 2.7 km^2.

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Delta is represented by a complex of low, marshy islands separated by bayous [5].

Border position of Velikaya river delta determines some features of its climate regime. The studied area differs from neighboring territories and has better conditions for vegetation due to its milder and shorter winter and longer and sunnier summer seasons as well as to a favorable balance of heat and moisture. The combination of these factors enables the potential the Velikaya river delta to form aquatic ecosystems primary production. It should be noted that this area is constantly exposed to local antropogenic impacts [5].

The purpose of the study was to research the ecological state of the Velikaya river delta based on hydrochemical parameters and structure of phytoplankton.

The tasks:

1. To investigate the hydrochemical parameters of the Velikaya river delta;
2. to study the taxonomic composition of phytoplankton Velikaya river delta in the summer period;
3. to give the ecological and geographical characteristics of phytoplankton organisms;
4. to conduct a saprobiological analysis of the Velikaya river delta for indicator organisms;
5. to study the parameters of the alpha and beta diversity of phytoplankton communities in the sampling points.

II MATERIALS AND METHODS

Sampling points

Collection of hydrochemical and hydrobiological materials was carried out in summer period 2016 in the Velikaya river delta at five sampling points (Fig. 1.):

1 – Vaymenka;
2 – Bolshaya Listovka;
3 – Srednyaya;
4 – Gorki;
5 – Murovitsy.

Water sampling is made according to GOST 31861-2012 (Water ... 2014). Hydrochemical study included quantitative determination of nitrite, nitrate, ammonium, phosphate ions, hydrogen carbonate and carbonate ions, biochemical oxygen demand within five days (BOD_5), total phosphorus concentrations (P_{total}), total nitrogen (N_{total}), total iron (Fe_{total}). Analysis were performed using titration and spectrophotometric methods in an accredited laboratory (accreditation certificate FSA (Federal Service for accreditation) № RA.RU.21AH24 by 22.10.2015) according to methods of series PND F (Environmental normative documents Federal) [7-14].

Hydrobiological and hydrochemical samples were collected with a plastic sampler (volume 0.5 liter) at the depth of 0,3-0.5m. Samples of water were taken simultaneously. Phytoplankton samples were fixed with a 40% formalin solution and treated by the standard procedure [15-17]. If possible, all algae were identified to species level using the Carl Zeiss Axio Lab microscope. A1. It was done with help of domestic and foreign references [18-22].

Determination of the number of phytoplankton in 1 liter of water was carried out by standard methods [23].

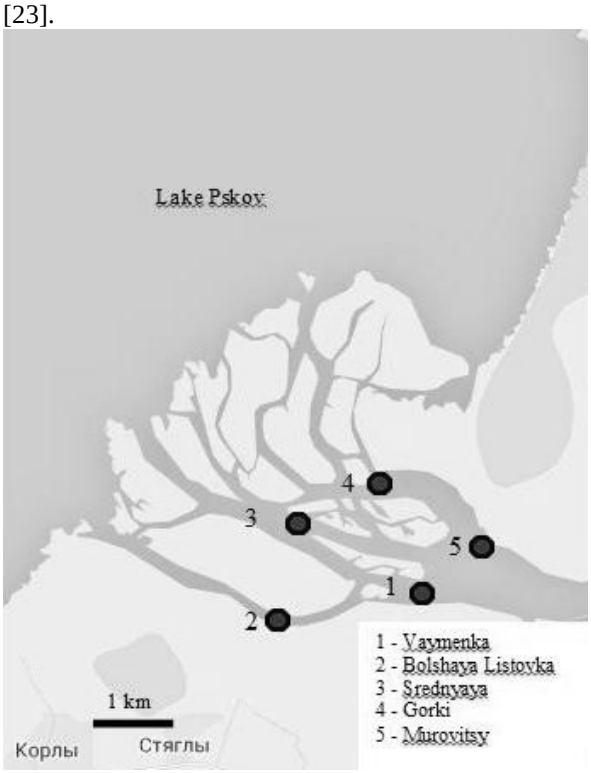

Fig. 1. Sampling points in the Velikaya river delta

Data from a number of researches and monographs were used to select ecological groups of microalgae and determining their ecological and geographical characteristics were used data from a number of monographs [24, 25]. Saprobic index was calculated by the method Pantle and Bukk in Sladechek modification [26].

For studying alpha-diversity of microalgae community were calculated Shannon index, Simpson index, Margalef index and Pielou's evenness index. Similarity of algae taxonomic composition in sampling points were analyzed using by Sørensen index [27]. A procedure of cluster analysis points was used to compare species structure of algae communities in different samples [28]. All stages of the statistical data processing were conducted by Statistica 8.0 and MO Excel programs.

III RESULTS AND DISCUSSION

Hydrochemical analysis was conducted in summer period 2016 on at all five sampling points. During the analysis were determined following indicators of water quality were determined (Tab. 1).

Table 1
Hydrochemical Analysis Results of Velikaya River Delta

Concentrati onmg/dm^3	Sampling points				
	1	2	3	4	5
NO_2^-	0.043	0.087	0.044	0.048	0.035
NH_4^+	1.110	0.930	1.100	1.040	0.540
NO_3^-	0.675	0.776	0.588	0.620	0.670
$N_{общ.}$	1.036	0.931	1.006	0.965	0.582
PO_4^{3-}	0.061	0.063	0.050	0.055	0.063
$P_{общ.}$	0.020	0.021	0.017	0.018	0.021
$БПК_5$	0.855	0.624	-	-	1.984
$Fe_{общ.}$	0.170	0.140	0.110	0.110	0.160
HCO_3^-	141.52	150.67	123.22	103.09	128.71
CO_3^{2-}	1.2	1.2	1.2	1.2	19.2

The concentration of HCO^{3-} at the sampling points “Vaymenka”, "B. Listovka" and "Murovitsy" somewhat higher than at the other sampling points. The decrease in concentration of bicarbonates in other points from 140-150 mg / dm^3 to 103-120 mg / dm^3 is due to the high concentration of humic acids formed in the process of swamping in middle and lower delta. In general, the comparative analysis of the mineral composition of the Velikaya river delta from 1992 to 2016 indicates to its slight change. By major-ion waters of the Velikaya river delta were characterized as bicarbonate-calcium. The concentration of carbonates was 16 times higher at the point "Murovitsy" than at the other sampling points. It can be explained by Devonian limestone deposits and change of river current in this area: the river here flows slower, thereby increasing the concentration of the mineral components of streamflow.

Assessment of nitrogen compounds affecting the trophic level of the waterbody revealed increased concentration of ammonium at the Velikaya river delta. In all sampling points except "Murovitsy" (0.54 mg / dm3), the level of ammonium-ions is almost same and exceeds the threshold limit value (TLV) twice. The presence of ammonium-ions in concentrations above background values, indicates a high organic content in the water. The concentration of nitrate-ions in all investigated areas of the delta was almost the same - 0.6-0.7 mg/dm^3 with a slight increase in the "B. Listovka" point. Also in "B. Listovka" area exceeds admitted standards slightly. Nitrites, in addition to ammonium are indicators of processes of organic decomposition and mineralization.

The values of iron concwntration were exceeded at sampling points "Vaymenka" and "Murovitsy". These sampling points are located the closest to the urban infrastructure and contain significant amounts of iron pumped into the water by municipal wastewater.

The most essential condition for the life of organisms in the aquatic environment is the concentration of dissolved oxygen. Results of chemical analysis showed that the level of dissolved oxygen was satisfactory for the existence of aquatic organism - 8.5-9.0 mg/dm^3.

Chemical monitoring data are consistent with hydrobiological studies and demonstrate the ability of Delta for natural self-purification. This is occurring in the first place by vegetation, including phytoplankton organisms.

During the study of the qualitative composition of summer phytoplankton of the Velikaya river 165 taxa below the rank of genus, belonging to 8 phylums, 11 classes, 18 orders, 43 families, 90 genera (Tab. 2) delta were identified.

Table 2
Taxonomic Composition of Phytoplankton of Velikaya River Delta (Summer, 2016)

Phylum	Class	Order	Family	Genus	Taxa
Bacillariophyta	2	5	15	29	61
Chlorophyta	3	5	17	32	56
Cyanophyta	1	3	6	11	16
Chrysophyta	1	1	1	7	10
Euglenophyta	1	1	1	6	10
Cryptophyta	1	1	1	2	5
Dinophyta	1	1	1	2	5
Xanthophyta	1	1	1	1	2
Total	**11**	**18**	**43**	**90**	**165**

The distribution by phylums were as follows: *Bacillariophyta* - 61 (37.0 %), *Chlorophyta* - 56 (33.9 %), *Cyanobacteria* - 16 (9.7 %), *Chrysophyta* - 10 (6.1 %), *Euglenophyta* - 10 (6.1 %), *Cryptophyta* - 5 (3.0 %), *Dinophyta* - 5 (3.0 %), *Xanthophyta* – 2 (1.2 %) taxa. Xanthophyceae algae were represented by only two species of the same genus - *Tribonema affine* (G. S.West) G. S. West. *И Tribonema vulgare* Pasch.

It was found that 38 families (88.4%) belong to the three phylums: Chlorophyta (39.5%), Bacillariophyta (34.9%) and Cyanobacteria (14.0%) and includes the 133 (80.6%) of taxon. The dominance of these phylums is typical for waterbodies of the North-Western region of Russia [29, 30].

Analysis of phytoplankton composition at all sampling points shows (Fig. 2.) that the greatest number of taxa observed in the "Vaymenka" - 131

taxa (79.4% of the total number of species), and the smallest - in the "Murovitsy" - 65 (39.4%).

In all the study areas of the delta diatomaceous-green algalflora complex dominated. At the study point "Murovitsy", unlike the others points, where the third place was taken by the Cyanobacteria, Chrysophyta dominated. No representatives of Euglenophyta were found at the point "Srednaya". Euglenophyta and Xanthophyta were not detected at "Murovitsy".

The results of ecological and geographical analysis of phytoplankton are presented in Tab. 3.

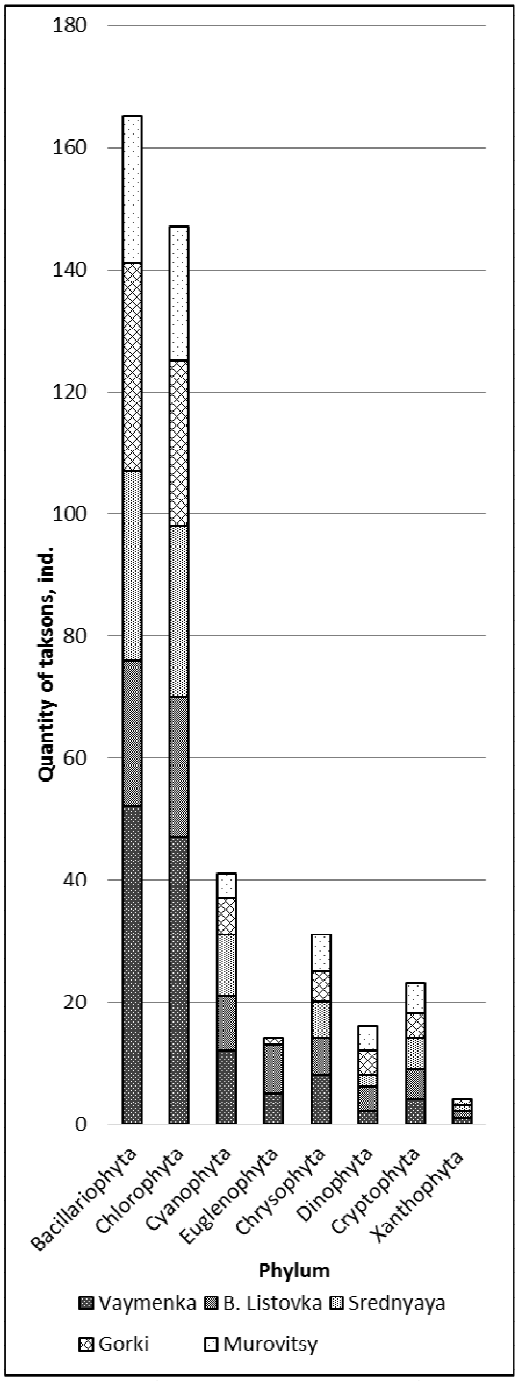

Fig. 2. Comparison of the taxonomic composition of phytoplankton in different sampling points in Delta

By the nature of the geographical distribution for algal flora of Velikaya river delta was characteristic absolute dominance of cosmopolitan forms (86.3% of the number of taxa that had data). By habitat most of the taxa belonged to plankton (43.6%) and planktonic-benthic (34.6%) forms. Benthos (17.6%) and fouling (4.2%) algae represented significantly less.

Table 3
Ecological and Geographical Characteristics of Phytoplankton Velikaya River Delta
(χ – xenosaprobionts, o – oligosaprobionts, β – beta-mezosaprobionts, α - alpha- mezosaprobionts, p – polysaprobionts)

Parameter	Number of species	% of the total number
Distribution:		
Cosmopolitans	107	86.3
Boreal	9	7.3
Holarctic	6	4.8
Circumboreal	1	0.8
Arctic	1	0.8
Total:	124	100
Habitat:		
Planktonic	72	43.6
Planktonic-benthos	57	34.6
Benthos	29	17.6
Fouling	7	4.2
Total:	165	100
Halobility:		
Indifferent	88	76.5
Halophyles	16	13.9
Halophobs	6	5.3
Oligogalobs	5	4.3
Total:	115	100
Related to pH:		
Indifferent	47	47.9
Acidophile	5	5.1
Alkaliphile	42	42.9
Alcalibionts	4	4.1
Total:	98	100
Saprobity:		
χ-o- saprobionts	1	0.8
χ-β- mezosaprobionts	2	1.6
oligosaprobionts	8	6.6
o-β, β-o-saprobionts	20	16.4
β- mezosaprobionts	54	44.3
o-α- mezosaprobionts	15	12.3
α-β, β-α- mezosaprobionts	13	10.7
α - mezosaprobionts	7	5.7
α-p, p-α - mezosaprobionts	2	1.6
Total species indicators	122	100
Mean Pantle-Bukk index	**2,1**	

All taxa in relation to water mineralization were oligohalobs. Of those prevailed indifferent - 76.5%, while the share of halophiles and halofobs represented up to 13.9% and 5.3% respectively.

A comparison of the taxonomic composition of phytoplankton of the Velikaya river delta with a list of algae-indicators of organic pollution [22] revealed the predominance of beta- mezosaprobionts (44.3%) which are indicators of moderate water pollution. 25.4% of total algae are inhabitants of clean water. One of detected species is xenooligosaprob - Sellaphora bacillum (Ehr.) 18% of the total number of indicator species are Mann. Microalgae, which preferred contaminated water including 2 species - inhabitants of polluted water - euglenophytes *Colacium cyclopicola (Gickl.) Woronich. et Popova* and *Euglena proxima P.A.Dangeard*.

Water quality assessment by Pantle - Bukk index in Sladecheka modifications identified β-mesosaprobic nature of waters in the Velikaya river delta, which allowed to attribute them to a category of moderately polluted water. The calculated saprobity indexes ranged from 2.0 to 2.2. The highest values of Pantel - Bukk index are noted at sampling points "B. Listovka" and "Gorki" (2.2).

The comparison of floristic composition of the Velikaya river delta with the studies of past years [5] shows that 57 and 33 taxa of phytoplankton were found in summer periods from 1992 to 2000 in delta, while in 2016 165 taxa were identified. This may result from a number of factors. Firstly, in 1992 difficult economic situation led to termination of work at Pskov enterprises, which consequently partially affected the cleanliness of water in the delta and as a result promoted an increase of biodiversity of phytoplankton. Secondly, in recent years there has been acceleration of eutrophication processes in the Peipus lake, leading to the "algal bloom" in the waterbody, starting from the beginning of summer. It reveals itself by an increase of nutrients in water that cause the intensification of microalgae growth. Nowadays, in comparison with previous years, there is a significant overgrowth of the Delta by macrophytes therefore samples show a lot fouling and benthic forms in addition plankton forms (Tab. 2).

In general, the observation of the area during the studied period proves that the basis of phytoplankton is diatomaceous-green algaecomplex.

Saprobiological analysis revealed no significant changes of values saprobity index since 1992 (Tab. 4). The waters of Velikaya river delta can be characterized as moderately polluted.

Table 4
Comparison of Values Saprobity Index in Different Years (Summer Season)

Years	Value of Pantle-Bukk index
1992	1.9 – 2.2
2000	1.7 – 2.2
2001	2.3 – 3.5
2016	2.0 – 2.2

The maximum values of Pantle-Bukk index have been observed in points "B. Listovka" and "Gorki" (2.2). The lowest value of index marked for point "Srednaya" (2.0). Generally, the index value at the sampling points did not differ significantly, which characterizes the delta area as relatively homogeneous territory by content organic pollutants.

For the analysis of the alpha-diversity of phytoplankton Velikaya river delta were used Shannon index, Simpson index, Margalef index and Pielou evenness index. The results of calculations for the sampling points are presented in Tab. 5.

The greatest value of Shannon index is characterized by a microalgae community of point "Vaymenka" (H = 3.36), which indicate maximum number of its species and absence among them expressed dominants. The smallest information diversity was typical for point "Srednaya» (H = 2.92). In general, the values of Shannon indices indicate the average complexity structure of microalgae communities in Velikaya river delta.

Table 5
Values of Biological Diversity Indices (H – Shannon Index; E – pielou's evenness index; C – simpson index; d – margalef index)

Sampling points	H	E	C	d
Vaymenka	3.36	0.78	0.06	5.96
B. Listovka	3.11	0.78	0.07	4.60
Srednaya	2.92	0.71	0.11	5.40
Gorki	2.98	0.70	0.11	6.01
Murovici	2.94	0.73	0.12	5.05
Average	3.06	0.74	0.09	5.41

Margalef index reflects the density of species, or species richness, in a certain area, i.e. the higher index value the even larger species richness characterized this territory. The largest value of Margalef index was observed at the study point "Vaymenka» (d = 5.96), and the least was in point "B. Listovka» (d = 4.60). Overall, values of Margalef index characterized Velikaya river delta as an area of high species richness.

Simpson index indicates the dominance of certain species in community. All investigated delta areas are characterized by extremely low values of Simpson index, which characterizes them as a communities with unexpressed dominant species.

Values of Pielou index were almost identical and had quite high values and as in case of Simpson index indicates high evenness of communities structure.

In the analysis of similarity of species composition algal communities of different sampling points of delta using Sørensen index the highest degree of similarity was found between points "Gorki" and "Murovitsy» (Ics = 0.82), the lowest - between points "Vaymenka" and "B. Listovka» (Ics = 0.57). In general, the degree of similarity between compared areas was high. Common to all five points studied were 30 species, most of which belonged to green algae and diatoms.

For comparison communities microalgae of Velikaya river delta by species composition was used procedure of cluster analysis was used. As a joining method was applied Ward method, This method is minimum variance criterion minimizes the total within-cluster variance., i.e. it creates the most compact cluster on degree of similarity between group members. The material for cluster analysis were the samples obtained from the delta's areas.

By peculiarities of species structure all sampling points of the delta is clearly divided into two clusters, one of which is represented by points "Vaymenka" and "Srednaya", and the other - points "Murovitsy", "Gorki" and "B. Listovka". The singularity of the species structure indicates that despite relatively small square of ecosystem of Velikaya river delta, it is different certain structural heterogeneity due to nature of currents, hydrochemical and hydrophysical characteristics, and the heterogeneity of input and migration of allochthonous substances of antropogenic origin (Fig. 3).

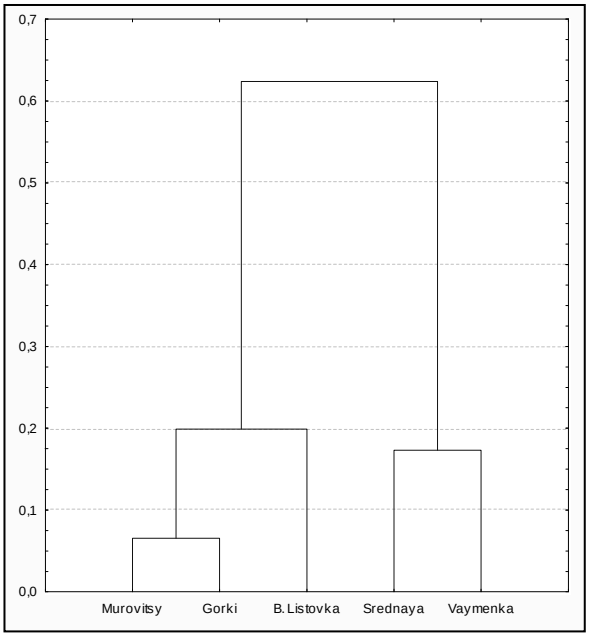

Fig. 3. Dendrogram similarities of species structure of phytoplankton communities of the Velikaya river delta

IV CONCLUSION

1. Hydrochemical analysis showed that waters of Velikaya river delta are carbonate-calcium , with a high content of nitrogen-ions group, indicating that active processes of organic matter mineralization.
2. The phytoplankton of the Velikaya river delta in summer period 2016, was represented by 165 species of taxa below rank of genus, belonging to 8 phylums, 11 classes, 18 orders, 43 families, 90 genera.
3. Ecological and geographical analysis of phytoplankton demonstrates that the Velikaya River Delta is dominated by freshwater, widespread, planktonic species preferring alkalescent water.
4. Data of saprobiological analysis shows moderate pollution of studied areas of the Velikaya river delta, which can be attributed to III water quality class.
5. The ecosystem of the Velikaya River Delta is characterized by relatively high species richness, average complexity of structure of its constituent algae communities, and high evenness of species, indicating relative stability of ecosystem. Comparison of species composition of phytoplankton communities in different parts of the Delta shows a fairly high degree of similarity (Ics = 0,57 - 0,82). Identification of differences in structure of communities of species proves the existence of ecological differentiation in microalgae complexes resulting from heterogeneity of delta.

REFERENCES

[1] Stefano Pagiola, Elías Ramírez, José Gobbi, Cees de Haan, Muhammad Ibrahim, Enrique Murgueitio, Juan Pablo Ruíz. Paying for the environmental services of silvopastoral practices in Nicaragua // ECOLOGICAL ECONOMICS 64 (2007) P. 374-385. Available at: DOI 10.1016/j. ecolecon.2007.04.014. [Accessed: Feb. 27, 2017].

[2] Nathanial Matthews. People and Fresh Water Ecosystems: Pressures, Responses and Resilience // Aquatic Procedia. Volume 6, August 2016, Pages 99–105. Available at: DOI 10.1016/j.aqpro.2016.06.012. [Accessed: Feb. 27, 2017].

[3] Junguo Liu, Giri Kattel, Hans Peter H. Arp, Hong Yang. Towards threshold-based management of freshwater ecosystems in the context of climate change // Ecological Modelling, Volume 318, 24 December 2015, Pages 265-274. Available at: DOI 10.1016/j.ecolmodel.2014.09.010. [Accessed: Feb. 27, 2017].

[4] Millenium Ecosystem Assessment Series. Ecosystems and human well-being: wetlands and water synthesis. Washington, D.C.: Island Press, 2005. 63 p.

[5] Environmental monitoring of the Velikaya river delta. Part I / ed. O.A. Lebedeva. Pskov. PSPI, 2003. 156 p.

[6] Shitikov V.K. Zinchenko T.D., Rosenberg G.S. Macroecology of river community: concepts, methods, models. Togliatti: Cassandra, 2011. 255 p.

[7] GOST 31957-2012 Water. Methods for determination of alkalinity and mass concentration of carbonates and bicarbonates. Moscow, 2013. 25 p.

[8] GOST 31861-2012 Water. General requirements for sampling. Moscow, 2014. 63 p.

[9] Environmental normative document (Federal)14.1:2:4.3-95 Methods of measurement of mass concentration of nitrite ions in drinking water, surface water and sewage of photometric method with Griess reagent. Moscow, 1995 (edition 2011). 17 p.

[10] Environmental normative document (Federal)14.1:2:4.4-95 Methods of measurement of mass concentration of nitrate ions in drinking water, surface water and sewage of photometric method with salicylic acid. Moscow, 1995 (edition 2011). 13 p.

[11] Environmental normative document (Federal) 14.1:2:4.50-96 Methods of measuring the total mass concentration of total iron in drinking water, surface water and sewage of photometric method with sulfosalicylic acid. Moscow, 1996 (edition 2011). 17 p.

[12] Environmental normative document (Federal) 14.1:2:4.112-97 Methods of measurement of mass concentration of phosphate ions in drinking water, surface water and sewage

by the photometric method with ammonium molybdate. Moscow, 1997 (edition 2011). 13 p.
[13] Environmental normative document (Federal)14.1:2:3:4.123-97 Methods of measurement of the biochemical oxygen demand after the n-days of incubation (BOD full) in surface freshwater, groundwater, drinking water, sewage and effluent sewage. Moscow, 1997 (2004 edition.) 34 p.
[14] Environmental normative document (Federal) 14.1:2:4.276-2013 Methods of measurement of the mass concentration of ammonia and ammonium ions in drinking water, natural water and sewage by photometric method with Nessler reagent. M., 2013. 14 p.
[15] Algae. Handbook / Wasser S.P., Kondratieff N.V., Masuk N.P. Kiev, "Nauk. Dumka", 1989. 608 p.
[16] Masuk N.P. Methods of collecting and study of algae / N.P. Masuk, M.I. Radchenko // Algae: Guide. By ed. S.P. Wasser. Kiev "Nauk. Dumka", 1989, pp. 170-188.
[17] Methods of study of inland waters ecosystems. / By ed. F.D. Mordukhay-Baltovski. Moscow. Nauka. 1975. 240 p.
[18] Carenko P.M. Summary determinant Chlorococcaceae algae of Ukrainian SSR / USSR Academy of Sciences. Institute of Botany named N.G. Kholodny. By ed. G.M. Palamar-Mordvintseva. Kiev, "Nauk. Dumka", 1990. 208 p.
[19] Komárek J., Anagnostidis K. Cyanoprokaryota 1. Teil: Chroococcales // Süsswasserflora von Mitteleuropa. Bd. 19/1. Jena; Stuttgart; Lübeck; Ulm. 1998. 548 s.
[20] Krammer K., Lange-Bertalot H. Bacillariophyceae. Teil 3. Centrales, Fragilariaceae, Eunotiaceae // Ibid. Stuttgart. 1991. Bd. 2/3. S. 1–576.
[21] Krammer K., Lange-Bertalot H. Bacillariophyceae. Teil 1. Naviculaceae // Die Süsswasserflora von Mitteleuropa. Stuttgart. 1986. Bd. 2/1. S. 1–876.
[22] Komárek J., Anagnostidis K. Cyanoprokaryota. 2 Teil: Oscillatoriales // Süsswasserflora von Mitteleuropa. Bd. 19/2. München. 2005. 759 s.
[23] Sadchikov A.P. Methods of studying freshwater phytoplankton: guide. Moscow, "University and school", 2003. 157 p.
[24] Barinova S.S., Medvedev A.L., Anisimova O.V. Biodiversity of algae-indicators. Tel Aviv, 2006. 498 p.
[25] Sudnitsyna D.N. Algae of waterbodies Pskov region. Pskov, "LOGOS Plus", 2012. 224 p.
[26] Sládeček V. System of water quality from biological point of view // Arch. Hydrobiol. Ergebn. Limnol. 1973. 7. P. 1-218.
[27] Schmidt V.M. Statistical methods in comparative floristry. Leningrad, 1980. 176 p.
[28] Khalafyan A.A. STATISTICA 6. Statistical data analysis: textbook. 3rd ed. Moscow, Binom, 2007. 512 p.
[29] Trifonova I.S. Ekology and lake phytoplankton succession. Leningrad, 1990. 184 p.
[30] Assessment of ecological status of Lake Ladoga basin by hydrochemical parameters and structure hydrobiocenoses / By ed. I.S. Trifonova. Sankt-Petersburg., 2006. 130 p.

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Approbation of Microbially Available Phosphorus (MAP) Determination Method by Flow Cytometry

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Abstract. Phosphorus (P) is among the most important nutrients required for bacterial growth. It has a great influence on microbial activity even at very small concentrations. Existing chemical methods are not able to determine P at low enough concentrations and to quantify biologically available phosphorus fractions. Therefore, a method of microbially available phosphorus (MAP) determination is used to quantify the amount of P at concentrations below 20 µg/l. Additionally, this method determines the amount of P that can be directly used by microorganisms.

Originally it was determined by inoculating sample by Pseudomonas fluorescens (now Ps. brenneri) P17 strain and spread-plated on R2A agar for enumeration. Further, a more rapid method was developed by replacing heterotrophic plate count (HPC) by flow cytometry (FCM).

In this paper the use of FCM for MAP determination is validated and compared with HPC method. The results of calibration are presented. The original pure P17 strain was used as inoculum and standards with different PO_4-P concentrations were inoculated at 30°C. The gained yield factor by FCM was $1.59x10^8$. FCM results showed strong correlation (R^2=0.99) with HPC results, as pure culture was used. Therefore, flow cytometry is a rapid alternative to heterotrophic plate count method for microbially available phosphorus determination.

Keywords: microbially available phosphorus, flow cytometry, drinking water.

I. INTRODUCTION

Phosphorus (P) compounds are among the most important microbial nutrients. The lack of P in the water to be transported or raw water may hinder the growth of microorganisms, thus preventing the formation of biofilm. P is considered to be the limiting nutrient in waters with high humic content or in boreal regions, e.g., northern Europe, Russia, and North America [1], as natural waters in these regions have high organic carbon content. Previous research has shown that by decreasing P concentrations water may become more microbiologically stable, as it limits bacterial growth [2], [3], [4].

Original MAP determination assay for drinking water relies on the growth potential of *Pseudomonas fluorescens* P17 strain [5] by means of heterotrophic plate count (HPC) method. However, in its original form it is regarded as time-consuming and labour-intensive enumeration. To overcome such problems, modifications have been made with natural microbial consortia and rapid enumeration tools, such as flow cytometer [6]. Here we used an originally suggested *Pseudomonas fluorescens* P17 (now *Ps.brenneri)* strain and approbated flow cytometer (FCM) as an alternative to classical cell cultivation. To ensure result compatibility, a thorough method comparison and calibration was performed. The approbation on artificially recharged groundwater station`s effluent was implemented.

II. MATERIALS AND METHODS

The method was adapted according to the one described by Lehtola et.al in 1999 [5]. Similar bacterial culture and stock solutions were used. The measurements were performed by means of flow cytometry, implementing optimized MAP determination method as recently described by Wen et al. in 2016 [6].

A. Preparation of glassware

All glassware and plastic caps were washed in the dishwasher with phosphate-free detergents, additionally rinsed several times with deionized water and left to dry. Then everything was sealed with aluminium folium. Glassware was placed into the oven for three hours at 500°C. Bottles` plastic caps were autoclaved at 121°C for 20min.

B. Inoculum

Freshly cultivated pure microbial culture *Pseudomonas brenneri* P17 (ATCC 49642) was used, as suggested by Lehtola et al., as this strain has phosphatase activity [5]. At first cells were grown in liquid R2A medium. Afterwards they were washed

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and inoculated into 0.1µm filtered Evian (Danone, France) water with added CH_3COONa as a carbon source to achieve the concentration of 1mg C l^{-1}. Incubation was performed at 30°C using orbital shaker at 150RPM for 24hours.

C. Preparation of standards and samples for MAP determination

Salts and acetate stock solutions were added to standards and samples in excess to ensure that P would be the only limiting nutrient. Salts stock consisted of NH_4NO_3, $MgSO_4$ x $7H_2O$, $CaCl_2$ x $2H_2O$, KCl and NaCl suspension in deionized water, resulting in final concentrations of 250µg N l^{-1}, 10µg Mg l^{-1}, 27µg Ca l^{-1}, 53µg K l^{-1} and 40µg Na l^{-1} in samples and 15,000µg N l^{-1}, 600µg Mg l^{-1}, 1,600µg Ca l^{-1}, 3,200µg K l^{-1} and 2,400µg Na l^{-1} in standards. As additional carbon source, acetate (CH_3COONa) stock solution was added to reach a concentration of 2,000µg C l^{-1} in the standard or sample.

Disodium hydrogen phosphate (Na_2HPO_4) was added to standard in different concentrations as phosphorus reference with values in the range 0–12.6µg P l^{-1}.

Afterwards water samples were pasteurized in a heated water bath at 60°C for 50min. After cooling till the room temperature, *Ps.brenneri* cells were added to achieve the concentration of 10^3TCC ml^{-1}. Prepared samples were kept in a shaker-incubator at 30°C and 150RPM until steady state of bacterial growth was reached. All samples were prepared in triplicates to ensure greater precision.

D. Measurements

Total cell count was measured using flow cytometer PartecCyFlow® SL (Partec, Germany) by method described previously in recent studies [7], [8]. Briefly, 1ml of sample was heated for at least 3min at 35°C. Further, 10µl of SYBR Green I (Invitrogen, Switzerland) and 10µl of EDTA was added and left to stain for 10min at 35°C in the dark before measurement. Prior to measurements samples were optionally diluted in 0.1µm filtered Evian in order not to exceed instrumental detection limit. PartecCyFlow® SL has a blue 25mW solid state laser

emitting light at a fixed wavelength of 488nm. Green fluorescence was collected at 520±10nm, red fluorescence above 630nm, and high angle sideward scatter (SSC) at 488nm. The instrument was set on parameters described by Nescerecka et al. [9], i.e., the trigger was set on the green fluorescence channel and data were acquired on two-parameter density plots while no compensation was used for any of the measurements. Results were expressed as total cell count (TCC) in microbial cells per ml of water sample.

For classical cultivation, heterotrophic plate count method was used by spread-plating sample on R2A agar medium [10] and incubated for 2 days at 30°C in the dark before enumeration. Results were expressed in colony forming units (CFU) per ml of water sample.

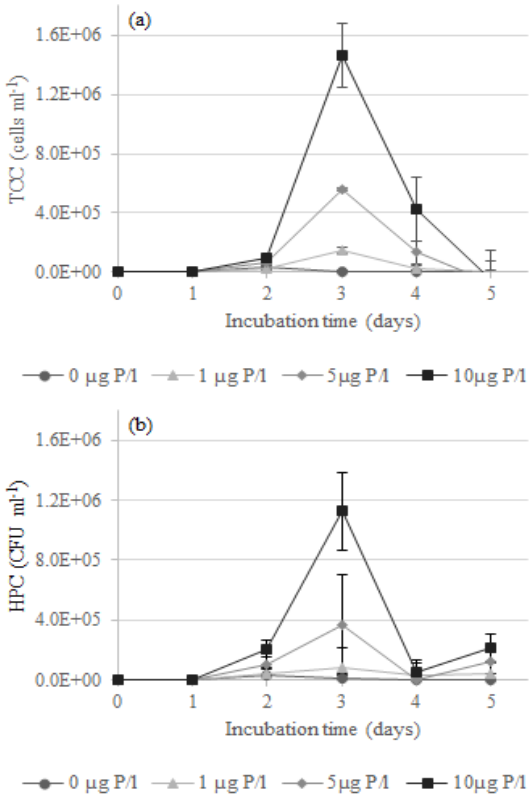

Fig. 1 Comparison between maximum growth of *Ps.brenneri* cells by FCM (a) and HPC method (b) in standards with different phosphorus concentrations

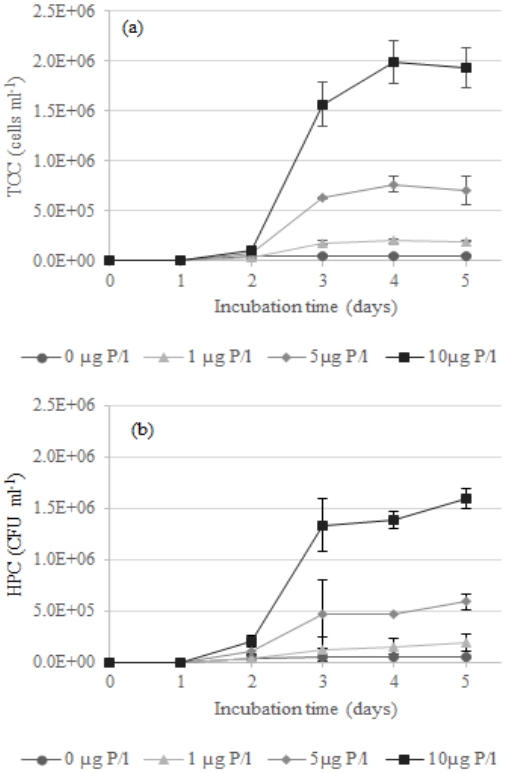

Fig. 2 Comparison between cumulative growth of *Ps.brenneri* cells by FCM (a) and HPC method (b) in standards with different phosphorus concentrations

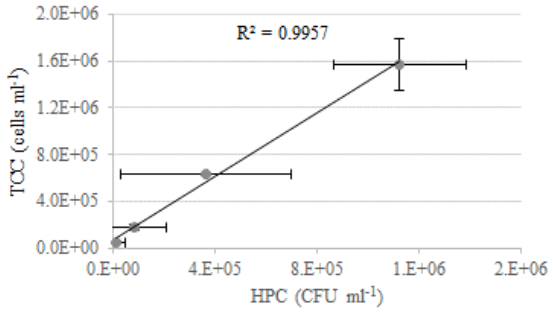

Fig. 3 Relationship between total cell count (TCC) on the day of steady state reached, measured by FCM, and colony forming units (CFU) on the day of maximum cell growth, measured by HPC method

III. RESULTS AND DISCUSSION

A. Method comparison between MAP determination by flow cytometry and heterotrophic plate count methods

The comparison was made for four phosphorus concentrations in the range of 0–10µg P l^{-1}. To compare the methods, the day of maximum growth (Fig. 1) and the day of steady state reached (Fig. 2) was determined. Both, cultivation and flow cytometry enumeration methods, showed that the maximum growth of *Ps.brenneri* in standard sample was reached on the third day and steady state was reached on the third or fourth day, depending on the sample. A very strong correlation was achieved between FCM and HPC (Fig. 3) results, displaying R^2 of 0.99.

In case of HPC, the day of maximum growth of bacteria in a water sample is used for conversion into MAP. For Lehtola et al. [5] it was day four to six. The time required to reach the maximum growth was longer due to a lower temperature, as they incubated samples at 15°C in contrary to 30°C used in this study.

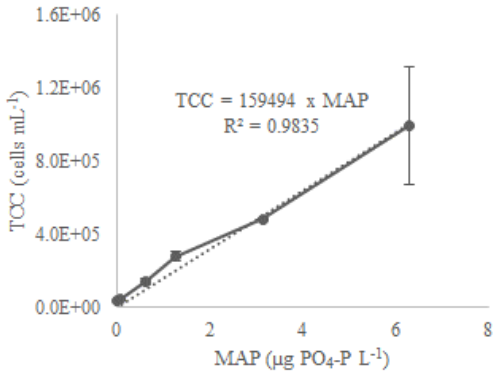

Fig. 4 Relation between the growth of *Pseudomonas brenneri* cells, measured with FCM, and phosphorus concentration in MAP standardization

B. Calibration curve

The MAP concentration for calibration was measured at the day, when steady state of bacterial growth was reached, i.e., when the maximum amount of TCC was registered, on contrary to HPC method, when the day of maximum growth was used, i.e., the day, when the greatest increase of CFU was registred. That is due to different appearance of result curves directly gained by each method. Additionally, at the point of steady state the maximum possible bacterial growth would be reached and no further growth would be possible due to P limitation. In this study the fourth day was used for further determination of yield factor.

The calibration was made for seven phosphorus concentrations in the range of 0–12.6µg P l^{-1}. The point of 12.6µg l^{-1} was not used in calibration as it was more away from linear correlation. That corresponds to observations by Lehtola et al. [5], who also amended standards with 2,000µg C l^{-1} in form of CH_3COONa and found no linear correlation with P concentrations above 10µg l^{-1}. Therefore, this range might be applied as MAP detection limit within this study.

Nevertheless, Wen et al. [6] found that linear range was 0–5µg l^{-1}, 0–10µg l^{-1} and 0–20µg l^{-1} if the amount of acetate spiked was 0.5mg l^{-1}, 1mg l^{-1} and 2mg l^{-1}, respectively. However, in this study the amount of carbon spiked to reach final concentration of 2mg l^{-1} did not show linear correlation for the point of 12.6 µg l^{-1}.

The calibration curve (Fig. 4) displayed strong linear correlation with R^2=0.98. The transformation of TCC into MAP was made using following equation (1):

$$TCC = 159494 \times MAP. \quad (1)$$

It gives a yield factor of 1.59×10^8, which means that 1µg of PO_4-P corresponds to 1.59×10^8 cells of *Ps.brenneri*.

Lehtola et al. gained a yield factor of 3.7×10^8 [5], Polanska et al.– 3.2×10^8 [3], Jiang et al.– 1.1×10^9 [11] by spread-plating method and using *Pseudomonas fluorescens* as inoculum.

Wen et al. [6] compared P17 strain and natural microbial consortium of Evian water as inoculum and gained slopes of 1.8×10^8 and 9.4×10^8, respectively, using flow cytometry. They explained lower yield factor as a result of lower phosphatase activity, when comparing pure culture with natural microbial consortium. The value gained in this study is comparable to the value gained by Wen et al. by FCM [6]. Although, there is a lower phosphotase activity of P17 if compared to natural microbial consortium, the method is still applicable for MAP determination.

IV. APPROBATION IN LATVIAN CONDITIONS

The gained equation (1) was applied to determine the amount of MAP in artificially recharged groundwater effluent from the station (Riga, Latvia). A three weeks long study with three days per week sampling gave an average MAP concentration of 18.2±2.9µg P l^{-1} for groundwater samples. Such

concentration is out of calibration range and is nearly twice as high as data obtained in 2007 at the same station by HPC method (10.2±1.9µg P l^{-1}) [12] and the difference is even greater if compared to the amount presented in 2004 (3.4±2.4µg P l^{-1}) [2]. That might be attributed to increased pollution level or seasonal variations. To note, the consumption of drinking water in Riga has decreased almost threefold since 1995 [13] and in the last years infiltration basins for artificial recharge are used only to insure their serviceability.

Furthermore, as calibration limit is out of range, an increased acetate concentration needs to be applied, as suggested by Wen et al. [6]. However, a precise amount of carbon dose needs to be specified to fit the necessary conditions.

V.CONCLUSIONS

Flow cytometry is more advantageous method for MAP determination if compared to heterotrophic plate count due to its rapidness, ease of operation and safer sample measurement backup, as any doubtful cases can be detected immediately and remeasured.

The gained yield of this study by using FCM is $1.59x10^8$ cells µg of PO_4-P^{-1}. At last, it is useful to provide wider MAP determination range by increased sodium acetate concentration.

ACKNOWLEDGEMENTS

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REFERENCES

[1] I. T. Miettinen, T. Vartiainen, and P. J. Martikainen, "Phosphorus and bacterial growth in drinking water," *Appl. Environ. Microbiol.*, vol. 63, no. 8, pp. 3242–3245, 1997.

[2] M. J. Lehtola, T. Juhna, I. T. Miettinen, T. Vartiainen, and P. J. Martikainen, "Formation of biofilms in drinking water distribution networks, a case study in two cities in Finland and Latvia," *J. Ind. Microbiol. Biotechnol.*, vol. 31, no. 11, pp. 489–494, 2004.

[3] M. Polanska, K. Huysman, and C. Van Keer, "Investigation of microbially available phosphorus (MAP) in flemish drinking water," *Water Res.*, vol. 39, no. 11, pp. 2267–2272, 2005.

[4] T. Juhna, "Aspects of Drinking Water Supply in Areas of Humic Water."

[5] M. J. Lehtola, I. T. Miettinen, T. Vartiainen, and P. J. Martikainen, "A New Sensitive Bioassay for Determination of Microbially Available Phosphorus in Water A New Sensitive Bioassay for Determination of Microbially Available Phosphorus in Water," vol. 65, no. 5, pp. 5–8, 1999.

[6] G. Wen, Q. Deng, T.-L. Huang, and J. Ma, "An improved method for determining microbially available phosphorus in drinking water," *Water Sci. Technol. Water Supply*, 2016.

[7] F. Hammes, M. Berney, Y. Wang, M. Vital, O. Köster, and T. Egli, "Flow-cytometric total bacterial cell counts as a descriptive microbiological parameter for drinking water treatment processes," *Water Res.*, vol. 42, no. 1–2, pp. 269–277, Jan. 2008.

[8] E. I. Prest, F. Hammes, S. Kötzsch, M. C. M. van Loosdrecht, and J. S. Vrouwenvelder, "Monitoring microbiological changes in drinking water systems using a fast and reproducible flow cytometric method," *Water Res.*, vol. 47, no. 19, pp. 7131–7142, 2013.

[9] A. Nescerecka, J. Rubulis, M. Vital, T. Juhna, and F. Hammes, "Biological instability in a chlorinated drinking water distribution network," *PLoS One*, vol. 9, no. 5, pp. 1–11, 2014.

[10] D. J. Reasoner and E. E. Geldreich, "A new medium for the enumeration and subculture of bacteria from potable water," *Appl. Environ. Microbiol.*, vol. 49, no. 1, pp. 1–7, Jan. 1985.

[11] D. Jiang, Y. Chen, and G. Ni, "Effects of Total Phosphorus (TP) and Microbially Available Phosphorus (MAP) on Bacterial Regrowth in Drinking Water Distribution System," *Syst. Eng. Procedia*, vol. 1, pp. 124–129, 2011.

[12] J. Rubulis and T. Juhna, "Evaluating the potential of biofilm control in water supply systems by removal of phosphorus from drinking water," *Water Sci. Technol.*, vol. 55, no. 8–9, pp. 211–217, 2007.

[13] [A. Spalviņš, J. Šlangens, I. Lāce, R. Janbickis, I. Eglīte, and T. Juhna, "Baltezera ūdensgūtves režīmu optimizācija un mangāna koncentrācijas dinamikas pētīšana izmantojot nestacionāro hidroģeoloģisko modeli," Rīga, 2009.

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Rehabilitation of Polluted Urban Areas

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Abstract. Industrial structures, residential buildings and other objects of infrastructure are being constructed in many Russian cities now. In addition to new constructions, reconstruction and rebuilding of existing buildings is also being performed. Meanwhile, such construction objects are situated not only in open suburban areas but also in urban districts and city zones. Often it is necessary to dismantle or demolish old run-down buildings or distressed structures before constructing new buildings. Such works always cause large amounts of construction waste.

To accommodate constructive materials for new structures and to store elements of disassembled buildings and construction wastes special storage grounds are used. Being of temporal nature, these storage grounds are not capable to ensure full protection of the environment from pollution.

The team of employees of Samara State Technical University investigated several districts of the city of Samara. This investigation revealed that in all temporary dumping sites construction wastes amount to 8% and dumping sites of a mixed type containing construction wastes – to 35%.

The majority of temporary dumping sites are removed in a short time. Mostly, it is done by collection and removal of construction waste to special waste landfills. At the same time, the investigation demonstrated that though these dumping sites are temporal, their existence causes environmental pollution of underlying open ground as repugnant substance penetrates the ground with rains and pollution of airspace as light pollutants are dispersed by wind. Moreover, even after these temporary dumping sites are removed, already polluted soil layers continue to pollute soils as a secondary pollutant source.

The authors offer a technical solution which allow to carry out rehabilitation of polluted urban areas more effectively. In particular, it is recommended to remove waste from the temporary dumping sites stage by stage. At the first stage, off-site areas should be inspected and the extent of pollution (pollution depth) of underground layers should be estimated. At the next stage, a protective barrier in the ground around the dumping site and on the surface should be built. Only after that we recommend that wastes should be removed and sent to a waste recycling plant or to a specially equipped waste landfill. Then, it is required to cut off all polluted soils and to remove them to a special waste landfill for storage.

Thus, this solution makes it possible to reduce the risk of secondary environmental pollution.

Keywords: wastes, shell and core dumps, liquidation, land improvement.

I. INTRODUCTION

Change of urban development is marked as a result of acceleration of development of residential locations. At the same time more modern and comfortable buildings, serving and auxiliary facilities, such as shopping centers, parking areas and others are often constructed on the place of old dilapidated and obsolete buildings.

Renovation of real estate development is inseparably linked with release of the built-up territories and demolition of buildings that complicates the direct process of building and carrying out construction works in the restricted area.

The main method of collection and utilization of the buildings waste which is left after dismantle of buildings and constructions is warehousing directly on the building site within a certain yard territory [1-3].

The organization of collection and centralized export of construction waste in the restricted area is difficult, that leads to emerging shell and core dumps in the yards of residential quarters.

Infil construction leads to the urgent rise of question of emergence of such dumps, where the building site is located closely to private or country sector.

The general view of a shell and core dump is provided in Fig. 1.

Fig. 1. Shell and core dump of construction waste

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It should be noted that on the territory of the city there are not only dumps of construction waste, but also shell and core dumps of household waste which are quite often located near construction wastes.

II. MATERIALS AND METHODS

Construction Sites

Staff of higher education institution together with a group of students made inspections of several districts of the city of Samara. During the research about 50 shell and core dumps were recorded and analysed.

Morphological structure shows the diversity of the studied dumps: dumps only with household waste constitute 57%, building wastes – 8% and 35% of shell and core dumps are of the mixed type.

Construction dumps are formed, as a rule, nearby or directly to the construction site. Shell and core dumps with household waste are often located near a private sector or in the yards of multi-storied houses, where there are no equipped platforms in the yards for accumulating household waste or the schedule of export of waste by the municipal companies.

Shell and core dumps of the mixed type are of special interest. Their formation usually begins with lack of the built-up platform for building waste collection and its untimely export from the construction site territory. Then, eventually, construction waste begins "to mix" with the household waste made by inhabitants of adjacent residential buildings [4-6].

Territory Pollution

Emergence of shell and core dumps leads to littering of the urban area, loss of appeal of domestic sites, change of esthetic perception. Besides, waste leads to various ongoing processes. For example, such household waste as food can undergo the process of oxidation and filtrate formation. The filtrate, concentrated on the surfaces of the soil, pollutes it, getting to the top layers. The filtrate is also a source of an unpleasant smell near a dump and at the adjacent territory.

Research

Research of process of penetration of pollutants has been conducted in order to define the area of influence of a shell and core dump on the soil. Research was conducted on twelve substances. Tests of soil at different depths under a dump were made and quantitative characteristics were determined by the chosen substances.

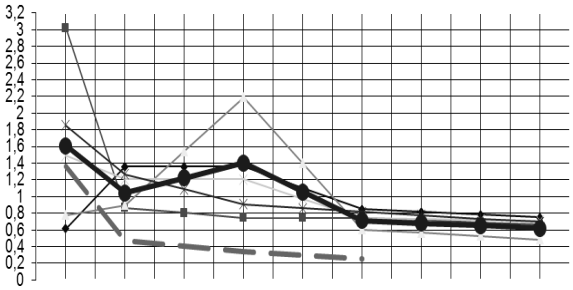

Fig. 2. Research results of soil pollution with cadmium

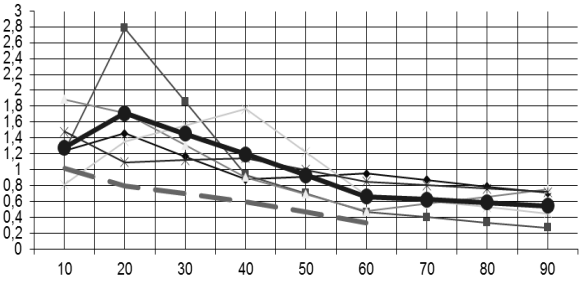

Fig. 3. Research results of soil pollution with copper

Research results of pollution of the soil by one of substances – cadmium are reflected in Fig. 2. The vertical axis shows amount of pollutant in mg/kg, a horizontal axis – depth of penetration of substance into soil. Apparently, the maximum quantity of pollutant was revealed on the soil surface.

Fig. 3 presents the results of copper penetration of into soil. It should be noted that for this substance the maximum sizes correspond to 10-15 cm depth.

One of the most dangerous pollutants is lead, by results of researches, concentrates at a depth of 15-20 cm, at the same time the maximum depth of penetration of lead into soil is 35-40 cm.

The analysis of other studied pollutants has shown approximately similar changes of quantitative characteristics with increase of depth of penetration into soil.

III. RESULTS AND DISCUSSION

Research has shown that the greatest pollution is concentrated on the top layer of earth which doesn't exceed, as a rule, 40-45 cm. The amount of the concentrated pollutants depends not only on component structure of waste of a shell and core dump, but also on duration of a dump existence.

For prevention of pollution of soil as a result of emergence and development of shell and core dumps on the territory of the city, the stage-by-stage scheme of liquidation of the most shell and core dump (fig. 4), and also the polluted soil [7] has been developed.

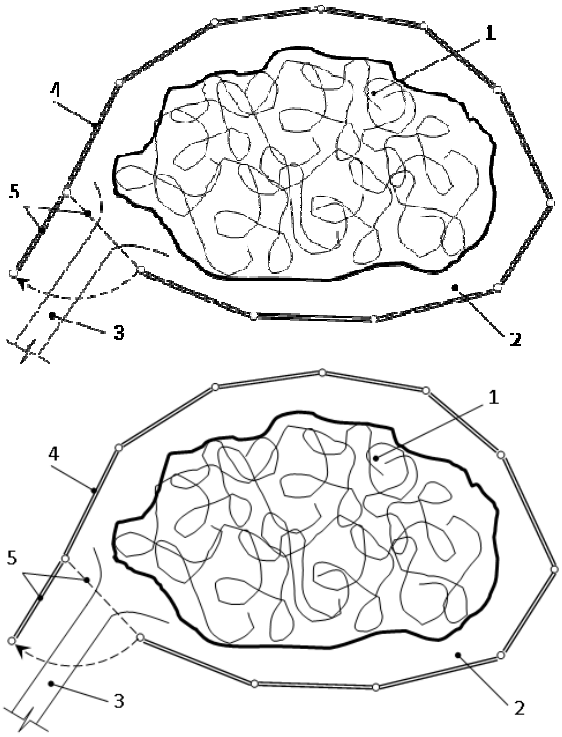

Fig. 4. The method of shell and core dump liquidation
1 - dump, 2 – dump territory, 3 – motor driveway, 4 – protection barrier, 5 – the barrier's door open

As the origin of a dump is not always defined and depth of filtrate penetration is not calculated, it is necessary to conduct a territory research prior to dump liquidation. The natural research of the adjacent territory, and also chemical analysis of soil for definition of extent of pollution is conducted in order to start dump liquidation. In case of a possible high bedding of ground waters, it is also necessary to carry out chemical research of waters.

It is rational to install a protective barrier to prevent further penetration of pollutants. The barrier needs to be established both under, and over the Earth's surface. In soil – for restriction of distribution of pollution in soil, and also penetration of pollution into adjacent massifs. For this purpose the barrier is arranged deep into to a confining bed. The barrier over the Earth's surface prevents pollutants' transfer on the soil surface as a result of rain or animals life.

After installation of a barrier it is necessary to start liquidation of the dump. Waste is loaded on a specialized transport and taken out to the testing area for further utilization.

During the full removal of a waste layer, it is necessary to carry out removal of the polluted soil as well. Power of the liquidated layer is determined by results of the research conducted earlier.

Besides cleaning of a surface of soil there happens its 'baring'. The pollutants concentrated on a surface, especially after rainy weather, have an opportunity to extend deeply. Installation of a tent that covers a dump within the established barrier is recommended for prevention of further pollution distribution.

After liquidation of a dump and polluted soil, improvement of the territory (fig. 5) is made: filling of formed cut by uncontaminated soil, and also, if necessary, arrangement of the stationary constant platform for household waste [8].

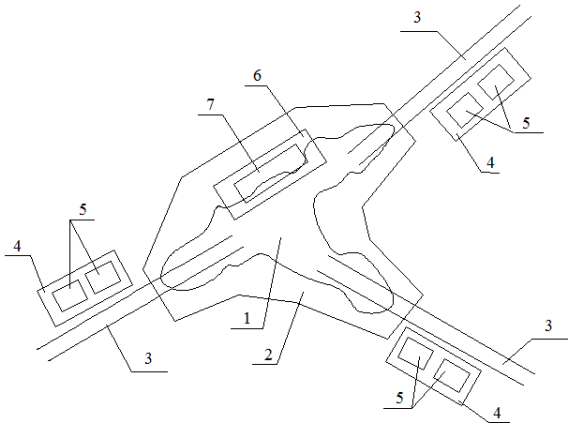

Fig. 5. Method of dump liquidation with further improvement
1 – dump, 2 – contaminated soil area, 3 – approach roadways, 4 – temporary special lands, 5 – temporary containers for household waste, 6 – stationary asphalted area, 7 – stationary containers for household waste

Also, it is possible to make implantation of green trees, to provide parking facilities, children or sports ground in order to improve the territory.

IV. CONCLUSION

Timely export of waste, prevention of its long storage at construction sites or at the domestic territories is necessary for prevention of origin of shell and core dumps of construction wastes after dismantling of buildings and constructions, and also mixed and household waste. The organization of platforms for building wastes storage within the construction site territory combined with nature protection actions for minimization of negative impact of waste on the environment is also recommended.

It is necessary to liquidate already formed and existing dumps and carry out events for improvement of the cluttered-up territories, using the described method in this paper.

The method of shell and core dump liquidation will allow making the territory of the city more comfortable and attractive for living. Such approach of shell and core dumps liquidation of household waste will provide the slightest polluting impact on the adjacent territory. Application of the method is possible not only in megalopolises and large cities, but also in other populated areas.

V.ACKNOWLEDGMENTS

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REFERENCES

[1] Kravtsova M.V., Vasilyev A.V., Nagaitseva M.P., Kravtsov A.V. Nomenklaturniy analiz objemov obrazovaniya otkhodov stroitelstva i snosa [Nomenclature analysis of waste production volume and demolition]. Izvestiya Samarskogo nauchnogo zentra Rossiiskoi akademii nauk [Bulletin of Samara research center of Russian Academy of Sciences], 4-4, 2015, pp.810-816.

[2] Zhigulina A.Yu., Chumachenko N.G. Vybor stroitelnykh materialov dlya uluchsheniya komforta i ekologicheskoi bezopasnosti zhilya [Choice of construction materials for comfort improvement and ecological safety of a residential building]. Urban Construction and Architecture, 4 (21), 2015, pp. 94-99.

[3] Kravtsov M.V., Vasilyev A.V., Kravtsov A.V., Nosarev N.S. Analis metodov utilizatsii otkhodov stroitelstva s posleduyuschim vovlecheniyem ikh vo vtorichniy oborot [Analysis of utilization methods of construction waste, using them in the secondary recovery]. Izvestiya Samarskogo nauchnogo zentra Rossiiskoi akademii nauk [Bulletin of Samara research center of Russian Academy of Sciences], V.17. 4-4, 2015, pp. 804-809.

[4] Maryin V.V., Risnik V.V., Pisarenko V.N., Timofeyev V.B., Shyshov V.P. O problem bytovykh otkhodov megapolisov i putyakh eye rescheniya [Problems of household waste in metropolitan areas and ways of its solution]. Gorniy infomatzionniy bulleten (naychno-tekhnicheskiy zhurnal [Gorniy information bulletin (research and technical journal)], V.2, 2000, pp.85-91.

[5] Kolychev N.A. Optimizatsiya obrascheniya s tevrdymi bytovymi i blizkimi k nim po sostavu promyschlennimy otkhodami krupnykh i srednikh nasellennykh punktov Rossii [Optimization of processing firm household and similar in structure industrial wastes of large and average populated areas of Russia]. Biosphera [Biosphere], V.5, 4, 2013, pp. 393-418.

[6] Malakhov V.M. Gritsenko V.M., Druzhinin S.V. Gorodskiye otkhody v Rossii: sostoyaniye, problemy, puti rescheniya [Urban waste in Russia: current situation, problems, ways of solution]. Ekologiya. Seriya analitecheskikh obzorov mirovoi literatury [Ecology. Series of analytical review of world literature], 98, 2012, pp.1-126.

[7] Balzannikov M.I., Galitskova Yu.M. Sposob zaschity okruzhauschei sredy ot zagryazneniy bytovimy i promyshlennimy otkhodami [Method of environmental protection from pollutants of household and industrial waste]. Patent RF, 2294245, 2007, Bul. № 6.

[8] Balzannikov M.I., Galitskova Yu.M. Sposob zaschity okruzhauschei sredy ot zagryazneniya tverdimy bytovimy otkhodami [Method of environmental protection from pollution by solid household waste]. Patent RF, 2372154, 2009, Bul. № 6.

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Mathematical Tasks as a Means of Improving the Ecological Culture of the Future Teachers

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Abstract. With the development of civilization, the environment takes an increasing place in our lives. Analysis of the current state of environmental education of students in the University allows to make a conclusion about the need for a comprehensive approach to the problems of formation of ecological culture of future teachers. One of the directions is the integration of mathematics and ecology. Environmental knowledge can be generated when the study of mathematics through the solution of tasks with environmental content. This article presents mathematical tasks with environmental contents of the different sections of mathematics. Jobs can be used in the process of teaching mathematics students of a direction "Pedagogical education".

Keywords: ecological culture, environmental education, mathematical tasks with environmental content.

I. INTRODUCTION

With the rapid development of technology, the growth of world population, its economic activity is increasingly important for humanity to become environmental problems and their solutions.

Tough conditions of a global ecological crisis lead to the necessity of the formation and development of ecological culture of the population in the course of continuous ecological education.

Ecological culture is a combination of various qualities, such as environmental knowledge humanistic in nature, the assimilation of values, cultural traditions, rules and norms of behavior in the environment are the cultural achievements of the society [13].

Environmental education is a purposefully organized, planned and systematically carried out the acquisition of ecological knowledge, abilities and skills [9].

The main goal of ecological education in Russia is the formation of socially active personality with high environmental culture is able to adapt to the rapidly changing socio-environmental conditions, aware of the consequences of their actions with a sense of responsibility contemporaries to our descendants for their environmental behavior, focused on continuous self-development [9]. In addressing the objectives is a role for higher education, especially teaching.

The modern teacher, which forms the ecological culture of the personality through various educational processes, needs to be very ecological-active person. The objective condition for this is to ensure that future teachers of integrated system of ecological knowledge, including the study of mathematics.

The analysis of the current status of environmental education and training of future teachers in mathematics leads to the conclusion about inadequate capacity assessment of the relationship of such disciplines as "ecology" and "mathematics". Meanwhile, these Sciences are closely intertwined.

Whole branches of mathematics are created for the analysis of natural phenomena and to solve engineering problems. A universal language suitable for the description of processes of different nature and capabilities based on many factors, is the mathematical apparatus. Mathematics creates conditions for the development of skills among students to quantify the state of natural objects and phenomena, both positive and negative consequences of human activities in the natural and social environment.

In the process of learning mathematics by the students of direction of preparation "Pedagogical education" it is possible to find a material that will present an element of environmental education and illustrate the practical importance of the material being studied, contributing to the development of professional qualities of the teacher. In this connection, you need to define the multidisciplinary context of ecology and mathematics based on the analysis of their role and importance in the process of forming modern scientific picture of the world at the pedagogical University, to develop methods and means of formation of ecological culture of future teachers [6].

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II. MATERIALS AND METHODS

Because of the importance of environmental issues essential principles of the methodology of environmental education should become the principle of its continuity.

The formation of ecological culture at all stages of learning should be a gradual process, in the process of learning different branches of mathematics.

One means of formation of ecological culture of students in the study of mathematics can be tasks with environmental content. Under objective environmental content understand the challenges associated with quantitative assessment of environmental problems – a model of situations occurring in nature and society, the task – prediction of environmental phenomena, the tasks associated with production labor and management [16].

In the study of mathematics can be used to set the next types:

- information (the content of the job gives an idea about the objects and phenomena related to the environment);
- research (purpose of the job - identify mathematical regularities in natural phenomena, processes);
- demo (the content of the job descriptions of monuments, of the laws of structure of natural objects) [16].

Consider the examples of tasks that teachers use the physics and mathematics faculty of the Pskov state University in the study of the disciplines of basic and elective units for students of a direction "Pedagogical education".

Discipline base unit "Fundamentals of mathematical analysis", "Differential equations"

The analysis of the fundamental concepts of mathematical analysis from the point of view of continuity of the high school and University we have found that most of the concepts, which are formed in school at different levels of rigor in College courses are treated with the same positions, only deepened, and expanded the range of their application.

The object of study of mathematical analysis are functional dependencies. As is known, the function came into mathematics in connection with the study of the phenomena of nature, and, in particular, physical phenomena and processes. Therefore, in the University in the "Function" it is advisable to include tasks with an environmental content, to show the changes in the environment resulting from production and economic activities of people.

Based on the knowledge of the properties and graphs of basic elementary functions can be offered to students using literature to construct the tasks of environmental issues. They can be made on the issue of soil contamination or air, waste disposal, plant ecology, etc.

With the aim of strengthening the environmental aspect in the initial phase, students can be offered the combined job of the following type.

Task 1: I. Pick up the material on the problem of air pollution and answer the following questions:

- what are the main sources of air pollution on the planet?
- which industries are the most dirty?
- what are the main pollutants today, you know?
- what industries are in your area and how they affect the environment?
- what is the "greenhouse effect"?

II. Make a chart that reflects the percentage of industries that pollute the atmosphere. Make conclusions.

III. Construct a text task with environmental content in which the relationship between the concentration of carbon dioxide and drought on the planet is determined by the linear law.

IV. Decide your objective, plot.

Task 2. Set the dependencies between the variables (environmental indicators) and the construct:

- tasks on the problem of air pollution;
- tasks on the problem of water pollution;
- tasks on the problem of purification of used water;
- task of environmental management;
- the task of feeding ecology;
- the task of ecology and energy resources.

With this organization of learning activities, the student plays the role of the researcher, i.e., collects the facts, analyzes, compares, establishes interdisciplinary connections, builds a mathematical model that translates the problem into natural language. [5]

If the function describes the process of change of one quantity depending on another change, the rate of change function describes the derivative. The huge value of the derivative is that the study of all processes and phenomena of nature with its help it is possible to estimate the rate of change of related quantities.

Task 3. The decay of radium according to the law where the quantity of radium in the initial time t=0, and R is the number neraspavshemsya of radium at time t. Determine the law of dependence of the rate of decay of radium with time. Show that the decay rate is proportional to the cash amount of radium.

Senior students are offered tasks with environmental content, which can be solved using differential equations. Many of the processes and phenomena occurring in nature, quantitatively described by ordinary differential equations. They can be used to create a mathematical model of the studied physical, chemical or biological process. The solution of these equations allows to predict the properties of the phenomenon under study and to predict the final result.

Task 4. The rate of multiplication of certain bacteria is proportional to their number at a given moment of time t. The number of bacteria has tripled within 5 hours. To find the dependence of the number of bacteria with time.

The solution of problem 4 shows that under favorable conditions the increase of bacteria over time is exponential. This law is of interest not only from theoretical but also from a practical point of view. He says that creating a useful population for favorable conditions, it is possible to quickly obtain a population with greater numbers. The exponential law of reproduction is subject to the so-called "ecological explosion", when one or the other species, once in favorable conditions, in a short time reaches large numbers. For example, you can point to the disastrous invasion of hordes of insects (locust, silkworm, etc.).

Discipline base unit "Foundations of mathematical processing of information»

The purpose of discipline: to form at students the system of mathematical knowledge, abilities, skills, competences necessary for work with information. The studied sections of the discipline: statistical methods for collecting experimental data, methods of primary processing of statistical information the main statistical indicators, statistical indicators and relationships indicators. Official statistical information on the state of the environment can be used as:

- examples of the theoretical concepts;
- content design assignments;
- job statistical research on a particular topic.

Consider the theme of "Series. Performance indicators". The necessary theoretical material used in the solution of problems: determination of a number of speakers, types of time series a graphical representation of the series dynamics, the parameters of intensity development, medium intensity development, development trends, and methods of smoothing of time series.

As an example, an interval of a number of speakers at the lecture provides information on waste production and consumption in the processing of wood and manufacture of wood products in Russia from 2010 to 2015.

Tab.1

t, year	2010	2011	2012	2013	2014	2015
y_i, million tonnes	9,6	3,9	3,7	5,3	5,0	4,5

In the formation of knowledge and skills to carry out statistical processing of information at practical classes is given the following task: create a series of speakers, to determine its type, to graph, to find analytical indicators, average dynamics, smoothing of time series method, moving average, and draw conclusions. For the job are used statistical data on emissions of air pollutants, which are produced by stationary and mobile sources in Russia from 2009 to 2015y.: 2006 y. – 35510 thousand tonnes; 2007 y. – 35532 thousand tonnes; 2008 y. – thousand tonnes; 2009 y. – 32754 thousand tonnes; 2010 y. – 32353 thousand tonnes; 2011 y. – 32628 thousand tonnes; 2012 y. – 32469 thousand tonnes; 2013 y. – 32063 thousand tonnes; 2014 y. – 31228 thousand tonnes.; 2015 y. – 31269 thousand tonnes.

This task, which uses real statistical data, is information. When executed, the problem is not only mathematical, but also ecological education of future teachers. The above task can be supplemented by research done by the student independently. Additional task: a) find information about the most common types of substances that pollute the atmosphere, their impact on the environment; b) to find statistical information on emissions of most common air pollutants produced by stationary and mobile sources; C) to carry out statistical processing of information; g) draw up the results into a concise report. This work can be performed by a group of students. The grouping happens in the mind of air pollutants. Self-employment can be organized in the form of an environmental conference. Fulfillment of additional tasks contributes to the formation of professional qualities of a teacher, development of his ability and willingness to ecological and pedagogical activities.

Discipline of choice "Mathematics and the harmony of the surrounding world"

The goal of the course is to expand students ' ideas about the concepts of symmetry and proportion, as well as building skills to identify the principle of symmetry (and different types) and the Golden proportion in the phenomena of the surrounding reality, in particular, in ancient architecture.

Teaching about symmetry and the Golden ratio has made significant changes in the scientific picture of the world, has formed a new way of scientific thinking. These concepts have a very broad meaning. They are associated with medicine, biology, chemistry, crystallography, physics, mathematics, philosophy. The proportionality of the Golden section and its related Fibonacci series manifest in the human body at all levels of the organization and functioning of all systems, including the geometry of molecules and cells; the proportions of liquids; dynamics of the heart; the brain biorhythms. The principles of symmetry and the Golden ratio is inherent in nature: in the structure of plants, insects, animals, gems, Earth. The same mathematical patterns that permeate all life. The study of these concepts shows that the world is not random and chaotic, but by the same laws. Therefore, these fundamental knowledge expand opportunities in the field of nature protection as such, and, in particular, of its resources. Moreover, in the future, this knowledge may not only be an

additional factor in the awareness of the importance of conservation, but also to predict its development and influence on it. So, some studies show that in nature there is a balance that obeys the Golden ratio. If there is a violation of this balance, the natural habitat can be lost [17].

The course content integrate knowledge from different subject areas based on the mathematical concepts of symmetry and the Golden ratio.

By the end of the course students are encouraged to submit a project based on real objects – Pskov churches that dot the city. The aim of the project is to realize the uniqueness of the architecture of ancient Pskov, the importance of saving this cultural heritage, the importance of environmental protection of the city.

Today in the city there are about 40 churches, which require your savings. Pskov is very ancient architecture in harmony with nature, as it is based on the laws of nature – dissymmetry and the Golden ratio. This suggests that Pskov masters knew very well the nature and its laws, and very kind to her, in a world largely lost. One of the reasons for the loss of the harmony of architectural structures – the introduction of measurement standards, in particular the meter.

At the same time, the ancient masters were the units that went from the size of the person – fathoms, cubits, spans, etc. As well as the size of the man laid the Golden proportion, the laws passed and the size of the buildings. Therefore, the architectural features of ancient temples is unique, which in turn requires careful conservation.

For successful completion of the project students are offered the following plan.

1. My goals.

Specify the priority goal, towards which you will strive in carrying out the work.

2. A work plan.

Make a real plan that you follow when it is executed.

3. My first impression.

Describe your first impression about selected objects, their mathematical features. Formulate questions (if any) that you would like to get answers.

4. The facts of history.

Try to collect all possible information about the objects. The result of this work you can collect the following material: the name of the object (and its explanation); if this religious building, information about the Saint in whose honour it was erected; erection time, in honor of the event; alterations (dates, pictures, description of the previous species); the modern form, its function; architecture description; photographs of a modern view of the building from different angles, photos of the modern buildings (if any), plan of the building.

5. Photo gallery.

Make a selection of photos (sketches, images) required for your job. You can view photos of the modern look of the building and its parts from different angles, photographs of the building up to modern construction, building layout, etc.

6. Symmetry and proportionality (mathematical work)

Main directions of the analysis:

- analyze the symmetry of the plan, the individual parts and building as a whole (consider the presence of different types of symmetry elements of symmetry), see how accurately observed symmetry in various parts of the building;
- isolate the building geometric shapes, flat and spatial, and explore their symmetry, scroll shape, having the same symmetry;
- if the architectural elements borders and ornaments, will study their symmetry;
- analyze the building to the presence in its composition of classic types of symmetry (as in the whole building and its separate parts);
- what breaks the overall symmetry of the building and how it affects the harmony of the building?
- analyze the building to the presence in its composition of non-conventional types of symmetry, try to find the cause of a broken symmetry. Is it possible to find the angle from which the building (or any part of it) will look symmetrical?
- try to relate the symmetry of the temple with its history, alterations, functionality of its individual parts.
- look at the numerical patterns in the size structure and its parts, particularly the Golden ratio.

7. Analysis of the state of the environment on the rate of destruction of the temple.

Prepare summary information on the environmental impact of the selected object. Try to talk to the temple workers, museums, architects and restorers on the state of the temple and the environmental impact of its destruction. Analyze the statistics of the state of the climate and the number of anomalies and man-made disasters over the past 10 years and previous 10 years, the change in the chemical state of the air and the impact of these changes on the state of the Church.

8. Areas of concern.

Highlight those issues and problems (if any) that have arisen in the course of work.

9. The results of the study and conclusions.

Analyze your research and make the major your own conclusions on the work done.

10. Interesting information.

Include the material (if any) that seem most interesting in the work.

11. Versions of the reports.

Prepare the message text for 5-7 minutes about the work done.

12. Bibliography.

Include in this category a list of information sources.

13. The introspection work.

Analyze all the work done.

III. RESULTS AND DISCUSSION

The experience of teaching mathematical disciplines for students of the Pskov State University in the direction of "Pedagogical Education" training using assignments of different types allows us to draw the following conclusions:

1. Mathematical tasks of informational type can form the following representations in future teachers:
   - about environmental problems;
   - on the environmental situation in a particular region;
   - on the directions of environmental research;
   - on the impact of human activities on the environment;
   - on the relationship between the state of ecology and the preservation of monuments of the cultural heritage, the environment.

2. With the help of mathematical tasks of the research type, the formation of representations takes place:
   - on the connection between ecology and mathematics;
   - on the possible causes of environmental problems and their solutions;
   - that the world is organized according to single laws, the violation of which can lead to irreparable consequences.

3. Demonstration tasks allow us to visualize not only the mathematical concepts that are being studied, but also how different spheres of human activity influence the ecological situation, what consequences may have in the "ecological crisis".

4. The use of different types of tasks with environmental content contributes to the formation of beliefs about the need to preserve the environment, cultural traditions, the need to comply with rules and norms of behavior in the environment, the wise use of natural resources, which is an integral part of the environmental culture of the future teacher.

IV. CONCLUSION

At present, modern research scientists and educators focused on the study of various aspects of environmental education and, in particular, of ecological culture of future teachers.

One of the areas of research can be integration of disciplines "mathematics" and "ecology" through inclusion in educational process of mathematics with environmental content.

The article is recommended for teachers of mathematical disciplines at higher education institutions.

REFERENCES

[1] Федоров А.Е. Симметрия и искажения в русской традиционной архитектуре: Московский Кремль и другие архитектурные комплексы. – М.: Книжный дом «ЛИБРОКОМ», 2013. – 312 с.

[2] Стахов А., Слученкова А., Щербаков И. Код да Винчи и ряды Фибоначчи. – СПб.: Питер, 2006. – 320с.

[3] Божьеволина И. М. Эколого-педагогическая подготовка студентов в условиях классического университета. Диссертация.... канд. пед. наук.- Казань, 2002. - 230 с.

[4] Перькова Н.В. Методика организации самостоятельной деятельности студентов 1 курса педвуза на занятиях по математическому анализу. Диссертация ... канд. пед. наук. – Санкт-Петербург, 2002.-154 с.

[5] Файрушина С. М. Формирование экологической культуры студентов педагогических вузов в процессе изучения естественнонаучных дисциплин. Диссертация ... канд. пед. наук.- Казань, 2007.- 217 с.

[6] Барышникова Г.Б. Моделирование системы экологического образования студентов направления «Педагогика» (Бакалавриат) // Актуальные проблемы гуманитарных и естественных наук. - 2010. - №9. – С.277-281.

[7] Гаваза Т.А. Формирование статистической культуры студентов гуманитарно-педагогических направлений вузов как одной из составляющих общекультурной и профессиональной компетенций //Вестник Псковского государственного университета. Серия «Естественные и физико-математические науки». Выпуск 1. – Псков : Псковский государственный университет, 2012.– С. 111 – 115.

[8] Дараган Н.Д. Становление экологической культуры будущих педагогов как педагогическая проблема // Вестник Таганрогского института имени А.П. Чехова. – 2016. - №2. – стр. 86-91.

[9] Захлебный А.Н. Концепция общего экологического образования в повестке дня XXI века.// Научные исследования в образовании.- 2011- №9. – с.3-6

[10] Лебедева С.В. Роль математического учения о симметрии и золотой пропорции в современном образовании (научная статья) //Вестник Псковского государственного университета. Серия «Естественные и физико-математические науки». Выпуск 4. – Псков : Псковский государственный университет, 2014. – С. 110 – 113.

[11] Перькова Н.В. Некоторые аспекты изучения темы «Дифференциальное исчисление функции одной переменной» в вузе // Вестник Псковского государственного университета. Серия «Естественные и физико-математические науки». Выпуск 2. – Псков: Псковский государственный университет, 2013.– 220 с. - С. 185 – 188.

[12] Подзорова М.И. Особенности преподавания математики студентам-экологам.//Ученые записки Российского государственного университета.- 2013- №5. – с. 127-131

[13] Чуйкова Л.Ю. Концепции экологического образования, построенные на идее формирования экологической культуры//Гуманитарные исследования. - 2012 - №2.–с. 342-351

[14] Жолдасбеков А.А., Сихимбаева Ж.С., Шынгысбаева Ж.А. Исследования проблем экологического образования студентов // Современные проблемы науки и образования. – 2012. – № 1.; URL: https://www.science-education.ru/ru/article/view?id=5624

[15] Садыкова Э.Ф., Ниязова А.А. Формирование экологических компетенций в процессе подготовки будущих педагогов// Фундаментальные исследования. – 2014. – № 11-9. – С. 2066-2069; URL: https://www.fundamental-research.ru/ru/article/view?id=35897

[16] Яркова Г.А., Шебанова Л.П. О проблеме формирования практических умений учащихся при обучении математике в условиях реализации новых образовательных стандартов // Современные проблемы науки и образования. – 2013. - №4; URL: www.science-education.ru/110-9497

[17] Голиков А. Эколого-диссимметрический подход в генетике и селекции видов хвойных. – Германия: LAP LAMBERT Academic Publishing, 2014. – 163 с.

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Innovative Solutions for Building Envelopes of Bioclimatical High-rise Buildings

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Abstract. The paper examines innovative and promising trends in in the design of high-rise buildings that challenge traditional typologies and are adapted for specific climatic conditions. The purpose of the study is to investigate modern methods of designing building envelopes for bioclimatic skyscrapers taking into account heat impact of climate on the thermal balance of buildings.

The research methodology is based on a systematic analysis of advanced world experience in constructing innovative buildings, "conquering" climate. The paper provides the basic principles of bioclimatic architecture. The issues of buildings' forms and modes are considered. The authors analyze the efficiency of using double facades in different climatic conditions with account of their interaction with other technological, constructive and planning elements, such as "solar chimney", passive and active solar control systems, landscaping, intelligence control systems of temperature and humidity conditions in premises and buildings, etc.

The paper highlights that unique objects of bioclimatic skyscrapers are moving now into new typologies of buildings and help form dense, comfortable and convenient urban environment using natural resources effectively. The research shows how prospects and relevance of a systemic approach to introducing the related and interdependent projects for energy saving activities at all levels, starting from town-planning and architectural models, and ending with engineering and constructive solutions.

Keywords: bioclimatic architecture; double skin facade; high-rise buildings; natural ventilation.

I. INTRODUCTION

It is recognized globally that under intensive urbanization the traditional systems of forming the urban environment cause environmental, regional, social, economic, demographic and other problems. The urgent need to modify the existing approaches to designing buildings is becoming evident. That is why the bioclimatic trend is getting greater relevance in contemporary architecture and is actively used in high-rise construction. There are a lot of studies and published works trying to give the definition of the bioclimatic architecture and formulate its basic principles [1-12].

Summing up various definitions it can be said that in the framework of this concept nature does not perform as a passive backdrop for architecture anymore and is used as the inexhaustible source of energy opportunities. At that the ideas of creating harmony between architecture and nature are being developed. It means that consumer's attitude to the natural environment should be avoided. Buildings are designed in accordance with the unique regional, historical, cultural, environmental, infrastructural, social and economic features of a particular site development without causing any environmental damage. In this regard a building is considered as a unified energy system based on energy dependent principles. It effectively uses the potential of nature as a renewable energy source.

II. MATERIALS AND METHODS

It should be emphasized that high-rise construction is at the forefront of research. Huge energy consumption of traditional skyscrapers makes architects and engineers search for new, constructive systems, technologies and building materials. So a great number of scientific developments have been introduced in high-rise buildings in recent years. It allows extending the use of renewable energy and the efficient use of resources. More recently, the energy consumption of buildings has not been a defining quality factor of a design. Nowadays it is the dominant criterion in choosing the method for designing the thermal protection of building envelopes.

A key feature of bioclimatic high-rise buildings is their adaptability to the natural environment. It should be noted that despite the relevance of the topic, there are no researches systemizing various methods of buildings' adaptation to different climatic conditions. To study the building envelopes in high-rise buildings constructed in the regions with different climate is of special interest. It is necessary to keep in mind the importance of a *systemic approach* to the scientific research based on understanding an object as an

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integrated system consisting of a number of interrelated elements. Being a great energy consumer, a high-rise building is developed as a unified architectural engineering project. Therefore, it is impossible to examine the building envelope without analyzing its constructional and architectural planning features. It is very important to analyze engineering, heating, hot water, ventilation and air conditioning systems as well. Their optimal choice and combination depend on the external climatic conditions.

It is known that there are four main climatic zones in each hemisphere on our planet: equatorial, tropical, temperate and polar. There are transitional zones between main climatic zones: sub-equatorial, subtropical and subpolar. The following concepts related to climate features are used in climatology as well, i.e. mountain climate; arid climate of deserts and semi-deserts; humid subtropical climate; nival climate where not all the amount of solid precipitation can melt and evaporate. Climatic characteristics depend on a complex of astronomical and geographical factors. Major climatic factors are solar radiation, atmospheric circulation and topography. It should be noted that while designing high-rise buildings some special data should be taken into consideration. The values of outdoor temperature and outdoor barometric pressure are used in the calculations. These values are taken not only on the ground level, their changes height along are taken into account as well.

III. RESULTS AND DISCUSSION

In order to consider different climatic conditions the following high-rise buildings in equatorial, tropical, sub-tropical and temperate zones were taken for analyzing. While designing these unique buildings the experimental component was of great importance. At the experimental level they searched for the shape of buildings, the type of the whole building envelope and its elements, selection of building and finishing materials, etc. The analytical survey of the results obtained through introducing the principles of bioclimatic architecture is presented.

A. Experiments in designing façade systems of high-rise buildings under the conditions of equatorial climate.

Equatorial climate is characterized by very little temperature and humidity changes throughout the year. Average annual temperature ranges from +25° C to +31° C. So it is always wet and hot, annual rainfall is about 2300 mm. The concept of “a tropical skyscraper” in Singapore was created in such climatic conditions. The efforts of architects and engineers were focused on searching for the ways of using natural ventilation, double skin facades for protecting buildings from overheating by vertical landscaping as well. Systems for collecting rainwater are introduced, etc.

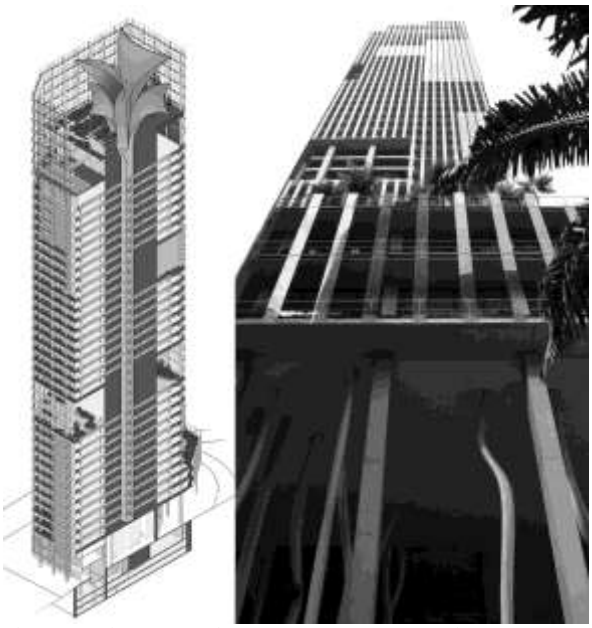

Fig. 1. «CapitaGreen», Singapore, Toyo Ito & Associates [13].

The skyscraper **"CapitaGreen"** (242 m, 40 floors, completed in 2014) has a unique double skin façade system made from low-e glass, consisting of three main elements: 1-fragment monolithic frameless glazing of outer layer; 2- glazing unit of inner layer; 3-vegetation integrated in the interlayer space covers 55% of the façade (Fig. 1). The double skin façade is equipped with a wind scoop. It is an unusual element of the building's HVAC system made in the form of giant petals on top of the tower that reaches the height of 245 m. At this height wind speed is higher while air temperature is lower. The wind scoop captures the wind flows and guides them into the cool void, located in the core of the building. It runs through all floors and delivers cool and fresh air there. The expected annual energy saving is 4563420 kWh [13].

The hotel “Oasia Downtown” (206.6 m, 27 floors, completed in 2016) is another unique "green" skyscraper in Singapore. The basis of the bioclimatic concept is green façade that turns the high-rise building into an oasis, a tropical “living tower” in the dense urban environment. The task of constructing a great number of open end-to-end spaces in the form of green terraces in the tower was solved. For this purpose a non-standard construction system was developed. The system includes four stiffening cores located at the corners instead of one central core. This solution is directed not only at achieving visual transmission, but provides excellent natural cross ventilation. Thus, all public open spaces are provided with comfortable conditions, optimal microclimate, natural lightning and fresh air. As in the previous example the building envelope represents an unusual double skin façade. The outer layer is a red aluminum mesh. Tropical plants sprout through it (Fig. 2).


Fig.2. «Oasia Downtown», Singapore, WOHA Architects.

B. Experiments in designing façade systems of high-rise buildings under the conditions of tropical desert climate

In the United Arab Emirates high-rise construction is developed under the conditions of very hot and dry climate that can be called tropical desert climate. This kind of climate has the following characteristics: sand storms; the average summer temperature in the shade is from +40 to +50° c; daytime winter temperature is from +20 to +23°C; it is cooler at night; rainfall is irregular, annual rainfall is about 100 mm. The environmental strategy is to minimize the negative climatic effects of high temperature on the building by reducing greatly the use of air conditioners for creating comfortable conditions inside the building.

"The Index" (326 m, 80 floors, completed in 2011) is one of the first bioclimatic skyscrapers in the Middle East (Fig. 3a). The structure has four powerful A-concrete frames that in addition to bearing functions form the selfshading plastic of the façade. The basis of the unique system of air-conditioning is the position of the skyscraper exactly to east-west. The east and the west facades are exposed to low and deeply penetrating rays of the morning and afternoon sun. Therefore, in the office block staircase and elevator units are located on the east and west facades blocking the sunlight. The residential block in the west and in the east is protected by impressive bulging concrete pylons that create a shading effect, preventing overheating of the premises. The southern glass façade of the office block is protected from the noon sun rays that have low penetrating power by fixed sunshade shelters with a large console eave. Deep loggias are added on the southern façade in the residential part of the building. Orientation, planning structure and plastic of the tower façade is performed so that the temperature does not exceed 28°C in the premises at the height of summer without any air conditioners.

The high-rise complex **"Sowwah Square"** in Abu Dhabi (131, 155 m; 31, 37 floors, completed in 2012) can be taken as an example of designing building envelopes as a combined system. The facades represent the integration of three technologies: ventilated double skin façade, passive shading and active shading. Active shading is presented by movable shutters, reacting to the sunlight intensity. Thanks to these efforts, the average temperature in the air gap of the double skin façade does not exceed +32°C while temperature outside reaches +46°C. The calculations showed that the double skin façade in **"Sowwah Square»** saves kWh/7200 of electric power a day and provides more comfortable temperature environment close to the wall perimeter [14] (Fig. 3b).

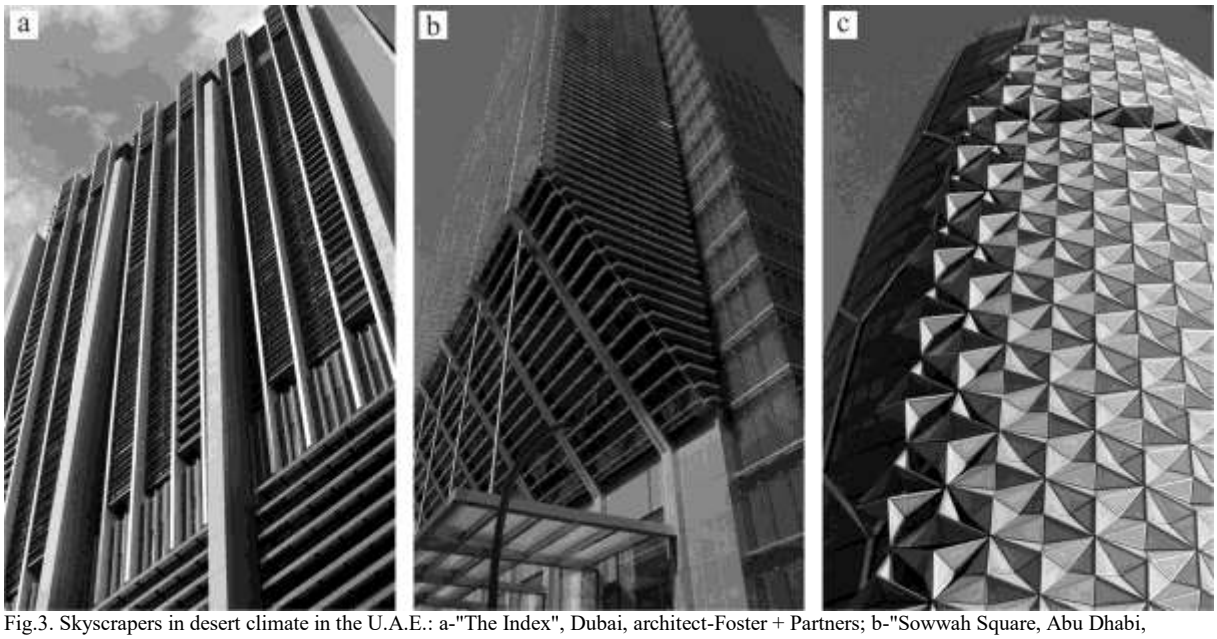

Fig.3. Skyscrapers in desert climate in the U.A.E.: a-"The Index", Dubai, architect-Foster + Partners; b-"Sowwah Square, Abu Dhabi, architect-Goettsch Partners; c-Al Bahar Tower, Abu Dhabi, architect-Aedas UK.

In this climatic zone in bioclimatic buildings movable shutters are actively used to keep the sunlight out. A high-rise complex **"Al Bahar Tower"** (145 m, 29 floors, completed in 2012) in Abu Dhabi, consisting of two office towers is another example of the building designed to withstand aggressive hot climate with sand storms. A distinguishing feature of the towers is a responsive dynamic facade, built of triangular screens which are combined in arrays much like umbrellas. Each array opens and closes in direct reaction to the sun's position, allowing indirect sunlight to enter the building while blocking the strongest rays. Each tower has an innovative external shading shell located at the distance of two meters from the main façade and consisting of approximately 1000 "screen umbrellas" covered with fiberglass. The screens are operated by a smart control system. In the evening all the screens are open. The shape of the tower was optimized to improve the shading system. The innovative façade of the skyscraper allows reducing the intensity of solar radiation by 50% (Fig. 3c).

C. Experiments in designing the façade systems of high-rise buildings in subtropical climate

Nowadays China is the world leader in high-rise construction. China is located in different climatic zones from subequatorial to temperate. Shanghai, one of China's largest cities, has humid subtropical climate with monsoon features. The seasons are distinct -winter, spring, summer and autumn. The lowest temperature in winter is -10° C. It often snows. The average temperature in summer is + 32°C. Annual rainfall is 1149 mm.

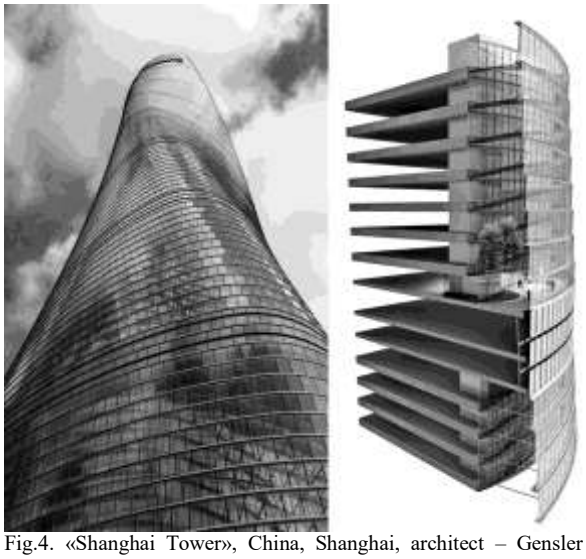
Fig.4. «Shanghai Tower», China, Shanghai, architect – Gensler (Photo: © Gensler via CTBUH)

"Shanghai Tower" (632 m, 121 floors, completed in 2015) is one of the most advanced high-rise buildings in the world (Fig.4). The concept of environmental sustainability and energy efficiency of the tower is based on the integrated approach and meets the requirements of "green" standards. The greening degree of this megatall building is estimated at 33%. Numerous innovations concerning constructive, space-planning and engineering characteristics were introduced. To reduce wind loads the tower is twisted in a spiral, making a turn of 120°. Wind turbines with vertical axis of rotation located in the top of the tower can generate up to 350000 kWh of extra electrical power annually. Geothermal energy is used. At that the key element of the bio-climatic concept that allows reducing the need for heating and air conditioning is an innovative transparent double skin façade. The envelope structure consists of two

independent glass layers. The outer layer determines the curved shape of the design while the inner layer has the correct round shape. The space between the layers forms ventilated landscaped atriums that improve air quality, create visual links between the city and the tower's interior. The atriums represent multi-functional public spaces- the "urban areas" for this vertical city. Energy-saving low-e glass is used. The issue of sunlight reflection on neighboring buildings by curved glass facades was carefully considered. This kind of façade reflects much less light than the smooth one [15].

D. Experiments in designing façade systems of high-rise buildings in temperate continental climate

The construction of high-rise buildings in temperate continental climate has some peculiar features as this kind of climate is characterized by hot summers and frosty winters. The temperature fluctuation during the year is from -35°C to +34°C. A striking example of a responsible environmental approach and reasonable use of combined air-conditioning system is an office building "Manitoba Hydro Place" (114.9 m; 22 floors; completed in 2008), located in the center of Winnipeg in Canada. The introduction of double skin façade technology refutes the skepticism referring to its efficiency under such climatic conditions.

The key innovative solution is a double envelope of the building. The inner layer with single glazing is separated from the glazed unit of the outer layer by a buffer zone of one meter width. In winter, when the façade is sealed, it acts as a solar collector. Without using active heating the temperature in the space between the facades reaches +20°C even if the temperature outdoors is below -25°C. "Solar ventilation" is used for effective air circulation in the system of natural ventilation of the building. Solar chimney is introduced in the building. It represents a shaft of 115 m height (Fig.5). The exhaust air is removed from the building through this "solar vent" through solar radiation heating. Heating and cooling system is based on using the geothermal heat of the earth. Three atrium recreation zones of 24m height are constructed in the building. They are a part of the natural ventilation system. The atriums have artificial "waterfalls" that regulate the humidity indoors. A systemic design approach to this object makes it possible to minimize and even abandon the use of air conditioning systems and save 70% of energy in comparison with a typical large office tower [16, 17].

Fig.5. «Manitoba Hydro Place», Canada, Winnipeg, Kuwabara Payne McKenna Blumberg Architects.

IV. CONCLUSION

1. The basis of designing a new generation of innovative modern high-rise buildings is a system analysis of climatic factors that link the town-planning, space-planning, construction, engineering and technological solutions into a single urban concept.
2. Despite comprehensive design solution and the combination of climatic elements the envelop façade system acts as a key element of climate adaptation and energy saving in bioclimatic high-rise buildings.
3. The most promising trend is the use of multilayer ventilated facade systems, i.e. double skin facades adapted to different climatic conditions.
4. Experiments on adapting double skin façades to the climatic conditions are conducted in the following areas: 1-selecting the type of outer and inner layers (single glazing, glazed unit, fragment glazing, perforation, dynamic structure, etc.); 2-introduction of passive shading in the building envelopes or in the space between them, active shading, landscaping, etc.; 3-the introduction of a unique system for natural ventilation, for example, a wind scoop or a solar chimney acting along with the double skin façade.
5. Huge power consumption of traditional skyscrapers makes architects and engineers search for new constructive systems, technologies and building materials. Being unique the objects described in this study are not single innovative projects. They represent the new typology of high-rise buildings for sustainable development of urban environment being formed on the compact, adaptive, energy efficient and ecological principles. .

REFERENCES

[1] Generalov V.P., Generalova E.M. Sustainable architecture. Energy efficiency and sustainability of affordable housing on the example of Hong Kong. Urban Construction and Architecture, 4 (21), 2015, pp.32-38.

[2] Zhigulina A.Y. Foreign and home experience in designing energy efficient residential houses. Urban Construction and Architecture, 1, 2011, pp. 29-30.

[3] Vavilova T. A. The principle of environmental compliance as the condition for the development of high technologies, Scientific Journal of the Volga Region, 2, 2010, pp. 110-116.

[4] Generalova E.M., Generalov V.P., Kuznetsova A.A. Modular buildings in modern construction. Procedia Engineering, V. 153, 2016, pp. 167-172.

[5] Generalova E., Generalov V., Potienko N. Affordable housing under shaping dense vertical urbanism. Proceedings of the CTBUH 2016 International Conference; Shenzhen, Guangzhou, Hong Kong, China 16-20 October 2016. Volume I, 2016, pp. 650-659.

[6] Balzannikov M.I., Sosina T.N., Chumachenko N.G. Cluster «Ecoindustry»: the analyses of basic parameters, Environment for us and future generations: Works of XII International Conference, SSUACE, Samara, 2007, pp. 99-102.

[7] Generalov V.P., Generalova E.M. Revealing the special features of the concepts «comfortable living» and «comfortable living environment». Urban Construction and Architecture, 2(23), 2016, pp. 85-90.

[8] Holdsworth B. Ecological high-rise: Solar architects of the 21st century: Dr. Ken Yeang Refocus, Volume 6, Issue 1, 2005, pp. 58–60.

[9] Lotfabadi P. High-rise buildings and environmental factors. Renewable and Sustainable Energy Reviews, V.38, 2014, pp. 285–295.

[10] Wood A. Rethinking the Skyscraper in the Ecological Age: Design Principles for a New High-Rise Vernacular. Proceedings of the CTBUH 2014 Shanghai Conference «Future Cities: Towards Sustainable Vertical Urbanism». Shanghai, China. 16th-19th September 2014, pp. 26-38.

[11] Lotfabadi P., Alibaba H.Z., Arfaei A. Sustainability; as a combination of parametric patterns and bionic strategies. Renewable and Sustainable Energy Reviews, V.57, 2016, pp. 1337–1346.

[12] Broduch M.M., Engineering equipment of high-rise buildings. Under editorial of M.M. Broduch, M, AVOK-PRESS, 2007, 320 p.

[13] Capita Green. Green Features. [Online]. Available: http://capitagreensingapore.com/green-features/ [Accessed: Jan. 9, 2016].

[14] Sowwah Square, Abu Dhabi. [Online]. Available: http://www.ctbuh.org/TallBuildings/FeaturedTallBuildings/FeaturedTallBuildingArchive2013/SowwahSquareAbuDhabi/tabid/6065/language/en-US/Default.aspx [Accessed: Jan. 9, 2016].

[15] Shanghai Tower Façade Design Process. [Online]. Available: http://www.gensler.com/uploads/documents/Shanghai_Tower_Facade_Design_Process_11_10_2011.pdf [Accessed: Jan. 9, 2016].

[16] Kuwabara B., Auer T., Akerstream T., Clim G. And others. The conquest of climate. [Online]. Available: http://zvt.abok.ru/upload/pdf_articles/7.pdf [Accessed: Jan. 9, 2016].

[17] Brodach M.M., Shilkin N.V., Double glass facades. [Online]. Available: http://zvt.abok.ru/upload/pdf_articles/201.pdf [Accessed: Jan. 9, 2016].

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Modelling of Urban Traffic Flow

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Abstract. In this paper non-deterministic motion of urban traffic is studied under certain assumptions. Based on those assumptions discrete and continuous mathematical models are developed: continuous model is written as the Cauchy initial-value problem for the integro-differential equation, whence among other things it is obtained the Fokker-Planck equation. Besides, the sufficient condition ensuring the mathematical legitimacy of the developed continuous model is formulated.

Keywords: traffic flow, mathematical model, Cauchy initial-value problem.

I. INTRODUCTION

The main classical question of the traffic flows theory, which is of essential interest also to the contemporary applied sphere of urban traffic management, is to study the existing relationship between the basic physical characteristics of the traffic flow – density, flux and velocity ([1]). The question of exact and unambiguous determination of the main physical characteristics of a traffic flow, in particular, of traffic flow density, is considered to be the most significant question. For this purpose, as a rule, various mathematical models (for instance, see [1]-[9] and respective references given in these), describing the behavior of traffic flow under various conditions are used. The unequivocal finding of the traffic flow density in a desired point of given area at any point in time will allow to exercise more effective and resource-saving management of traffic flows ([10]). In addition, the unambiguous finding of the traffic flow density in the studied areas of the urban transport system will allow changing the controlled parameters of the transport system in such way, so that the vehicles distribution both in the scale of individual road sections, in the scale of certain residential districts as well as in the whole city scale would become admissible, i.e. traffic flows density in the "bottlenecks" road sections during the rush hours were staying within admissible limits, the excess of which leads to various negative consequences, for example, such as formation of traffic jams. One of the greatest difficulties encountered in mathematical modeling of traffic flow, is that the behavior of vehicles on the one hand, must be subject to the restrictions and requirements of the traffic regulations, and on the other hand, is determined by aspiration to achieve the individual goals of the drivers in the general traffic flow. Therefore, in the model there should be introduced additional assumptions, which are allowing not to consider an individual contribution of each possible factor that may affect the dynamics of changes in road conditions, but do not result in distortion of the resulting system behavior as a whole. For this reason, the concept of an equilibrium condition of transport system ([10]) is introduced while constructing mathematical model of the non-deterministic motion of traffic flow. Traffic tends to return to the equilibrium state in the event of possible local deviations. The equilibrium state of the transport system requires that the average flow rate (traffic velocity) at each time point corresponds to its equilibrium value at a given density of vehicles. The specified requirement stated as assumption considerably narrows a scope of application of mathematical models, being limited to consideration of traffic flow only at road sections without crossings, etc. The fundamental work [1] describes in details the main properties of traffic flow (uncertainty, finiteness, dependence of the distance on time and so forth), which ignoring, does not allow to consider the constructed mathematical models as rigorous and real enough that they could be taken as full-fledged traffic models.

This paper considers a non-deterministic motion of urban traffic flow on the assumption that the vehicle can move both forward and backward. At every fixed period of time there are no limitations imposed on vehicles motion within traffic flow, i.e. there are no restrictions imposed that a change of the current location of any vehicle can be carried out only at the adjacent position: such a restriction, as shown in [10], means the traffic flow with preference, and it

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leads to linear mathematical models (both discrete and continuous). In this paper, we give up the above-mentioned restriction, which means the following: at every fixed period of time vehicles in traffic flow can replace any of the current locations to any other with a given probability, where the motion to free neighboring location represents just one of the possible particular cases. Such non-deterministic traffic flow will be called traffic "without preference". From a mathematical point of view, the assumption of traffic flow "without preference" is equivalent to the following four assumptions:

- at each moment of time $t = 0,\ \Delta t,\ 2\cdot\Delta t,\ 3\cdot\Delta t,\ldots$ any of the vehicles may have one of the arbitrary coordinates $0,\ \pm\Delta x,\ \pm 2\cdot\Delta x,\ \pm 3\cdot\Delta x,\ldots$;
- if some vehicle at the time moment $n\cdot\Delta t\ \left(n\in\mathbb{Z}_+\right)$ has a coordinate $i\cdot\Delta x\ \left(i\in\mathbb{Z}\right)$, then at the subsequent time moment $\left(n+1\right)\cdot\Delta t$ the same vehicle can be at any (but not only at adjacent with $i\cdot\Delta x$ coordinate $\left(i-1\right)\cdot\Delta x$ or neighboring $\left(i+1\right)\cdot\Delta x$) of these coordinates with probability $p_{n;i,j}\overset{def}{\equiv} p\left(n;i,j\right)$;
- for each vehicle in the traffic flow the probability $p_{n;i,j}$ that the vehicle, which had at the time moment $n\cdot\Delta t\ \left(n\in\mathbb{Z}_+\right)$ coordinate $i\cdot\Delta x\ \left(i\in\mathbb{Z}\right)$, would be at the coordinate $j\cdot\Delta x\ \left(j\in\mathbb{Z}\right)$ at the next time moment $\left(n+1\right)\cdot\Delta t\ \left(n\in\mathbb{Z}_+\right)$, has a Markov character, i.e., $p_{n;i,j}$ is subject to Markov process: which means that for each vehicle in a traffic flow these probabilities $p_{n;i,j}\ \left(n\in\mathbb{Z}_+;\ i,j\in\mathbb{Z}\right)$ do not depend neither on the state of transport system in the previous time moments, nor on behavior of other vehicles in the same traffic flow;
- the studied traffic flow is assumed uniform (or nearly uniform), and physical properties of the traffic flow – density, intensity and velocity are supposed to be not dependent on the direction of vehicles motion in the transport system.

As it will be shown in the following sections, the above listed four assumptions allow to construct a discrete model, and then, using the principles of continuum mechanics, proceed to the continuous mathematical model for the unknown traffic density.

II. MODELLING OF THE NON-DETERMINISTIC MOTION OF TRAFFIC FLOW "WITHOUT PREFERENCE"

The first of the four assumptions outlined in the introduction of this work, along with another assumption (see [10]) that if any vehicle in time moment $n\cdot\Delta t$ has a coordinate $i\cdot\Delta x$, in the subsequent moment of time $\left(n+1\right)\cdot\Delta t$ the same vehicle may have a coordinate $\left(i-1\right)\cdot\Delta x$ or $\left(i+1\right)\cdot\Delta x$, wherein the probability of finding vehicle in these two points are equal, i.e. $P\left\{x=\left(i-1\right)\cdot\Delta x\right\}=P\left\{x=\left(i+1\right)\cdot\Delta x\right\}=\frac{1}{2}$, that leads to the discrete linear model

$$U\left(m,n+1\right)\approx\frac{U\left(m-1,n\right)+U\left(m+1,n\right)}{2},\qquad(1)$$

where function $U\left(m,n\right)\ \left(n\in\mathbb{Z}_+;\ m\in\mathbb{Z}\right)$ means the number of vehicles at time moment $n\cdot\Delta t$ at the point having coordinate $m\cdot\Delta x$. For a given value of the initial distribution of vehicles $U\left(m,0\right)$ in the traffic flow, the discrete linear model (1) makes it possible to find approximately the required distribution of vehicles in traffic at all subsequent moments of time. Furthermore, from (1) follows the property that specifies the nature of vehicles distribution changes with time: when the number of vehicles at any point becomes smaller than the arithmetic mean values at neighboring points, then this number increases, and vice versa (in [10] this property has been called the traffic flow restoration property). Thus, the first of the four assumptions mentioned in the introduction of this work generates a linearity property: by adding the initial distributions of vehicles in traffic flow, their distributions at any subsequent time are added as well. Looking ahead, let us note that the latter assumption (i.e., the fourth assumption) will not be active during the construction of the mathematical model, however, this assumption would be essential during the study of already constructed mathematical model, namely, during the proof that constructed mathematical model carries catholicity property in some sense (see the next section). The second and third assumptions, as it will be shown below, radically change the basis of the traffic flow probabilistic process ([10]), which supports the construction of a mathematical model (1). Indeed, first of all, let us note that in view of the fact that in the traffic flow vehicle has to appear somewhere, it could be written

$$\sum_{j\in\mathbb{Z}}p_{n;i,j}\equiv 1\ \forall\left(n\in\mathbb{Z}_+,\ i\in\mathbb{Z}\right).\qquad(2)$$

However, by analogy with the identity (15) it could not be stated that $\sum_{i\in\mathbb{Z}}p_{n;i,j}=1$, because the value $\sum_{i\in\mathbb{Z}}p_{n;i,j}$ may have a value greater than one, if the

point $j\cdot\Delta x\ (j\in\mathbb{Z})$ of the considered section of a one-dimensional road $[-l,+l]$ having a length $2\cdot l$ is preferable for the driver; and this sum can be less than one in case when the point $j\cdot\Delta x\ (j\in\mathbb{Z})$ is something not preferable for the driver. Within the time interval $[n\cdot\Delta t, n\cdot\Delta t+\Delta t]\ (n\in\mathbb{Z}_+)$ the number of vehicles moving from the point $m_1\cdot\Delta x\ (m_1\in\mathbb{Z})$ of the studied one-dimensional road segment having $2\cdot l$ length to any other point $m_2\cdot\Delta x$ $(m_2\in\mathbb{Z};\ m_2\neq m_1)$ in this section, is equal to $U(m_1,n)\cdot p_{n;m_1,m_2}$. Within the same time interval in the opposite direction, i.e. from point $m_2\cdot\Delta x$ $(m_2\in\mathbb{Z})$ to point $m_1\cdot\Delta x\ (m_1\in\mathbb{Z};\ m_1\neq m_2)$, it is moving $U(m_2,n)\cdot p_{n;m_2,m_1}$ number of vehicles.

Hence, it is possible to write down "vehicle balance" using the following recurrence relation:

$$U(m_1,n+1)\approx U(m_1,n)-U(m_1,n)\cdot\sum_{\substack{m_2\in\mathbb{Z}\\ m_2\neq m_1}}p_{n;m_1,m_2}+$$

$$\sum_{\substack{m_2\in\mathbb{Z}\\ m_2\neq m_1}}\left\{U(m_2,n)\cdot p_{n;m_2,m_1}\right\}=\sum_{m_2\in\mathbb{Z}}\left\{U(m_2,n)\cdot p_{n;m_2,m_1}\right\}. \quad (3)$$

Then,

$$U(m_1,n+1)\approx\sum_{m_2\in\mathbb{Z}}\left\{U(m_2,n)\cdot p_{n;m_2,m_1}\right\},\ \forall m_1\in\mathbb{Z}.$$

The meaning of this equation is obvious: any vehicle within the studied traffic flow at the time moment $(n+1)\cdot\Delta t\ (n\in\mathbb{Z}_+)$ must be coming from somewhere to the point having coordinates $m_1\cdot\Delta x\ (m_1\in\mathbb{Z})$. From (3) it is obvious that the discrete model (1) is a special case of the discrete model (3). Indeed, for the $\forall m_1,m_2\in\mathbb{Z}$ in (3) assuming that

$$p_{n;m_2,m_1}=\begin{cases}\dfrac{1}{2},\ if\ |m_1-m_2|=1;\\ 0,\ if\ |m_1-m_2|\neq 1,\end{cases}$$

the recurrent formula (1) could be received.

Similarly, to how in work [10] when receiving continuous model

$$\frac{\partial\rho(x,t)}{\partial t}=\lim_{\substack{\Delta x\to 0\\ \Delta t\to 0}}\left(\frac{\Delta x}{\sqrt{2\cdot\Delta t}}\right)^2\cdot\frac{\partial^2\rho(x,t)}{\partial x^2} \quad (4)$$

limit transitions $\Delta x\to 0,\ \Delta t\to 0$ in discrete model (1) have been carried out, in this section in (3) there will be also carried out limit transitions $\Delta x\to 0,\ \Delta t\to 0$. In this connection it is essential to distinguish between two possible scenarios:

(A) If the average "jump" of each vehicle in the studied traffic flow at a single time step also tends to zero at $\Delta x\to 0,\ \Delta t\to 0,$ then the limit transitions $\Delta x\to 0,\ \Delta t\to 0$ in the discrete model (3) will lead again to a differential equation with respect to the required density $\rho(x,t)$ of the traffic flow, and in this equation there will be "bound "only those vehicles of the flow, which form a kind of continuum, where vehicles do not interact directly, but are "infinitely close" to each other. For example, if a discrete function $p_{n;i,j}$ is independent of $n\in\mathbb{Z}_+$ and has the form $p_{i,j}=p(i-j)\ (i,j\in\mathbb{Z}),$ then the average "jump" of each vehicle in the considered traffic flow for a single time step tends to zero;

(B) If the average "jump" of each vehicle at a single time step does not have to tend to zero at $\Delta x\to 0,\ \Delta t\to 0,$ then the limit transition $\Delta x\to 0,\ \Delta t\to 0$ in the discrete model (3) will lead to the integral (resulting) ratio with respect to the required density $\rho(x,t)$ of the traffic flow, i.e., in this case at $\Delta x\to 0,\ \Delta t\to 0$, sums will turn to integrals, but not into partial derivatives.

We will not dwell on the scenario (A), and examine the scenario (B). However, after the study of scenario (B), we will return to the scenario (A) in two different ways, namely, in the results obtained for the scenario (B) we will assume at once that the scenario (A) takes place.

So, let the scenario (B) takes place. Let us rewrite the discrete model (3) as follows:

$$U(m_1,n+1)-U(m_1,n)\approx$$

$$\sum_{\substack{m_2\in\mathbb{Z}\\ m_2\neq m_1}}\left\{U(m_2,n)\cdot p_{n;m_2,m_1}\right\}-U(m_1,n)\cdot\sum_{\substack{m_2\in\mathbb{Z}\\ m_2\neq m_1}}p_{n;m_1,m_2}.$$

Having divided this equation by $\Delta t,$ and then introducing designations

$$x=\lim_{\substack{\Delta x\to 0\\ m_1\to\pm\infty}}m_1\cdot\Delta x;\ y=\lim_{\substack{\Delta x\to 0\\ m_2\to\pm\infty}}m_2\cdot\Delta x;\ t=\lim_{\substack{\Delta t\to 0\\ n\to\pm\infty}}n\cdot\Delta t;$$

$$\rho(x,t)=\frac{m_{\text{weight}}}{\Delta x}\cdot U(m,n),$$

we obtain the following integro-differential equation for the required density $\rho(x,t)$ of the traffic flow:

$$\frac{\partial\rho(x,t)}{\partial t}=\int_{-l}^{+l}K(t;y,x)\cdot\rho(y,t)\,dy-$$

$$\rho(x,t)\cdot\int_{-l}^{+l}K(t;x,y)\,dy;\ x\in(-l,+l),\ t\in(0,T], \quad (5)$$

where the kernel $K(t;z_1,z_2)\geq 0,\quad t\in[0,T],$ $z_i\in[-l,+l]\ (i=1,2)$ of integro-differential equation (5) is interpreted as follows: the probability that the vehicle in the traffic flow, which at the time moment $t\in[0,T]$ was at the point $z_1\in[-l,+l]$ of a road section, during the next time moment $t+\Delta t$ will appear in the interval $[z_2,z_2+dz_2]\subset[-l,+l]$

$(z_1 \neq z_2)$, will be equal to the value $K(t;z_1,z_2)dz_2dt$. In other words, the kernel $K(t;z_1,z_2)$ is defined as a vehicles "jump" probability density in a traffic flow from the point $z_1 \in [-l,+l]$ to the point $z_2 \in [-l,+l]$ $(z_1 \neq z_2)$ in a time moment $t \in [0,T]$. In other words, the function $K(t;z_1,z_2)$ is the relative velocity of such a "jump" of vehicles in the traffic flow at time moment forms out 1D mathematical model of the non-deterministic motion "without preference" of a traffic flow, where the required function $\rho(x,t)$ is a density of a traffic flow.

III. INVESTIGATION OF THE CONSTRUCTED MODEL (5), (6)

Let us recall that the mathematical model (5), (6) has been obtained only under the assumption that scenario (B) takes place. Therefore, it is interesting to find out the "automatic" presence (or absence) of the scenario (A) in the mathematical model. In fact, this aspiration means that we would like to find out the catholicity of a mathematical model (5), (6) among the similar traffic flow model classes aimed at finding of the traffic flow density characteristic. It is obvious Then for $\forall y \in [-l,+l]$ we can write the identity

$$\int_{-l}^{+l}\left\{K(t;y,x)-\delta(x-y)\cdot\int_{-l}^{+l}K(t;x,\xi)\,d\xi\right\}dx \equiv 0. \quad (7)$$

By denoting

$$\tilde{K}(t;y,x) \overset{def}{\equiv} K(t;y,x)-\delta(x-y)\cdot\int_{-l}^{+l}K(t;x,\xi)\,d\xi$$

let us take into account identity (7) in equation (5):

$$\frac{\partial\rho(x,t)}{\partial t}=\int_{-l}^{+l}\tilde{K}(t;y,x)\cdot\rho(y,t)\,dy. \quad (8)$$

It is obvious that the equations (5) and (8) are equivalent and, therefore, the model (8), (6) is also a 1D mathematical model of the traffic flow non-deterministic motion "without preference" in respect to required density and it is constructed in the assumption that the scenario (B) takes place. Now in (8) we will assume that the scenario (A) takes place. Then at any fixed x and t values the kernel $\tilde{K}(t;y,x)$ of the equation (8) as function of one argument y is different from zero only in the small vicinity of a point $x = x_0 \in [-l,+l], t = t_0 \in [0,T]$

$$\tilde{K}(t_0;y,x_0)=\begin{cases}\overline{K}(y)\not\equiv 0,\ y\in B(\varepsilon;x_0),\\ 0,\ y\notin B(\varepsilon;x_0),\end{cases} \quad (9)$$

where $B(\varepsilon;x_0) \overset{def}{\equiv} \{x:\forall\varepsilon>0\ |x-x_0|<\varepsilon\}$ denotes the small vicinity of a point x_0. Hence, the scenario (A) suggests that in (8) the main contribution to the t. It is important to note that in (5) (hereinafter and throughout this paper), the value T may be equal to infinity, and consequently, in this case, instead of the interval $[0,T]$ and the half interval $(0,T]$ it is necessary to take $(0,\infty]$ and $(0,\infty)$, respectively.

Thus, integro-differential equation (5), together with the initial condition

$$\rho(x,t)\big|_{t=0}=\rho_0(x),\ x\in[-l,+l] \quad (6)$$

that if the model (5), (6) will appear to be more general, than, for example, the continuous model (4) describing the traffic motion "with equiprobable preference", then there comes out a question of finding sufficient conditions under which transition from the model (5), (6) to other models, in particular, to model (4) becomes possible. In this section these and other questions are studied.

In a well-known formula $f(y)=\int\delta(x-y)\cdot f(x)\,dx$, where $\delta(\bullet)$ is a delta Dirac's function, let us select as function $f(\bullet)$ the following function $f(\bullet)\equiv\int_{-l}^{+l}K(t;\bullet,\xi)\,d\xi$.

integral is carried out in $B(\varepsilon;x)$ by the variable y.

Let us expand the density function $\rho(y,t)$ in a Taylor series at the point x:

$$\rho(y,t)=\sum_{i=0}^{\infty}\frac{\partial^i\rho(x,t)}{\partial x^i}\cdot\frac{(y-x)^i}{i!}. \quad (10)$$

Substituting (10) into the right-hand side of the integro-differential equation (8) gives us the following integro-differential equation:

$$\frac{\partial\rho(x,t)}{\partial t}=\sum_{i=1}^{\infty}\frac{1}{(2\cdot i)!}\cdot\frac{\partial\rho^{2\cdot i}(x,t)}{\partial x^{2\cdot i}}\times \int_{-l}^{+l}K(t;|y-x|)\cdot(y-x)^{2\cdot i}\,dy, \quad (11)$$

where the record $K(t;|y-x|)=K(t;y,x)$ is legitimate by virtue of the fourth assumption from the introduction section (assumption of independence of density of the uniform traffic flow on the direction of vehicles motion). From the obtained equation (11), it is now easy to derive the 1D mathematical model (4). Indeed, from (11) follows:

$$\frac{\partial\rho(x,t)}{\partial t}=\frac{1}{2}\cdot\frac{\partial\rho^2(x,t)}{\partial x^2}\cdot\int_{-l}^{+l}K(t;|y-x|)\cdot(y-x)^2\,dy+$$

$$\sum_{i=2}^{\infty}\frac{1}{(2\cdot i)!}\cdot\frac{\partial\rho^{2\cdot i}(x,t)}{\partial x^{2\cdot i}}\cdot\int_{-l}^{+l}K(t;|y-x|)\cdot(y-x)^{2\cdot i}\,dy=$$

$$\frac{1}{2}\cdot\frac{\partial\rho^2(x,t)}{\partial x^2}\cdot\int_{-l}^{+l}K(t;|z|)\cdot z^2dz+o\left((y-x)^3\right)=$$

$$a^2(t)\cdot\frac{\partial\rho^2(x,t)}{\partial x^2}+o\left((y-x)^3\right),$$

where

$$a^2(t)\overset{def}{\equiv}\int_0^{+l}K(t;z)\cdot z^2dz>0. \qquad (12)$$

It is obvious that having the assumption (9), we can neglect the terms of higher order of smallness $o\left((y-x)^3\right)$, and then we receive the Fokker–Planck equation (for instance, see [13]) $\frac{\partial\rho(x,t)}{\partial t}=a^2(t)\cdot\frac{\partial^2\rho(x,t)}{\partial x^2}$. It is obvious that the discrete model (4) is a special case of the Fokker-Planck equation: $a^2=\lim\limits_{\substack{\Delta x\to 0\\ \Delta t\to 0}}\left(\frac{\Delta x}{\sqrt{2\cdot\Delta t}}\right)^2=\frac{h^2}{2\cdot\tau}>0.$

It is important to highlight that the method by which model (4) was obtained from equation (11) allows other continuous 1D models to be obtained from the same equation (11) (for instance, see [2], [3], [11], [12] and appropriate references given in these). In this sense the equation (11) is the general equation (naturally, within similar/comparable classes of models) for determination of required density of a traffic flow. It should be noted that the designation (12) is a purely formal designation, since we have not clarified the question of the convergence of the integral on the right-hand side of this notation. Let us study this question. In order to do this, let us first note that equation (5) (or (8)) implies straight only convergence of the integral $\int_0^{+l}K(t;z)\,dz$, and based on that we do not have the right to assert the convergence of the integral $\int_0^{+l}K(t;z)\cdot z^2dz.$ Therefore, there arises a question of the decrease rate of a kernel $K(t;z)$ with a growth of z for each fixed parameter $t=t_0\in(0,T]$. In other words, it is necessary to find a condition under which influence of a kernel $K(t=t_0;z)$ would be concentrated in the small vicinity of zero. To find this required condition, we note that on the right-hand side of equation (11) for each value $i=2,3,\ldots$ ignoring the term

$$\frac{1}{(2\cdot i)!}\cdot\frac{\partial\rho^{2\cdot i}(x,t)}{\partial x^{2\cdot i}}\cdot\int_{-l}^{+l}K\left(t;|y-x|\right)\cdot(y-x)^{2\cdot i}\,dy$$

is possible only in case if

$$2\cdot i\cdot\left|\frac{\partial\rho^{2\cdot(i-1)}(x,t)}{\partial x^{2\cdot(i-1)}}\right|\int_{-l}^{+l}K\left(t;|y-x|\right)(y-x)^{2\cdot(i-1)}\,dy\gg$$

$$\frac{1}{2\cdot i-1}\cdot\left|\frac{\partial\rho^{2\cdot i}(x,t)}{\partial x^{2\cdot i}}\right|\int_{-l}^{+l}K\left(t;|y-x|\right)(y-x)^{2\cdot i}\,dy.$$

Hence, for the legitimacy of the designation (12) (in other words, for the legitimacy of equation (4)) it is sufficient that for $\forall x\in[-l,+l]$ and $\forall t\in(0,T]$ the relation would be fulfilled

$$\left|\frac{\partial\rho^2(x,t)}{\partial x^2}\right|\cdot\int_0^{+l}K(t;z)\,z^2dz\gg$$

$$\frac{1}{12}\cdot\left|\frac{\partial\rho^4(x,t)}{\partial x^4}\right|\cdot\int_0^{+l}K(t;z)\,z^4dz. \qquad (13)$$

Since in the resulting relation (13) there appears a functions $\left|\frac{\partial\rho^i(x,t)}{\partial x^i}\right|(i=2,4)$, this relation is of little use from the practical point of view: in explicit problems it is not possible to verify the fulfilment of condition (13) because of the unknown function $\rho(x,t)$. However, in many cases it is easy to measure the averaged range of density variation of a homogeneous traffic flow and, using this characteristic of the studied transport system, from relation (13) it is easy to establish from a practical point of view a sufficient condition for a transition from a complex model (11) to a relatively simple model (4). Indeed, taking the value Δx as the averaged interval of the vehicle "jump" in the traffic flow and taking $\Delta\rho$ as the averaged density changes range of the homogeneous traffic flow on given "jump" interval Δx we can assume that the functions $\left|\frac{\partial\rho^i(x,t)}{\partial x^i}\right|(i=2,4)$ have orders $\frac{\Delta\rho}{(\Delta x)^i}$. Therefore, instead of relation (13), we can write down a new relation

$$12\cdot(\Delta x)^2\cdot\int_0^{+l}K(t;z)\,z^2dz\gg\int_0^{+l}K(t;z)\,z^4dz. \qquad (14)$$

Despite the fact that the relations (13) and (14) seem to be similar, however, there are essential distinctions between them: first, the relation (13), unlike the relation (14), does not contain unknown functions, and, consequently, from the practical point of view, the condition (14) is much more preferable, since it could be easily verified; secondly, the relation (14) binds the kernel $K(t;y,x)$ in the non-local way to the averaged range of variation in the density of a homogeneous traffic flow, and from the relation (13) this could not be concluded, since functions $\left|\frac{\partial\rho^i(x,t)}{\partial x^i}\right|(i=2,4)$, being present in that are unknown, and hence, are not being subject to comparative analysis.

Finally, it should be noted that the found sufficient condition (14) also makes it possible to discover the following interesting property of

equation (11): even if the kernel $K\left(t;\left|y-x\right|\right)$ of the integro-differential equation (11) remains unchanged (see the probabilistic interpretation of the kernel, which has been made immediately after the derivation of the equation 5)) for two traffic flow problems, in one of which the value Δx (that is, the average interval of the vehicle "jump" in the traffic flow) is comparatively less than the corresponding value Δx in another problem, then the integro-differential equation (11) can lead to completely different models. As it has been already mentioned in the introduction, the main physical characteristics of the traffic flow are its density $\rho\left(x,t\right)$, traffic flux $q\left(x,t\right)$ and velocity $\vartheta\left(x,t\right)$. The obvious equality $q\left(x,t\right)=\vartheta\left(x,t\right)\cdot\rho\left(x,t\right)$ shows that, firstly, the flux of the traffic flow is in direct proportion to both traffic density and velocity: increase / decrease the traffic flux could be reached due to both increase / decrease in density, and due to increase / decrease the velocity of vehicles within the traffic flow; secondly, knowledge of traffic density and flux is sufficient to uniquely determine the velocity of the traffic flow. Therefore, at four assumptions listed in introduction the developed mathematical model (5), (6), (14) in respect to required density of a traffic flow doesn't allow to find other two characteristics of a traffic flow: at the same assumptions, it is necessary to develop mathematical model in respect to required traffic flux or in respect to required velocity of a traffic flow. In regards to the aforesaid, in conclusion of this section it is worth pointing out that at given four assumptions listed in introduction and assuming that scenario (B) takes place, authors of this work have succeeded to construct continuous model in respect to required traffic flux $q\left(x,t\right)$: as a result, it has been obtained again an integro-differential equation in respect to required traffic flux $q\left(x,t\right)$, but having more complex structure rather than the integro-differential equation (5). Unfortunately, the imposed restriction on the length of this article does not allow us to outline the course and result of the development process for this mathematical model.

IV. CONCLUSION

In this paper, non-deterministic motion of urban traffic flow is studied under the assumption that vehicles can move both forward and backward within a traffic flow, and at each fixed time interval vehicles in the flow can change any of the current locations to any other vacant space with predefined probabilities. Based on these assumptions, a discrete model is developed, and then, using the principles of continuum mechanics, a transition is made from the developed discrete model to a continuous model with respect to the required traffic flow density. The received continuous model has the form of the Cauchy initial-value problem for the integro-differential equation, from which, in particular, there follows the Fokker-Planck equation. Further, in this paper, a sufficient condition is found, which first, ensures the mathematical legitimacy of the developed continuous model, and, secondly, proves the catholicity of the developed mathematical model among the similar classes of traffic flow models used for determining the density of the traffic flow: it is proved that fulfilment of the found condition is sufficient to obtain (under the same assumptions) other models for finding the density of the traffic flow based on the developed continuous model.

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REFERENCES

[1] F. A. Haight, *Mathematical Theories of Traffic Flow*. New York, USA: Academic Press, 1963, xi+242 pp.

[2] D. Helbing, "Traffic and related self-driven many-particle systems", Reviews of Modern Physics, vol. 73, pp. 1067-1141, 2001.

[3] R. Mahnke, J. Kaupuzs, and I. Lubashevsky, "Probabilistic description of traffic flow", Physics Reports, vol. 408, pp. 1-130, 2005.

[4] N. H. Gartner, "Traffic Flow Theory", Transportation Research Board, Special Report 165, World Scientific Press, 1992, 365 pp.

[5] C. F. Daganzo, *Fundamentals of Transportation and Traffic Operations*. New York, USA: Pergamon Press, 1997, 356 pp.

[6] B. S. Kerner, "Three-Phase Traffic Theory and Highway Capacity", Physica A, vol. 333, pp. 379-440, 2004.

[7] K. Nagel, P. Wagner, and R. Woesler, "Still flowing: Approaches to traffic flow and traffic jam modeling", Journal of Operations Research, vol. 51, No. 5, pp. 681-710, 2003.

[8] C. F. Daganzo, "A Behavioral Theory of Multi-Lane Traffic Flow. Part I: Long Homogeneous Freeway Sections", Transportation Research, Part B: Methodological, vol. 36, No. 2, pp. 131-158, 2002.

[9] C. F. Daganzo, "A Behavioral Theory of Multi-Lane Traffic Flow Part II: Merges and the Onset of Congestion", Transportation Research, Part B: Methodological, vol. 36, No. 2, pp. 159-169, 2002.

[10] A. V. Berezhnoy, "Investigation of the traffic flow models managing parameters influence on the efficiency of the urban traffic control", Doctoral Thesis, Transport and Telecommunication Institute, Riga, Latvia, 2008, 256 pp.

[11] N. N. Smirnov, A. B. Kiselev, V. F. Nikitin, and M. V. Yumashev, Mathematical Theory of Traffic Flow. Moscow, Russian Federation: Lomonosov Moscow State University Press, 1999, 30 p.

[12] V. I. Shvetsov and D. Helbing, "Macroscopic dynamics of multilane traffic", Physical Reviews E., vol. 59, 1999, pp. 6328-6339.

[13] H. Risken and T. Frank, The Fokker-Planck Equation: Methods of Solution and Applications. Berlin, Germany: Springer-Verlag, 1989, xiv+472 p.

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Employers' Role in the Improvement of Safety Level in Estonian Enterprises

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Abstract. The key persons in safety activities at enterprises are: top manager, his(her) representatives, working environment specialist, all acting for the employer; and working environment representatives, selected by the workers and holding the workers' rights in safety and health area. The main possibilities to improve the safety level in the firm have the working environment specialists, as they are usually educated and supported by the employer and the law. The current paper is looking for the possibilities to raise the employers' interest for improvement of their knowledge in safety and through this also the safety level in the workplace. Safety level in 12 Estonian enterprises was investigated using MISHA method (based on standard OHSAS 18001). Some of the firms have implemented OHSAS 18001 or belong to the foreign companies. The investigated enterprises were from different industries and agriculture firms. The safety level is very much depended on the owner of the firm. The larger the enterprise is the better are the possibilities to educate the employers and employees. One of the ideas to improve the safety level at enterprise is the method "learning through the interviews". The interview is worked out basing on MISHA method. The latter is a tool of quantitative study. The safety performance key elements were divided into three parts: formal, real, combined ones. Three hypothesis were formulated and the area in which they are proved concerning employer's activities were as follows: H1) Standard OHSAS 18001 has an impact on Formal safety performance in companies (p value< 0.013) – if OHSAS 18001 has been implemented, then: the assignment of tasks and responsibilities in OHS is committed to the top management, the employer is revising the safety policy, and the personnel's responsibilities in OHS are clearly defined. H2) Standard OHSAS 18001 has an impact on Real safety performance. (p< 0.013) - if OHSAS 18001 is implemented, then: the top manager promotes dissemination of safety policy: the policy is made available to all of the personnel; resources for improvement are arranged by the top management; the top manager arranges meetings in OHS; there is a system for redesigning the workplaces for the persons who have difficulties in coping with the work. H3) Standard OHSAS 18001 has an impact on Combined safety performance (p< 0.007) - if OHSAS 18001 implemented, then: the top management is participating in the preparation of safety policy, top manager is reviewing the safety policy, is it operating effectively? He is informing the external bodies about the company's safety policy's effectiveness; the top manager arranges safety training for all of the personnel; there is a plan for reduction of accidents; it has been elaborated by the top manager; the company has a system for measuring the social climate in the company.

Keywords: employer's responsibilities in safety and health, occupational health and safety (OHS), safety and health management, safety in small and medium-sized enterprises, work environment.

I. INTRODUCTION AND THEORETICAL PART

The work environment is a large term and it occupies not only the physical work environment, but also the psychological and psychosocial elements that are depended on the people's character and attitudes. There are different key persons in the enterprise who have to take care of occupational health and safety (OHS): the employer, the working environment specialist (safety engineer) and working environment representatives. All these people have the possibility to improve the safety and health at workplaces. The roles of these key-actors in different countries are different [1], [2].

A safety management system in the standard OHSAS 18001 [3] is designed in order to deal with occupational health and safety (OHS) in a systematic way by the following activities: setting company's safety targets and objectives; designating roles and responsibilities for safety personnel; planning and performing the hazards mitigations; monitoring, measuring and improving the on-going system and its effectiveness [4]. Although the implementation of safety standards, particularly OHSAS 18001 usually declines the number of accidents and occupational diseases in the enterprises, it has not leaded to larger interest to use the OHS systems in some countries [5].

In the previous studies, the authors of the current paper have carried out the investigations in different workplaces [1], [2], [6], [7] and determined the nature of the *real*, *formal* and *combined* safety elements. The importance and possibilities to use the safety progress derived by the successful in OHS companies (e.g. enterprises which possess OHSAS 18001) for the companies without any systematic work in OHS was determined. The role of the workers' representation in OHS activities has been investigated [2]. The conclusion was: the position of safety representative has often a low status in the company; working

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environment specialists do not have enough time to fulfil their safety functions to keep employees safe. It was also postulated that the employers had limited understanding about the role of working environment representatives (WER). The WER are elected formally, there is no practical value of them. From this investigation arise the research questions of the current paper: how it is possible to enhance the interest of the employers towards safety matters and what role plays in this process OHSAS 18001 implementation? What are the main obstacles for the employers to show more interest against health and safety in managed by them companies?

There are different new models and methods for investigating the safety level at enterprises [8] - 10]. Gautam et al. [10] present a new scheme for measurement of safety performance in work systems using segmented point process models that can capture the points of changes in the working conditions as well as changes in safety activities. The findings of the case study application showed that the injury occurrences data fit the models for all accidents and first aid cases.

The risk assessment is one of the main areas, where the investigations are carried out and it is also very important and the basis for the development of safety and health improvements in the enterprises. Risk evaluation depends on the exposure limits established in the country [11] and also the international rules have to be followed [12]. In the study of Isik and Atasoylu [11], the main objectives were to determine the employer's awareness of the OHS law and to find out to what extent the employers fulfil their obligations to conduct risk assessments. This was possible through the interviews and written surveys of employers of small and medium-sized enterprises. One of the hypothesis in the paper [11] postulated that risk assessments are ineffective. The hypothesis was not approved: on the contrary, the risk assessment are always effective if reasonable limitations are settled.

New tool for risk assessment (RA) of psychological risks is presented recently. This area has been always the hardest area in RA. A novel approach is presented by Kyaw-Myint et al. [13] to identify critical exposure levels or health-based benchmarks of job control using the benchmark dose (BMD) method, which enables to determine the critical exposure levels for job control.

The current study is mainly dedicated to small and medium-sized enterprises, where there are fewer resources to improve the safety and health [14].

The OHS activities in the Nordic countries are organized [15], combining a top-down and bottom-up approach to the organization of OHS activities. The overall responsibilities rests with the employer, who seeks for the support both from the professional staff and from the participants in the OHS organization of the company.

The MISHA method [16] has four areas: A) organization and administration, B) participation, communication, and training; C) work environment, D) follow-up (accidents investigation etc.).

The safety key elements in MISHA method are divided into three parts: *formal* safety elements, like safety documents, content of the policy (R=0.895: the correlation between the safety activities and the implementation or non-implementation of OHSAS 18001), revising the safety policy (R=0.972), written safety policy (R=0.964), assignment of tasks and responsibilities (R=0.885).

The *real* safety elements include the top management's, line management's and supervisor safety knowledge, their commitment to the safety policy, communication, participation in workplace design etc. In this part of the key elements, OHSAS 18001 implementation influences on the resources (R=0.968), top management's commitment to the safety policy (R=0.964), and the dissemination of the safety policy (R=0.929).

In the part of *combined* safety, OHSAS 18001 has the strongest influence on the safety policy (R=0.888), workplace hazard analysis (R=0.737) and assessment of the work environment (R=0.805) [1].

Very often the enterprises implement integrated management system: ISO 9000, ISO 14000 and OHAS 18001 [17] are all taken into consideration.

II. MATERIAL AND METHODS

Twelve Estonian enterprises (Table 1) were examined with modified MISHA method [16] for clarifying the role of the employers in OHS matters as well as for studying the perspectives to improve the safety level of the enterprise through more effective employers' activities.

The enterprises were from the manufacturing industry (chemical, plastic, food and metal), construction, agriculture and transport. These enterprises agreed to carry out the MISHA-questionnaire-based investigation (the length of the questioning is over 2 hours).

Four (4) of the enterprises (group 1) had implemented OHSAS 18001, three (3) were belonging to the foreign corporations (group 2), in the last their own rules on safety were compulsory and implemented and five (5) enterprises represented the locally owned companies who had not implemented OHSAS 18001 (group 3, some of them even did not have knowledge about existing OHSAS 18001).

The qualitative study was carried out in these 12 companies in the form of interviews of employers (active managers, production managers). The interviewing of the employers gives the information about the present and possible role of the managers. The interviews were assessed by the first author of the paper. The interviews were taken as the basis for the quantitative study.

For assessment to the MISHA questionnaire, the Likert scale (1- poor, 2- average, 3- good, 4- very good, 5- excellent) was used.

The questions from the MISHA questionnaire that concern the employers' activities, analysed in the current study, are as follows:

A1.2. Top management commitment to the safety policy: has company's top management (factory manager, managing director) committed itself to the goals of the policy? Is the commitment visible in the management's everyday activities?

A1.4. Assignment of tasks and responsibilities: are the tasks and responsibilities assigned to the top management?

A1.5. Participation in the preparation of the policy: has the top management participated in the preparation of the safety policy?

A1.6. Initial status review: is the current safety management system operating effectively?

A1.7. Safety documents: the employer is responsible? Are the responsibilities shared by the employer?

A1.8. Revising the safety policy: has the employer defined, how often the policy is revised?

A1.9. Dissemination of the policy: has the company defined how the policy is made available to the personnel? How the revised versions of the policy are distributed?

A1.10. Informing external bodies about the company's safety policy (how the temporary workers, sub-contractors, clients can have access to the company's safety policy)?

A1.11. Safety policy's connections to the company's other activities (to the company's quality and environmental policy).

A2.1. The top management's safety knowledge (is the top management aware of OHS implementation in the company, what are the indicators of OHS in the company?)

A2.4. Does the company has a safety committee or some other cooperative safety teams? Does the employer is included to the safety committee and does he take part in the meetings?

A2.8. Resources: does the company has the resources for OHS improvement?

B2.1. Does the manager arrange the information meetings on OHS?

B3.1. Does the employer affords the safety training for all the personnel on a regular basis?

C2.3. Does the personnel's responsibilities and authorities are clearly defined?

C3.1. Are the workplace risk analysis carried out on a regular basis? Are the results looked through by the manager? Are the reduction means financed by the manager?

C3.2. Does the top manager enters into a contract with the occupational health services? Does he reviews the results of the medical examinations?

C3.3. Does the activities of the safety organization are discussed with the top management?

D1.1. Does the top manager is aware of the statistics on work accidents and occupational diseases?

D1.2. The reduction of accidents: has the plan been elaborated and presented to the top manager?

D1.3. Does the company make statistics on absenteeism rates and summaries on absenteeism causes? Are the statistics available to the top management?

D2.1. Does the company has the system for redesigning the work or workplace of a person who has difficulties in coping with the work?

D2.2. Does the company measure the employees' mental work ability on a regular basis? Is the manager aware of the results?

D3.1. Does the company have a system for measuring the social climate (social relations between the workers if some problems have observed)?

The statistics used in the paper involved IBM SPSS Statistics 22.0 and R.2.15.2. The following statistical methods were used: correlation, MANOVA, factor analysis, principal component method, independent T-test [18].

III RESULTS

The results of the quantitative analysis are given in Table 1. In the second column the characterization of the investigated enterprises is given. The interviews in the companies were carried out with the employer (if it was possible), but mainly with the production manager, who was mainly present in the workplace from the top management representatives (column 5). The total average score by MISHA method is presented in column 6.

The total MISHA score for the companies of group 1 was 78-92; for the group 2 it was 75-86; for the group 3 the total score was 46-65 from the 100 possible. It shows that the implementation of OHSAS 18001 helps to upgrade the safety level at enterprises. The corporated companies also have their own rules to keep the safety and health matter on a comparatively high level.

The safety key elements mostly correlated with the employers' activities at enterprises in the safety and health area are presented in Table 2, 3, 4 (column 1). The results of the statistics between these connections in the *real, formal* and *combined* safety area (sum of squares by KMO and Barlett's test and *p* value are presented in the columns 2 and 3).

A. Hypothesis H1

Factor analysis were carried out with KMO and Bartlett's test [18]. *The alpha correction (ANOVAs with Tukey's HSD post-hoc tests) was implemented and so the H1, H2, and H3 were confirmed.* Three hypothesis were formulated and the area in which they are proved concerning employer's activities were as follows:

H1) Standard *OHSAS 18001* has an impact on f*ormal* safety performance in the companies. If OHSAS 18001 is implemented, then: the assignment of tasks and responsibilities in OHS is committed to the top management (p=0.000), the employer is revising the safety policy (p=0.000), the personnel's responsibilities and authorities in OHS are clearly defined (p=0.013). The lower p-value (p=0.072) have the following activities, which are dependent on the top manager's activities: the top manager is aware about the statistics of accidents and occupational health diseases and the rates of absenteeism are not directly committed to the manager. These obligations are usually more directed to the safety manager in the company, if the company has the job of safety engineer or working environment specialist. The small enterprises have no resources to hire the safety manager, therefore these obligations have to be held by the manager him(her)self. The lowest score (p=0.241) have the safety documents responsibility, these documents are usually hold also by the safety manager, particularly in medium-sized companies.

Table 1
The Characterization and Results of Quantitative Study by MISHA Method in Investigated Enterprises (N=12)

Id.of the company	The activity area	Size, employees	OHSAS company /corporated company	The person interviewed	Total score (100 max)
1	2	3	4	***5***	6
I	Chemical industry	50-249	+/	Management's representative, 45; External auditor, 34	87 78
II	Chemical industry	50-249	+/	Management's representative, 55 External auditor, 34	88 78
III	Metal industry	50-249	-/-	Management's representative, 40 External auditor, 53	61 50
IV	Metal industry	>250	-/+	Trade union representative, 60	86
V	Agriculture farm (milk production)	<50	-/-	Employer, 50	46
VI	Agriculture farm (grain production)	<50	-/-	Employer, 56	60
VII	Construction	<50	-/-	Active manager, 40	50
VIII	Transport	50-249	-/-	Personnel manager, 45	65
IX	Plastic industry	50-249	+/	Quality manager, 41	78
X	Electronics	>250	/+	Quality manager, 35	84
XI	Electronics	>250	+/	Quality manager, 59	92
XII	Food industry	>250	/+	Safety manager, 62	75

Table 2
Correlation Between the Formal Safety Key Elements Hypothesis H1

Safety key element	SUM of squares (KMO) and Barlett's test	p-value
A1.4. Assignment of tasks and responsibilities to the top management	13.375	.000
A1.7. Safety documents: the employer is responsible?	1.299	.241
A1.8. Revising the safety policy: has the employer defined how often the policy is revised?	25.688	.000
C2.3. Does the personnel's responsibilities and authorities are clearly defined?	4.576	.013
D1.1. Does the top manager is aware of the statistics on the work accidents and occupational diseases?	21.007	.072
D1.3. Does the company make statistics on absenteeism rates and they are available to the top management?	5.458	.072

Table 3
Correlation Between the Real Safety Key Elements Hypothesis H2

Safety key element	SUM of squares (KMO) and Barlett's test	p-value
A1.9. Dissemination of the policy: has the employer defined how the policy is made available to the personnel?	21.007	.000
A2.1. Top management's safety knowledge	3.005	.039
A2.8. Resources: does the company has the resources for OHS improvement?	22.688	.000
B2.1. Does the manager arrange the information meetings to the employers on OHS?	2.896	.006
D2.1. Does the company has the system for redesigning the work or workplaces of a person with disabilities?	0.047	.013
D2.2. Does the company measure the employees' mental work ability on a regular basis? Is he aware of the results?	1.188	.148

Table 4
Correlation Between the Combined Safety Key Elements Hypothesis H3

Safety key element	SUM of squares (KMO) and Barlett's test	*p*-value
A1.6. Dissemination of the policy: has the employer defined how the policy is made available to the personnel?	13.375	.001
A1.10. Informing external bodies about the company's safety policy	17.241	.001
A2.4. Does the company has a safety committee or some other cooperative safety teams?	3.200	.214
B3.1. Does the employer affords the safety training for all the personnel on a regular basis?	2.854	.004
C3.2. Does the top manager enter into a contract with the occupational health services?	0.611	.340
C3.3. Does the activities of the safety organization are discussed with the top management?	1.965	.143
D1.2. The reduction of accidents: has the plan elaborated and presented to the top manager?	4.125	.007
D3.1. Does the company have a system for measuring social climate?	19.125	.000

B. Hypothesis H2

H2) Standard *OHSAS 18001* has an impact on r*eal* safety performance in companies. If OHSAS 18001 is implemented, then: the top manager promotes dissemination of the safety policy: the policy is made available to all the personnel *(p*=0.001); the resources for improvement of OHS activities are arranged by the top management (*p*=0.000); the top manager arranges meetings in OHS (*p*=0.006); in the company there is a system for redesigning the workplaces for the persons who have difficulties in coping with the work (*p*=0.013). The top management's safety knowledge has to be advanced continuously. The employees' mental work ability is not measured even in OHSAS 18001 implemented companies (*p*=0.39). This standard OHSAS 18001 has to be modified in this area.

C. Hypothesis H3

H3) Standard *OHSAS 18001* has an impact on c*ombined* safety performance. If OHSAS 18001 has been implemented, then: top management is participating in the dissemination of the safety policy (0.001), top manager is reviewing the safety policy, is it operating effectively? He is informing of the external bodies about the company's safety policy (*p*=0.001); the top manager arranges safety training for all the personnel (*p*=0.004); there is a plan for the reduction of accidents: it has been elaborated by the top manager (*p*=007); the company has a system for measuring the social climate in the company (*p*=0.000). OHSAS 18001 does not influence on the organizing the safety committee work (*p*=0.214) and the top manager is not making the contract with the occupational health services influenced by OHSAS 18001 (*p*=0.340); not all activities in the safety area are consulted with the top management (*p*=0.143).

D. Comments to top management's activities in OHS

Usually the incorporation to the foreign firms influences positively to the management's attitudes to the safety activities. In one of the investigated firms, after the incorporation, the management started to implement the corporation-based safety system and first, the safety audit was conducted.

The result was: safety did not came important at once. Safety took the first priority only 10 year after the incorporation. After that, quality was emphasized even more. Now it could be said that "safety comes first".

The working environment representative's comments:

1. "*The management's attitude to safety has not reached the ordinary workers yet. We have not really understood that safety is the priority in our department. Often we feel we have to rush in order to meet the production deadlines. Yes, we know that management declares safety is very important, but in practice, there are some safety flaws occurring. I personally work with an out-dated equipment and there is no hope to receive new one in near future".*

2. The other WER from the same company, however, presents a slightly different opinion: *"I think the safety level in our company is very good compared to my first employer. Here, everything concerning safety, is documented."*

So, there are different perceptions on safety, concerning industrial workers. In OHSAS 18011 implemented companies they have more knowledge on safety matters compared for example with small enterprises were even the manager does not know that the Occupational Health and Safety act [19] exists in Estonia.

IV. DISCUSSION

Our study revealed that management plays an essential role in OHS improvement in the company. By O'Toole [21], it is also postulated that the leadership's position is influencing the employee's perceptions of the safety management systems. Those perceptions appear to influence on the employee's decisions that relate to at-risk behaviours and decisions on the job. Organizational commitment did affect the perceived safety at work, but not on work accidents [21].

In the current study, it was declared that the plan for reduction of accidents if it is worked out by the employer, has very strong influence on the combined safety at enterprises. If the Standards (OHSAS 18001 etc.) are implemented then the organizational climate will also be better [22].

In the current study the implementation of OHSAS 18001 has a strong impact on the improvement of safety level at enterprises.

V. CONCLUSIONS

The hypothesis H1, H2, H3 on the influence of the firm type (OHSAS-implemented or non-implemented) has an impact on the employer's activities in occupational safety and health area.

The general conclusion is: if the standard OHSAS 18 001 is implemented, then then the OHS tasks and responsibilities are under the surveillance of the top manager. The employer is always revising the safety policy, the safety policy is available to every worker, the top manager arranges the OHS meetings if needed and the top manager is participating in the work-out of the safety policy, he(she) is continuously reviewing the policy, policy is effective and training in OHS is available to every worker.

The employer is in the key position in the enterprise in occupational safety and health improvement means and also it is positive if he has the resources to perform the changes. The three investigated small enterprises (the number of the workers under 50), the safety knowledge of the active manager is extremely important.

REFERENCES

[1] Õ. Paas, "Development of the safety management system at enterprises," PhD Thesis, Tallinn University of Technology, Tallinn, Estonian, pp. 164, 2015.

[2] G. Hrenov, Õ. Paas, P. Tint, and K. Reinhold, "Workers' representatives in OHS activities: example of Estonian industrial sector," Agronomy Research, vol. 14, no. 2, pp. 377-391, 2016.

[3] OHSAS 18001:2007. Occupational health and safety management standard. British Standardization Board.

[4] L. S. Robson, and P. L. Bigelow, "Measurement properties of occupational health and safety management audits: a systematic literature search and traditional literature synthesis," Can/Public Health, vol.101 (Suppl. 1), pp. 534-540, 2010.

[5] Y. Kim, J. Park, M. Park, "Creating a culture of prevention in occupational safety and health practice," Safety and Health at Work, vol. 7, pp .89-96, 2016.

[6] Õ. Paas, K. Reinhold, and P. Tint, "Estimation of safety performance by MISHA method and the benefits of OHSAS 18001 implementation in Estonian manufacturing industry," Agronomy Research, vol. 13, no. 3, pp.792-809, 2015.

[7] Õ. Paas, Reinhold, K., and P: Tint, "OHSAS 18001 contribution to real and formal safety elements of safety management in manufacturing companies: results of statistical analysis," Agronomy Research, vol.13, no.5, 2015, pp.1260-1274.

[8] R. Muthuviknesh, and K. A. Kumar, "The effect of occupational health and safety management on work environment: a prospective study," International Journal of Advance Research in Computer Science and Management Studies, vol. 2, no. 6, pp. 63-70, 2014.

[9] S. M: Zin, and F. Ismail, "Employers' behavioural safety compliance factors toward occupational, safety and health improvement in the construction industry," Procedia, Social and Behavioural Sciences, vol. 36, pp.742-751, 2012.

[10] S. Gautam, J. Maiti, A. Suamsundar, and S. Sarkar, "Segmented point process models for work system safety analysis," Safety Science, vol. 95, pp. 15-27, 2017.

[11] I.N. Isik, and E. Atasoylu, "Occupational safety and health in North Cyprus: evaluation of risk assessment," Safety Science, vol. 94, pp. 17-25, 2017.

[12] E. Tompa, C. Kalcevich, M. Foley, C. Mcleod, S. Hogg-Johnson, K. Cullen, E. MacEachen, G. Mahood, and E. Irvin, "A systematic literature review of the effectiveness of occupational health and safety regulatory enforcement," American Journal of Industrial Medicine, vol. 59, pp. 919-933, 2016.

[13] S. M. Kyaw-Myint, L. Strazdins, M. Clements, P. Butterworth, and L. Gallagher, "A method of identifying health-based benchmarks for psychosocial risks," *Safety Science,* vol. 93, pp. 143-151, 2017.

[14] M. A. Gopang, M. Nebhwani, A. Khatri, and H. B. Marri, "An assessment of occupational health and safety measures and performance of SMEs: an empirical study," Safety Science, vol. 93, pp. 127-133, 2017.

[15] J. E. Karlsen, P.H. Lindoe, "The Nordic OHS model at a turning point?" Policy and Practice in Health and Safety, vol. 4, no.1, pp.17-30, 2016.

[16] A. Kuusisto. "Safety management systems: audit tools and reliability of auditing," PhD thesis, Tampere University of Technology, Tampere, Finland, 2000.

[17] A. A. Kadir, S. Sarip, N.H. N. Mahmood, S. M. Yusof, M. Z. Hassan, M. Y. Md. Daud and S. S. Aziz, "A review of integrated management system in the offshore oil and gas industry," Journal of Advanced Review on Scientific Research, vol. 12, no.1, pp. 11-25, 2015.

[18] A. Field, "Discovering statistics using IBM statistics. Fourth edition. SAGE Publications Ltd., [Online]. Available: http://www.uk.sagepub.com/field4e/main.htm. [Accessed Aug.2016].

[19] OHS Act (Occupational Health and Safety Act of Estonia). Passed 16.06.1999. State Gazette of Estonia, RTI 1999, 60, 616.

[20] M. O'Toole, "The relationship between employees' perceptions of safety and organizational culture. Journal of Safety Research, vol. 33, pp. 231-243, 2002.

[21] D. M. DeJoy, L: J. Della, R.J. Vanderberg, and M.G. Wilson, "Making work safer: testing a model of social exchange and safety management," Journal of Safety Research, vol. 41, pp.163-171, 2010.

[22] A. Neal, M.A. Griffin, and P. M. Hart., "The impact of organizational climate on safety climate and individual behaviour," Safety Science, vol. 34, pp. 99-109, 2000.

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The Natural Dynamics of the Diversity of Small Mammal's Communities in Primary Forests in the Central of the Caspian-Baltic Watershed

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Abstract. Diversity is one of the main characteristics of the system, which reflects its complexity and structure. Diversity of biotic communities is always being actively discussed in the consideration of their organization, functioning, and sustainability. However, many questions still remain debatable. The report deals with the results of long-term (1980-2015) studies of the diversity of micromammalia communities in the primary ecosystems of southern Taiga of the Central Forest State Natural Biosphere Reserve (Russia), which is located in the centre of the Caspian-Baltic watershed. The diversity change of small mammals' communities was connected with climatic trends, extreme and catastrophic climatic phenomena. The authors offer methods of research and evaluation of α - and β-diversity of communities in conditions of the continuum of the environment of primary forests with the use of the gradient approach and GIS analysis.

Keywords: biodiversity monitoring; α - and β-diversity of communities; small mammals' communities; primary forests; continuity environment; gradients of the environment; GIS analysis.

I. INTRODUCTION

One of the main measurable characteristics of the system is diversity, which reflects its complexity and structuredness. Diversity is always actively discussed when considering the organization, functioning, and stability of biotic communities, including responses to changes in the environment. However, quite a few questions are still discussed [1-7]. The multi-species groups of small mammals play an important cenotic role in ecosystems and are a universal model objects for different studies including biodiversity monitoring. Inventory and differentiation species diversity of small mammals' communities was investigated in the natural dynamics of the reference forest ecosystems of the European southern taiga. In addition to traditional methods for assessing the species diversity of communities in the conditions of the mosaic-continual habitat of the south-taiga forests the researchers used a complex gradient approach and the GIS-analysis.

II. MATERIALS AND METHODS

The basis for the article was the authors' long-term research which was carried out in 1981-2015 in the Central-Forest State Natural Biosphere Reserve located in the central part of the Caspian-Baltic watershed of the Russian Plain (Russia, the Tver Region). The climate of the territory is moderately continental with the determining effect of the warm North-Atlantic current. The region belongs to the subzone of the southern taiga [8]. The vegetation cover is mainly represented by spruce and secondary forests formed in their place (80%). Historical and paleoecological studies have shown that during the last millennium no more than 15% of the present territory of the reserve was developed [9]. Currently, the total proportion of anthropogenic habitats within the reserve is only 1.5%. There are no obvious sources of atmospheric pollution within the short-range territory. The Central Forest Reserve is a model area of natural processes of the southern taiga ecosystems of the Russian Plain.

The data for this work were obtained during the annual standard catches in stationary model areas of primary spruce forests of nemoral and boreal genesis. The total amount of the material is about 15,000 examples of small mammals of various species. Standard information measures were used for assessing the species diversity of communities: Shannon-Weaver index, Pielou's measure of species evenness [5]. As a measure of the differentiating species diversity of communities the authors used the Chekanovsky-Sőrensen difference coefficient in the form b: Ics =1-∑min (Pi,y; Pi,k), where Pi,y; Pi,k are the minimal species share in a pair of samples [7]. The results were verified by the T-test.

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Since 2010 the spatial distribution of small mammal species in the continuum of forest ecosystems has been studied using a gradient long trap-line. Long trap-lines application is well proved in a number others studies of small mammals communities [10-12]. The transect, which is 2280 m long, crosses different types of indigenous ecosystems of the southern taiga, first of all spruce forests of various genesis. The transect is marked with 114 endorse points which are linked through the GPS to the WGS 84 coordinate system (UTM Zone 36 North). The distance between neighboring points is 20 meters. The points have detailed geobotanical descriptions in areas of 20 × 20 and 5 × 5 meters. The descriptions contain 275 variables primarily of the phytocenotic environment as well as some microrelief and microclimatic parameters. Within the transect area the researchers made catching of small mammals (1,700 exemplars). The distribution of rodents made it possible to identify unit cells of small mammals' habitats that are minimal natural zones for their livelihood. For this very purpose the researchers calculated the total and particular autocorrelation functions using summarized data of micromammalia species representation at each point of the transect trap-line. Statistical processing of data was carried out in the program STATISTICA-8.0.

III. RESULTS AND DISCUSSION

13 species of rodents and 6 species of shrews were recorded in the micromammalia communities of the reserve. Long-term regular observations showed that biodiversity indicators increased in this study period in the forest ecosystems of the reserve (Table 1). It is determined by a more evened representational distribution of typical forest species which primarily refers to the increased role of the Eastern Palearctic species (by 15 times) for boreal spruce forests. In the rodents' guilds of nemoral spruce forests there is an increase in representing some western Palearctic species that are located here on the edge of their range. Their total participation in the guild of rodents increased 10 times. The increase in the alpha-diversity of rodent communities in native spruce forests was accompanied by a significant growth in the total number of species (Table 1).

Table I
Dynamics of Some Characteristics of Small Mammal Communities in the Spruce Forests of Different Genesis in the Period 1981-2015 Years.

Features		The nemoral spruce forests		
		1981-1990	1991-2000	2001-2015
The total number of communities of small mammals (individuals per 100 trap/nights)	Lim	2,9–52,6	7,5–74,5	10,5–82,0
	M±m	24,5±5,7	40,4±6,7	60,0±5,5
The total share of individuals of the Western Palearctic species on the edge of the area consisting of guilds of rodents (in %)		0,4%	3,0%	4,0%
Species diversity of rodents guilds	H'	0,105	0,242	0,242
	E	0,065	0,116	0,124
Features		The boreal spruce forests		
		1981-1990	1991-2000	2001-2015
The total number of communities of small mammals (individuals per 100 trap/nights)	Lim	0–55,0	8,0–64,8	10,0–59,9
	M±m	16,9±6,1	31,8±6,3	33,4±4,1
The proportion of individuals of species in East Palearctic species composition of the guilds (in %)	rodents	1,6%	24,6%	23,4%
	shrews	3,3%	43,8%	49,3%
Species diversity of rodents guilds	H'	0,125	0,829	0,691
	E	0,09	0,463	0,386

Lim – limits, M±m – the arithmetic mean with error, H'– the index of species diversity Shannon-Weaver (H'=-∑PilnPi, где Pi – the proportion of species in the community structure), E – equitability Pielou (E=H'/lnS где S – the number of species in the community)

In the 1980s groups of small mammals were much more homogeneous throughout the reserve. The degree of differences in the structure of rodent communities of nemoral and boreal spruce forests in 1981-1990 was insignificant (the mean of difference in Chekanovsky-Sőrensen Index was 0.06). The value of a similar index in 1991-2015 was five times higher (0.31, P = 0.999).

It proves the increase in the zonal contrast of climax spruce communities of different genesis. The increase in the heterogeneity of rodent communities in the later period of observations was detected not only among spruce forests of different genesis but also among individual model areas of the same genesis: for boreal spruce forests - 2 times, for nemoral spruce forests - 6-7 times. The growth in the heterotony of micromammalia guilds indicates the increase in the beta diversity of communities in the forests of the reserve in general.

The spatial heterogeneity of environment is known as one of the important factors in developing diversity in animal communities [2, 3, 5, 6, 13, 14]. As a rule, there is a fairly close positive relationship between the biodiversity and the structural complexity of the habitat. In our case the increase in the alpha-diversity of communities is apparently determined by the increase of the habitat heterogeneity as the result of massive windfall processes and a large-scale drying of spruce forests with their subsequent destruction, which led to the formation of an extremely mosaic plant cover. The obtained results are in good agreement with the modern forest GAP-paradigm considering that natural forests represent the succession mosaic of stains

which are at different stages of ecosystems development and provide biodiversity and sustainability. It is not sufficient for a mosaic environment to use only discrete model sites to assess the diversity of communities because a lot of ecotone variants are not taken into consideration. Therefore, we used the gradient approach and in 2010-2014 small mammal catches were made on the long transect that was described above.

The analysis of the spatial numbers of rodents showed that this is not a chaotic sequence but an organized structure. In particular, for the dominant species in all types of forest ecosystems - *Myodes (Clethrionomys) glareolus*, the autocorrelation function with an increase in the shift (Lag) is decaying. However, the autocorrelation corresponding to a shift in 5 points (100 meters) and 13 points (260 meters) goes beyond the boundary of a monotonically damped process denoting the existence of a harmonic in the investigated series (Fig. 1). Q-statistics shows that the process is sure not to be random.

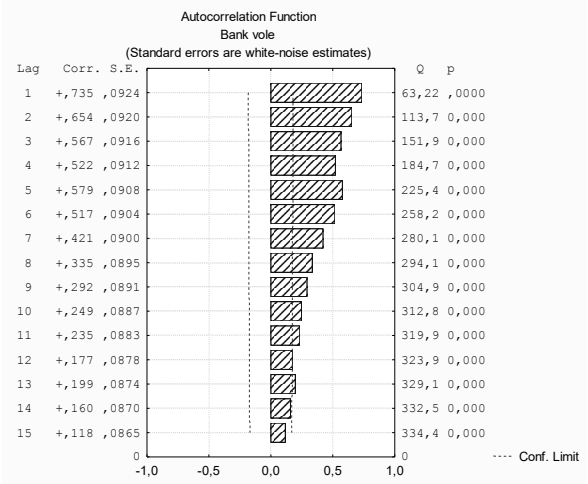

Fig. 1. Autocorrelation function of abundance bank vole

Analogous but more contrasting results were obtained in the analysis of a particular autocorrelation function (Fig. 2).

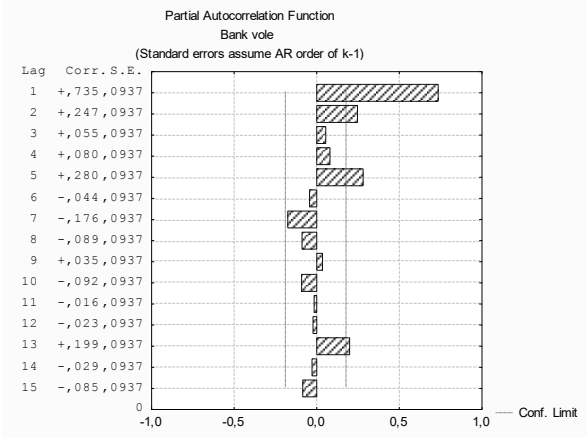

Fig.2. Partial autocorrelation function of abundance bank vole

Thus, the spatial series of bank voles' population in the continuum of the environment has a pronounced cycle character which represents a regularly repeated structure of territorial organization - the special unit cells. The two levels of community organization have been identified: cells of 100 to 100 meters and cells of 260 to 260 meters. Similar results were obtained for other rodent species studied. It indirectly indicates the certain synchrony in population processes in small mammals which is probably related to the Moran effect [15, 16].

This dimension of spatial cells is in a complete agreement with the data of some sources [17].

The model transect with the length of 2,280 m has 23 cells of 100 m in size and 9 cells with the dimension of 260 m. For all cells the species structure of rodents' guilds was defined and the indices of difference between them were calculated. For the dimension of 100 m the matrix constitutes 253 paired comparisons, for the dimension of 260 m it constitutes 36. The general results of the comparisons are presented in Table. 2.

Table 2
Indicators Differentiating The Species Diversity Of Rodent Communities In Primary Spruce Forests

The size of the spatial cells (m)	n	The dissimilarity index		Share reliable comparisons (P=0,95)
		Lim	M±m	
100 m	253	0,0-0,41	0,16±0,07	49%
260 m	36	0,02-0,39	0,15±0,04	86%

n – the number of pairwise comparisons matrix;
Lim – limits; M±m – the arithmetic mean with error

For the special unit cells of 100 m and 260 m we obtained similar results. It refers to both the diapason and the average difference index. A higher proportion of reliably differing pairwise comparisons for the dimension of 260 m is determined by the larger (2.5 times on the average) number of samples used to describe the structure of communities than for the dimension of 100 m.

The similarity of the obtained results to a certain extent proves the correctness of the allocated spatial unit cells and their application for characterizing the structure and diversity of forest communities of small mammals.

IV. CONCLUSIONS

At the turn of the 20th and 21st centuries there were significant changes in the structure, diversity, and abundance of small mammals' communities in the etalon forest ecosystems of the central part of the Caspian-Baltic watershed, which arose as a response to the change of the structural and functional organization of the entire forest area of the Central-Forest reserve. In many respects the observed tendencies are apparently determined by the climate fluctuations, the growth of the net production of forest ecosystems, and by the frequent catastrophic phenomena and extreme factors, the manifestation of

which is associated with climate change [18-20]. In conditions of the southern taiga forests these trends cause periodic mass windfalls, a large-scale spruce stands desiccation entailing their subsequent destruction and the formation of an extremely mosaic plant cover. The active succession dynamics of forest ecosystems in the natural complexes of the reserve caused certain changes in population and small mammals' communities functioning, which is related to the natural large-scale destruction of forests ecosystems [18, 20].

In the conditions of mosaic forest ecosystems the proposed method for estimating the β-diversity of small mammal communities is quite applicable. This method involves the use of long gradient trap-lines, the allocation of spatial unit cells, and a comparative analysis of the similarity of the animal communities' structure.

REFERENCES

[1] R. H. Whittaker Dominance and diversity in land plant communities. Science, 1965, vol.147, no. 365, pp. 250 –260.

[2] E.R.Pianka Latitudinal gradients in species diversity: A review of concepts // Amer. Nat. 1966. Vol. 100, N 910. pp. 33–46.

[3] E.R Pianka. Evolutionary ecology. – N. Y.; L. : Harper and Row, 1974. – 356 p.

[4] R.H. Whittaker Communities and Ecosystems. New York, 1975. 327 p.

[5] E. P.Odum Basic Ecology. Philadelphia: Sanders. 1983. 613 p.

[6] P.S. Giller Community Structure and the Niche. Chapman and Hall, London, 1984. 176 p.

[7] Pesenko Yu.A. Principles and methods of quantitative analysis in faunistic studies. Moscow: Nauka, 1982. 285 p.

[8] Factors of the regulation of spruce forest ecosystems. Leningrad : Nauka, 1983. 318 p.

[9] Karimov A.E., Nosova M.B. The use of land and the impact on the nature of the Central Forest Reserve (late 16th-early 20th centuries) // Succession processes in Russian nature reserves and conservation of biological diversity. St. Petersburg. Russian Botanical Society, 1999. P. 299-310.

[10] Joan L. Morrison and Patricia L. Kennedy. The use of line transects to evaluate the abundance of diurnal mammalian prey. The Raptor Research Foundation, Inc. 23(4). 1989, pp. 172-175.

[11] José M. V. Fragoso, Taal Levi, Luiz F. B. Oliveira, Jeffrey B. Luzar, Han Overman, Jane M. Read, Kirsten M. Silvius. Line Transect Surveys Underdetect Terrestrial Mammals: Implications for the Sustainability of Subsistence Hunting. PLoS ONE 11(4). 2016, pp. 1-18. Available at: DOI:10.1371/journal.pone.0152659, [Accessed: Mar. 5, 2017].

[12] Istomin A.V., Mikhalap S.G. The use of "gradient" trap-lines in the study of small mammals in natural conditions / / Intern. Conf. Actual problems of nature protection. Cheboksary., 2011. C.6-7.

[13] L. E. Lukyanova, O. A. Lukyanov An ecologically destabilized environment: Its effect on small-mammal populations Russian Journal of Ecology. 2004. T. 35. № 3. .P. 181-188.

[14] André Luís Luza, Gislene Lopes Gonçalves, Valério D. Pillar, Sandra Maria Hartz. Processes related to habitat selection, diversity and niche similarity in assemblages of non-volant small mammals at grassland–forest ecotones. Natureza & Conservação, Volume 14, Issue 2, July–December 2016, pp. 88-98. Available at: DOI: 10.1016/j.ncon.2016.09.003 [Accessed: Mar. 2, 2017].

[15] Koenig, W. D.. Global patterns of environmental synchrony and the Moran effect. – Ecography 25. 2002. pp. 283 – 288.

[16] Royama, T. Moran effect on nonlinear population processes. Ecological Monographs. 75. 2005, pp. 277–293. Available at: DOI:10.1890/04-0770. [Accessed: Mar. 3, 2017]

[17] Korosov A.V., Matrosova Yu.M., Bugmyrin S.V., Anikanova V.S., Bespyatova L.A. GIS-analysis of the factors of the territorial location of the bank vole (Clerthrionomys glareolus) in the mosaic landscape of South Karelia // Ecology. Experimental genetics and physiology. Proceedings of the Karelian Research Center of the Russian Academy of Sciences. Issue 11. Petrozavodsk, 2007. P. 70-84.

[18] A.V. Istomin, Influence of windfalls on dynamics of communities of small mammals in forests of southern taiga, Vestn. Mosk. Gos. Univ. Lesa — Lesnoi Vestn., 2009, no. 1, P. 196–201.

[19] T.Yu. Minayeva, A.V. Istomin, V.I. Abrazhko, Bazhenova T.P., Korablev N.P., Kuraeva E.N., Kurakina I.V., Pugatchevsky A.V., Rusanovich N.R. and Shaposhnikov E S 2001 Study on biota reaction on climate changes in the Central Forest Nature Reserve Climate Change Impact on Ecosystems. Nature Protected Areas in Russia. Analyses of Long-Term Information (Publications of WWF Russia) (Moscow: Russian University) pp 87-100 (in Russian)

[20] A. V. Istomin, The Role of "Blank" Stage in Supporting the Diversity of the Communities of Murine Rodents in Primary Spruce Forests of the Southern Taiga, in Biologicheskoe raznoobrazie lesnykh ekosistem (Biological Diversity of Forest Ecosystems), Moscow, 1995 . P. 144-146.

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Investigation of Hemp (*Cannabis sativa* L.) Fibre Quantity and Quality as Influenced by Genotype and Seed Rate

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Abstract. The investigation on hemp fibre quantity and quality as influenced by genotype and seed rate was carried out at the Upytė Experimental Station Lithuanian of the Lithuanian Research Centre for Agriculture and Forestry in 2014. Bi-factorial trial was carried out: Factor A – variety (A1 – USO 31; A2 – Bialobrzeskie); Factor B – sowing rate (B1 – 45 kg ha^{-1}; B2 – 70 kg ha^{-1}). Data showed that variety (genotype) had a significant influence on fibre content (after dew-retting as well after water-retting) – it was higher for variety Bialobrzeskie and amounted to 37.2 and 34.5%, respectively. Seed rate (or crop density) did not show significant influence neither on fibre content nor on fibre quality (flexibility, strength) parameters.

Keywords: Cannabis sativa L., density, fibre, quality, seed rate, variety.

I. INTRODUCTION

The interest in hemp (*Cannabis sativa* L.) as an industrial plant, its numerous application ways, as well as in ecology of it, is growing up continuously. In recent five years only in Lithuania the area of industrial hemp increased as much as forty times – from 54 ha in 2011, to 2345 ha in 2015 and 2454 ha in 2016 [1].

The yielding capacities of hemp and fibre quality depend on many factors such as genotype, seed rate, growing technology, pedoclimatic conditions, etc. [2; 3; 4].

Dew-retting and water-retting are two retting methods allowing fibre extraction from the stems of bast fibre plants, and both of them produce fibres of different quality, thus both ways should be investigated [3].

Different range of seed rates for hemp is reported when growing it for different purposes. Recommended sowing rates for fibre hemp vary between 40 and 150 kg per ha [5]. For textile purposes suggested seed rate varies from 40 to 80 kg ha^{-1} [2; 6; 7; 8; 9; 10].

The goal of the investigation was to evaluate how the hemp variety (genotype) and sowing rate influences on fibre quantity and quality indices.

II. MATERIALS AND METHODS

The trial was conducted at the Upytė Experimental Station of the Lithuanian Research Centre for Agriculture and Forestry in 2014. The soil – an Eutri-Endohypogleyic Cambisol, CMg-n-w-eu [11]. The pH_{KCl} level was 6.8 (potentiometrically), humus concentration – 2.23% (by Hereus apparatus), content of available phosphorus (P_2O_5) in the soil plough layer was 116 mg kg^{-1}, the content of available potassium (K_2O) – 85 mg kg^{-1} (determined in A-L extraction). Hemp followed winter wheat in the field rotation. Before sowing, complex fertilizers N9-P25-K25 (200 kg ha^{-1}) have been applied.

Bi-factorial trial was carried out: Factor A – variety (A1 – USO 31; A2 – Bialobrzeskie); Factor B – sowing rate (B1 – 45 kg ha^{-1}; B2 – 70 kg ha^{-1}). Both of selected varieties are monoecious.

Hemp was sown on 7th of May in 15 cm inter-row spacing by single-row sowing machine. The size of trial plots was 2 × 5 = 10 m^2, the size of record plots – 2 × 4 = 8 m^2 (trial was sown in tree replications). Randomised plot design was used. At both sides of the trial the protective plots of the same size as record plots were sown.

Hemp crop density was assessed at hemp harvest time. For this purpose 4 microplots of 0.25 × 0.25 m were marked in each trial plot after full crop emergence. Hemp was harvested when the first matured seed appeared (26th of August).

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After morphological analyses, the index, important for fibre quantity and quality, was calculated as the ratio between technical stem length and stem diameter [4; 12].

Before starting dew or water-retting, technical stalk part from hemp stalks was prepared (cutting away the top part of plant containing panicle and still left on the stem branches with leaves). One part of hemp stalk samples (0.5 kg per plot) was water-retted (temperature 37 º C) for 5 days, other part (0.5 kg per plot) was dew-retted on the grassland for 2 weeks; then dry straw was weighed and beaked by laboratory tool LM-3; obtained material was shaked by hand until the shives were withdrawn. Obtained fiber was weighed and fiber content in the straw was calculated by the formula (1):

$$Fc = Wf \times 100 / Wstr \quad (1)$$

where: Fc – fibre content in the straw, %,
Wf – weight of obtained fibre, g,
Wstr – weight of straw before scutching, g.

Later on fiber content in the stalks was recounted (2):

$$Fc = Wf \times 100 / Ws \quad (2)$$

where: Fc – fibre content in the stalks, %,
Wf – weight of obtained fibre, g,
Ws – weight of stalks before retting, g.

Fibre flexibility was evaluated by a device G-2, strength of fibre – by a device DK-60 [13].

For statistical data evaluation the statistical software developed in the Lithuanian Institute of Agriculture was used, ANOVA method applied [14].

Mean air temperature and amount of precipitation were assessed during hemp growing period (Table 1).

Table 1.
Mean weather temperature and precipitation during hemp growing period
Upytė, 2014

Month	Ten-day period	Mean weather temperature, ºC		Rainfall, mm	
		2014	Long-term average	2014	Long-term average
May	I	8.2	11.0	23.5	16.0
	II	13.8	12.6	34.0	16.0
	III	16.8	13.5	7.5	18.0
	Aver./total	**12.9**	**12.4**	**65.0**	**50.0**
June	I	17.0	14.4	12.0	22.0
	II	13.2	15.3	27.0	23.0
	III	12.6	16.2	71.0	24.0
	Aver./total	**14.3**	**15.3**	**110.0**	**69.0**
July	I	19.0	17.2	49.5	25.0
	II	18.8	18.0	20.0	25.0
	III	21.9	18.0	23.0	26.0
	Aver./total	**19.9**	**17.7**	**92.5**	**76.0**
August	I	22.4	17.2	58.0	28.0
	II	17.0	16.1	35.5	29.0
	III	13.2	15.0	79.5	28.0
	Aver./total	**17.4**	**16.1**	**173.0**	**85.0**

Hemp germinated approximately in two weeks after sowing. It was warm and rainy in the middle of May (the amount of precipitation was twice more than the long-term average for second ten-day period of May). June was slightly cooler that long-term average but abundant in precipitation. It was warm in July and August, but the amount of precipitation was again huge, and even oversupply as the water for some time was flooding some surfaces on the trial field. Hemp was thriving over the vegetation period.

III. RESULTS AND DISCUSSION

No doubts, that seed rate (Factor B) could have influence on crop density. The data of investigation show that seed rate had a significant influence on crop density at hemp harvest time (Table 2). The mean crop density was close 118 plants m^{-2} at seed rate of 45 kg ha^{-1}, and significantly higher – 188 plants m^{-2} – at seed rate of 70 kg ha^{-1}. Also some significant interaction of tested factors was found – crop density was significantly higher when sowing hemp of both varieties at seed rate of 70 kg ha^{-1}, than that when sowing at 45 kg ha^{-1}.

Table 2.
Crop density (plants m-2) at hemp at harvest
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	104.7	195.0*	149.8
Bialobrzeskie	130.3	179.7*	155.0
Mean for Factor B	117.5*	187.3*	-
R_{05} (variety) = 17.23 R_{05} (seed rate) = 17.23 R_{05} (variety x seed rate) = 29.85			

* – significant at 0.05 probability level;

As fibre content and quality could be influenced by many factors, thus the additional index, conventionally related to fibre quantity and quality, was calculated. Relational index of distribution of fibres in the stem is the ratio between the technical stem length and the stem diameter – the higher is the ratio, the better is the fibre quality [4; 12; 15]. The results of our investigation show that this index was significantly influenced by seed rate [16]. The plants sown at higher seed rate (70 kg ha^{-1}) had a higher ratio between the technical stem length and the stem diameter (376.8) than that sown at lower seed rate (45 kg ha^{-1}) (319.7) (Table 3).

Table 3.
The ratio between technical hemp stem length and stem diameter
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	303.8	386.4*	345.1
Bialobrzeskie	335.6	367.3*	351.4
Mean for Factor B	319.7*	376.8*	-
R_{05} (variety) = 21.86 R_{05} (seed rate) = 21.86 R_{05} (variety x seed rate) = 37.86			

* – significant at 0.05 probability level;

Hemp genotype (variety), as Factor A, showed a significant influence on the fibre content after dew-retting (Table 4). Variety Bialobrzeskie had significantly higher fibre content after dew-retting (37.2 %) than that of variety USO 31 (31.2 %). Unfortunately, the seed rate did not show any influence to this tested parameter.

The results of hemp fibre quality showed that neither fibre flexibility nor fibre strength was influenced by tested Factors (Tables 5 and 6). Hemp fibre after dew-retting was rough, inflexible, but enough firm.

Table 4.
Fibre content (%) in dew-retted stalks
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	31.3	31.0	31.2*
Bialobrzeskie	37.7	36.7	37.2*
Mean for Factor B	34.5	33.8	-
R_{05} (variety) = 0.88 R_{05} (seed rate) = 0.88 R_{05} (variety x seed rate) = 1.53			

* – significant at 0.05 probability level;

Table 5.
Dew-retted hemp fibre flexibility (mm)
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	16.8	19.6	18.2
Bialobrzeskie	17.3	18.7	18.0
Mean for Factor B	17.1	19.1	-
R_{05} (variety) = 1.10 R_{05} (seed rate) = 1.10 R_{05} (variety x seed rate) = 1.90			

Table 6.
Dew-retted hemp fibre strength (kg F)
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	19.8	17.8	18.8
Bialobrzeskie	17.9	18.7	18.3
Mean for Factor B	18.8	18.2	-
R_{05} (variety) = 2.26 R_{05} (seed rate) = 2.26 R_{05} (variety x seed rate) = 3.92			

Fibre content in hemp stems was slightly higher after dew-retting then that after water-retting. It means that more fibre could be obtained applying dew-retting method. Nevertheless, fibre quality parameters also should be taken into account.

The influence of hemp genotype (variety), as Factor A, again was highlighted on fibre content after water-retting (Table 7). Variety Bialobrzeskie had significantly higher fibre content after water-retting (34.5 %) than that of variety USO 31 (29.2 %). Unfortunately, the seed rate did not show any significant influence again.

The fibre flexibility after water-retting was more than twice higher than that after dew-retting (Table 8). Such high value of flexibility exceeded some results of previous trials [3], and sometimes could be related to flax fibres [17].

Only some tendencies could be noted that fibre flexibility was slightly higher when hemp grew at higher plant density, but the differences are insignificant.

Table 7.
Fibre content (%) in water-retted stalks
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	29.2	29.1	29.1*
Bialobrzeskie	34.3	34.7	34.5*
Mean for Factor B	31.8	31.9	-
R_{05} (variety) = 1.22 R_{05} (seed rate) = 1.22 R_{05} (variety x seed rate) = 1.395			

* – significant at 0.05 probability level;

Table 8.
Water-retted hemp fibre flexibility (mm)
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	44.6	50.9	47.7
Bialobrzeskie	46.1	47.8	47.0
Mean for Factor B	45.4	49.4	-
R_{05} (variety) = 1.65 R_{05} (seed rate) = 1.65 R_{05} (variety x seed rate) = 4.34			

In 2014, the fibre strength after dew-retting and water-retting was quite similar (Tables 6 and 9), and was much higher than in previous trials [3].

The differences in fibre strength between treatments were not established. Neither seed rate nor variety did not show any significant influence on fibre strength after water-retting.

Table 9.
Water-retted hemp fibre strength (kg F)
Upytė, 2014

Variety (Factor A)	Seed rate (Factor B)		Mean for Factor A
	45 kg ha^{-1}	70 kg ha^{-1}	
USO 31	17.9	19.0	18.4
Bialobrzeskie	19.5	19.8	19.6
Mean for Factor B	18.7	19.4	-
R_{05} (variety) = 1.46 R_{05} (seed rate) = 1.46 R_{05} (variety x seed rate) = 2.54			

Nevertheless the hemp plants sown at higher seed rate (70 kg ha^{-1}) had a higher ratio between the technical stem length and the stem diameter than that sown at lower seed rate (45 kg ha^{-1}) this was not reflected on fibre content or quality.

IV. CONCLUSION

Seed rate had a significant influence on crop density at harvesting time. Variety (genotype) had a significant influence on fibre content (after dew-retting as well after water-retting) – it was higher for variety Bialobrzeskie, and amounted to 37.2 and 34.5%, respectively. Seed rate (or crop density) did not show significant influence neither on fibre content nor on fibre quality (flexibility, strength) parameters.

REFERENCES

[1] V. Jonaitienė, Z. Jankauskienė, and I. Stuogė, "Hemp Cultivation Opportunities and Perspectives in Lithuania", in *Natural Fibres: Advances in Science and Technology Towards Industrial Applications From Science to Market*

(Eds: Raul Fangueiro, Sohel Rana), RILEM Bookseries, Vol. 12, 2016, pp. 407-414.

[2] S. Amaducci and H.-J. Gusovius, "Hemp – cultivation, extraction and processing", in *Industrial Application of Natural Fibres: Properties and Technical Application* (Ed. Müssing J.), A JohnWiley & Sons, UK, 2010, pp. 109–134.

[3] Z. Jankauskienė and E. Gruzdevienė, "Physical parameters of dew retted and water retted hemp (Cannabis sativa L.) fibers", Zemdirbyste-Agriculture, 100 (1), 2013, pp. 71-80.

[4] М.Д. Мигаль, *Біологія луб'яних волокон конопель*. Суми: ТОВ „ТД Папірус", 2011, 390 с.

[5] H. M. G. Van der Werf, W. C. A. van Geel and M. Wijlhuizen, "Agronomic research on hemp (Cannabis sativa L.) in the Netherlands, 1987–1993". Journal of the International Hemp Association, 1995, vol. 2, no. 1, pp. 14-17.

[6] I. Bocsa and M. Karus, "Hemp cultivation" in: *The cultivation of hemp: botany, varieties, cultivation and harvesting*. Sebastopol, USA, 1998, 186 p.

[7] L. Grabovska and W. Koziara, "The effect of nitrogen dose, sowing density and time of harvest on development and yields of hemp cultivar Bialobrzeskie", Journal of Natural Fibres, 2005, vol. 2 (4), pp.1-17.

[8] Poradnik plantatora lnu i konopi (koodinator Szalkowski Z.), Poznan, 1994, p.51-61.

[9] H. Burczyk, L. Grabowska, M. Strybe and W. Konczewicz, "Effect of sowing density and date of harvest on yields of industrial hemp". Journal of Natural Fibers, 2009, vol. 6, pp. 204-218.

[10] P. C. Struik, S. Amaducci, M. J. Bullard, N. C. Stutterheim, G. Venturi and H. T. H. Cromack, "Agronomy of fibre hemp (Cannabis sativa L.) in Europe", Industrial Crops and Products, 2000, vol.11, pp. 107–118,.

[11] V. V. Buivydaitė, M. Vaičys, J. Juodis and A. Motuzas, *Lietuvos dirvožemių klasifikacija*. Vilnius, 2001, p. 76.

[12] В.П., Понажев и О.В. Медведева, "Методы создания семян льна-долгунца с использованием отбора растений по признакам «мыклость» и «сбежистость»", Инновационные разработки – льноводству: Селекция, семеноводство, возделывание, первичная обработка, экономика. Тверь: Твер.гос.ун-т., 2011. с. 36.

[13] *Методики технологической оценки льна и конопли*. Moscow, 1961, 182 p.

[14] P. Tarakanovas and S. Raudonius, Agronominių tyrimų duomenų statistinė analizė taikant kompiuterines programas ANOVA, STAT, SPLIT-PLOT iš paketo SELEKCIJA ir IRRISTAT. Akademija, Kauno r. 58 p., 2003.

[15] Т.А. Рожмина, А.И. Рыжов, Т.А. Кудряшова и Л.М. Голубева, "Генетическое разнообразие мировой коллекции льна-долгунца по параметрам качества льноволокна (Genetic diversity of flax global collection according to fibre quality parameters)". Инновационные разработки – льноводству: Селекция, семеноводство, возделывание, первичная обработка, экономика. Тверь: Твер.гос.ун-т., 2011, с. 16-17.

[16] Z. Jankauskienė, E. Gruzdevienė, S. Ivanovs and E. Maumevičius, "Investigation of hemp (*Cannabis sativa* L.) morphological parameters as influenced by seed rate and genotype". Engineering for rural development. 15th International Scientific Conference, May 25-27, 2016, Jelgava, Latvia. Proceedings, Vol. 15, p. 893-897.

[17] Z. Jankauskienė and E. Gruzdevienė, "Genetic recourses: Evaluation of the value of some old Latvian flax accessions", Environment. Technology. Resources: proceedings of the 8th International Scientific and Practical Conference, Rezekne, June 20-22, Vol. II. 2011. Rezekne, 2011, pp. 297-304.

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Effect of the Acidic Treatment of Domestic Wood Residue on Biocomposite Wettability and Moisture Sorption Properties

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Abstract. The aim of the work was to evaluate the effect of the acidic treatment temperature of aspen sawdust as a filler on the moisture sorption, wetting and mechanical properties of wood-polymer composites. Aspen wood sawdust was treated with the dilute hydrochloric acid solution at 60ºC and 90ºC during 5 h. Both the treated particles and the filled composites were studied in terms of moisture sorption and wettability; their surface free energy was calculated using the Owens-Wendt-Rabel-Kaelble (OWRK) approach. The obtained results have shown that the acidic treatment of aspen wood sawdust at 90ºC leads to an increase in its hydrophobicity that decreases the wettability and moisture sorption of the obtained composite and increases its mechanical properties.

Keywords: Mild Acidic Treatment, Moisture Sorption, Wettability, Wood-Polymer Composite, Wood Residue.

I. INTRODUCTION

Wood-polymer composites (WPCs) are of great interest in various applications due to their low density, low equipment abrasiveness, high stiffness and strength, low maintenance requirements, and biodegradability [1-2]. Polyolefins such as polyethylene and polypropylene, the best-known thermoplastics, are often used as a matrix in WPCs. The volume of the produced WPCs increases every year. According to the NOVA-Institute statistical data, 350,000 tons of WPCs were produced in EU in 2015, but their amount will grow to 450,000 tons in 2020 [3]. Most of the produced WPCs are used for decking (about 67%), but 23% of their total amount are used in the auto industry. The remaining 10% are used for technical requirements, furniture etc.

Since recycled polymers, the amount of which rapidly grows in the USA, EU and Japan, can be processed below the degradation temperature of wood, they are suitable for producing WPCs. Nowadays, the use of recycled thermoplastics can be considered as a advancing trend for obtaining such a type of composites as decorative and interior building materials. It is very important that the use of recycled synthetic polymers as a polymer matrix in WPCs sufficiently decreases their disposal in landfills, reducing waste volumes, and sufficiently diminishes the pollution of atmosphere, decreasing CO_2 emission [4]. At the same time, the incompatibility between hydrophilic lignocelluloses and the hydrophobic polymer matrix leads to a weak adhesion between these ingredients in WPCs. To solve this problem, physical and chemical methods have been used to modify and functionalize the lignocelluloses for increasing their hydrophobicity and improving the interfacial adhesion. Wood functionalization can be realized by various modes, namely, with alkali, benzylation, graft copolymerization, treatment with fatty acids, peroxide, anhydride, permanganate, silane, plasma, etc. [5,6,7,8,9]. Acetylation, furfurylation and thermal modification of wood are often used for obtaining WPCs under industrial conditions. To increase the compatibility between the polymer matrix and the lignocellulosic filler, various coupling agents and compatibilizers are also applied in WPC compositions. It is known that maleic anhydride polymer derivatives are often used in practice as interface modifiers, which have a positive effect on the physicochemical properties of WPCs [10-11].

In Latvia, there is a very high amount of wood processing by-products as well as polymer wastes, which could be successfully used as a raw material for the development of new compositions of WPCs.

In this work, hardwood sawdust and recycled polypropylene granules from Latvian wood mechanical and polymer processing companies were used.

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The aim of the work was to evaluate the effect of acidic treatment temperature on the wetting properties, moisture sorption and surface free energy (SFE) of aspen wood sawdust and to determine the influence of the treated wood particles on the hydrophobic and mechanical properties of the WPC samples.

II. MATERIALS AND METHODS

A. Filler

The sawdust represented a by-product of the mechanical processing of aspen wood (*Populus tremula*). For the valorization, it was treated by acid hydrolysis with 0.1% hydrochloric acid solution under mild conditions (60ºC and 90ºC, 5 h, mass ratio of wood particles to water = 1/20), followed by milling. The fraction less than 100 mkm was used for filling the polymer matrix.

B. Matrix

For making the WPCs, recycled polypropylene (rPP) (0.9 t m^{-3}, 5.2/10 min at 230ºC, 2.16 kg) was used as a polymer matrix.

C. Obtaining Composite Material

An extruder "Haake MiniLab II" and an injection molding machine "Haake MiniJet II" were used for obtaining composite materials. Filling degree was 50%; processing temperature was 175-180ºC. The extruder screw rotation speed was 130 rpm; injection molding pressure was 600-700 bar.

D. Surface Properties

To study the surface properties, WPC samples with dimensions of 60x10x1 mm were prepared. Before testing, the samples were conditioned at 60ºC for 24 h and then stored for 1 h at room temperature in a desiccator with P_2O_5.

Contact angles of the hydrolyzed wood particles and the WPC samples were measured with Kruss K100M using Washburn and Wilhelmy methods, respectively. Work of adhesion was calculated using the Young-Dupre equation (1):

$$W_A = \sigma_l (1 + \cos \alpha) \quad (1)$$

W_A – work of adhesion (mN/m)

σ_l – liquid surface tension (mN/m)

α – contact angle (degrees)

The total surface free energy (SFE) and its dispersive (Lifshitz - van der Waals interactions) and polar (Lewis acid-base interactions) components were calculated using the Owens-Wendt-Rabel-Kaelble method [12], for which the contact angle values with different liquids: water, DMSO and diiodomethane were measured. For calculation of SFE, a special software program mounted in Kruss K100M was applied.

Moisture sorption was measured using the desiccator method with 98% relative humidity.

E. Mechanical Properties

Mechanical tests were carried out with a universal machine "Zwick" (Zwick/Roell, Germany) with a load capacity of 0.5 kN according to ASTM D638 and EN ISO 178 using a software program TestXpert. Before testing, the samples were conditioned at 60ºC during 24 h and then placed in an exicator with phosphorus pentoxide. Five replicates were made for each mechanical testing, and standard deviation for each index was found.

III. RESULTS AND DISCUSSION

A. Aspen Wood Particles

Table I demonstrates the cellulose, lignin, hemicelluloses content and the oxidation degree (O/C ratio) for the initial sample and the samples hydrolyzed at 60ºC and 90ºC. It can be seen that, with increasing hydrolysis temperature, the content of hemicelluloses in wood particles decreased from 23.4% at 60ºC to 19.1% at 90ºC. Evidently, this was caused by the cleavage of glycoside ether bonds in the hemicelluloses and the release of the degraded fragments into the hydrolyzate. The hemicelluloses content in the hydrolyzate was higher at 60ºC than at 90ºC. According to Table I, the cellulose relative content increased from 51% for the initial wood particles to 53.2% and 54.7% for the particles hydrolyzed at 60ºC and 90ºC, respectively. This increase in the relative content of cellulose was associated with decreasing amount of hemicelluloses during the hydrolysis. At the same time, the content of lignin varied insignificantly with increasing temperature to 60ºC. During the acidic treatment at 90ºC, lignin, which is chemically bonded with hemicelluloses, began partly to degrade.

Table I
Component composition of initial and hydrolyzed aspen wood sawdust

Sample	Cellulose (%)	Lignin (%)	Hemi-celluloses (%)	O/C
Initial	51.0±1.7	18.5±1.2	28.3±1.5	0.937
60ºC	53.2±1.8	18.5±1.5	23.4±1.7	0.958
90ºC	54.7±1.4	17.9±1.2	19.1±1.4	0.949

The decrease in the oxidation degree of the treated wood particles from 0.958 to 0.949, as the hydrolysis temperature increased from 60ºC to 90ºC, could be explained by the drop of the hemicelluloses content in the wood particles that promoted the lowering of the surface polarity of the hydrolyzed particles.

Work of adhesion is the work required to separate the surfaces of two different phases. The higher is the work, the harder is to separate two surfaces. The work of adhesion in respect to water was calculated from the values of the measured contact angles, and the obtained results are shown in Fig. 1. It can be seen that the initial aspen wood particles are characterized by the highest work of adhesion, namely, 90.8 mN/m. After the hydrolysis, the work of adhesion of the wood particles hydrolyzed at 60ºC and 90ºC decreased by 7.3% and 10.3%, respectively. This means that the hydrolyzed particles are less

likely to attract water molecules on their surface in comparison with the initial wood.

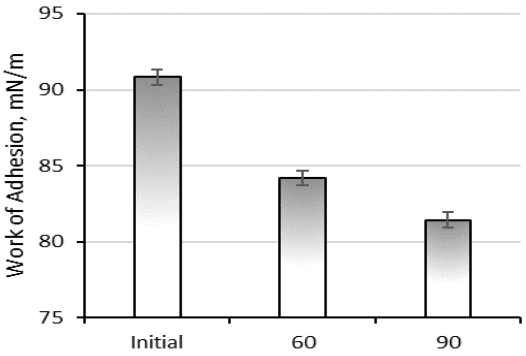

Fig. 1. Work of adhesion with water for the initial wood particles and those hydrolyzed at different temperatures.

The moisture sorption experiment was prolonged for 15 days, and its results are shown in Fig. 2. It is found that, in the first few days, the moisture content of all samples rapidly increased by about 10%, and then the sorption process became slower. The initial aspen wood particles had the highest moisture content, namely, 16.3%, and the particles hydrolyzed at 60ºC and 90ºC increased their own masses to a lesser extent, namely, by 15.5% and 14.7%, respectively. The obtained results on the moisture sorption for the treated particles correlate with the obtained values of the adhesion work.

To better understand the changes in surface properties of the treated wood particles, SFE as well as its dispersive and polar parts were calculated by the Owens-Wendt-Rabel-Kaelble method using for this purpose water, dimethyl sulfoxide and diiodomethane. The obtained results are shown in Fig. 3. It can be seen that the initial wood particles are characterized by an enhanced SFE value, namely, 31 mN/m. After the hydrolysis, SFE for the wood particles treated at 60ºC and 90ºC decreased by 22.1% and 26.6%, respectively. As shown in Fig. 3, the main drop of the SFE values of the particles is associated with the decrease of their SFE polar part, while the SFE dispersive part changes are insignificant (Fig. 3.).

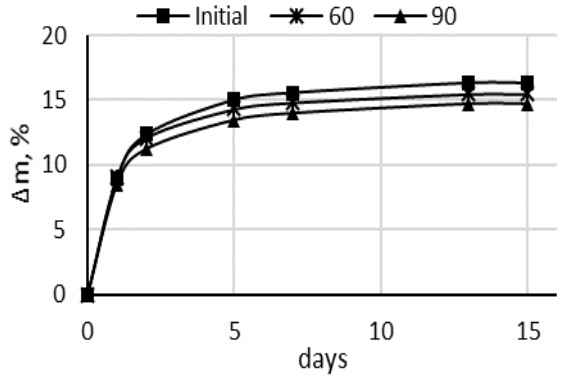

Fig. 2. Moisture sorption of initial aspen wood particles and those hydrolyzed at different temperatures.

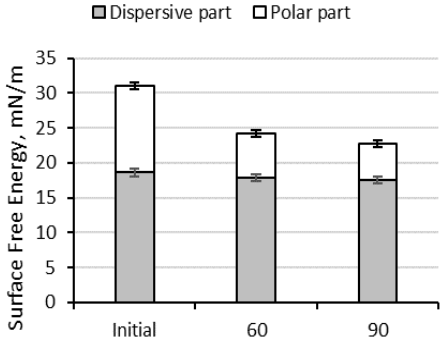

Fig. 3. SFE and its dispersive and polar part of initial and hydrolyzed wood particles.

It can be seen that the wood hydrolysis reduces the SFE polar part from 12.5 mN/m for the initial particles to 6.3 mN/m and 5.2 mN/m for the aspen particles hydrolyzed at 60ºC and 90ºC, respectively. Such a significant lowering of the SFE polar part indicates the increase in hydrophobicity of the hydrolyzed particles that is more pronounced for the wood particles treated at 90ºC.

Wood-Polymer Composites

The adhesion work values for the obtained WPC samples with a filling of 50% are shown in Fig. 4. According to the data, recycled polypropylene has the lowest work of adhesion, namely, 60.8 mN/m, which is associated with a hydrophobic nature of the polymer matrix. The WPC sample containing the initial wood particles has the highest work of adhesion equal to 70.8 mN/m, but for the WPC samples filled with the particles hydrolyzed at 60ºC and 90ºC, the work of adhesion decreases and is close to 65.3 mN/m and 64.2 mN/m, respectively.

The moisture sorption experiment was studied during 25 days. According to the results shown in

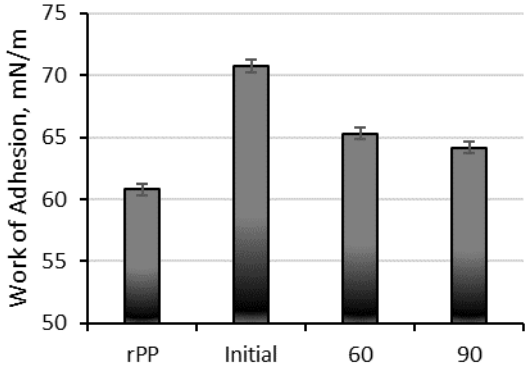

Fig. 4. Work of adhesion of recycled polypropylene (rPP) and WPC with initial and hydrolyzed aspen wood particles.

Fig. 5, the WPC sample filled with the untreated modified wood particles increased its mass by 3.5% after 25 days of the experiment. The use of the particles hydrolyzed at 60ºC and 90ºC as a filler allowed the reduction of the moisture sorption of the WPC samples to 2.9% and 2.7%, respectively. It can

be seen that the decrease in the filler moisture sorption leads to the lowering of the moisture sorption of the WPC samples. Fig. 6 illustrates the values of SFE and its dispersive and polar parts of the obtained WPC samples. It can be seen that the SFE values for the WPC samples with the treated wood particles are not changed significantly with temperature and are varied in the range of 26.2-25.4 mN/m.

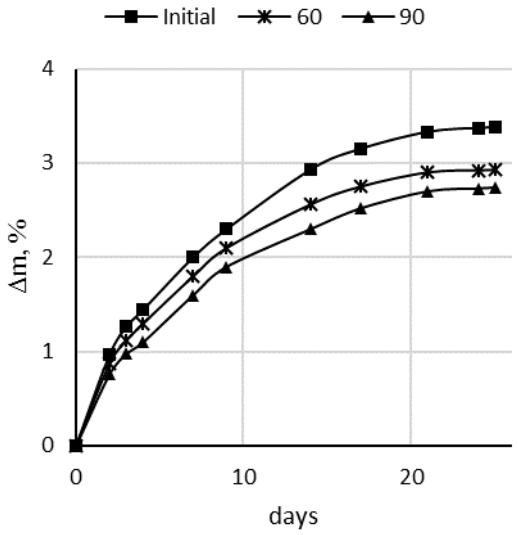

Fig. 5. Moisture sorption of WPCs containing 50 wt% initial and hydrolyzed aspen wood particles.

Because the WPC sample filled with initial particles has the highest total SFE value, its dispersive part has the lowest value equal to 16.2 mN/m that displays the hydrophilic nature of the filler. For the WPC samples containing the hydrolyzed aspen wood particles, the SFE dispersive part grows with increasing hydrolysis temperature. It is characteristic that the treatment at 90ºC essentially decreases the SFE polar part of the WPC sample containing 50% of the hydrolyzed particles. This phenomenon could be explained by an increase in the hydrophobicity of the particles, and as a result, a better compatibility between the recycled PP and the wood filler, which, in turn, leads to better mechanical properties of the WPC samples.

Table II
Tensile and Bending properties of WPC

Sample	Tensile			Bending		
	σ (MPa)	E (MPa)	ε (9%)	σ (MPa)	E (MPa)	ε (%)
rPP	20.9	495	25	26.9	898	9.3
Initial	21.2	590	17.5	28.5	1740	5.8
90	30.2	927	7.5	33.9	3210	2.1

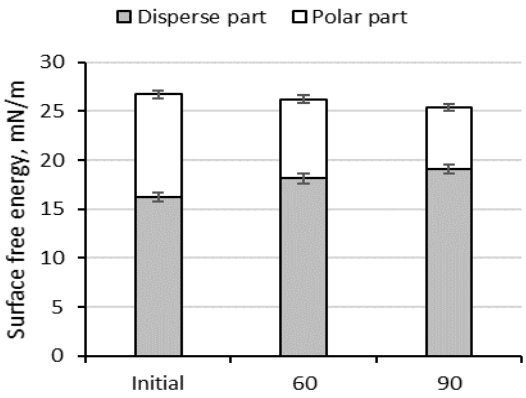

Fig. 6. SFE of the obtained WPC samples.

The studied mechanical properties (tensile and bending) of the obtained WPC samples are shown in Table II. Recycled polypropylene has the lowest values of tensile strength and elasticity modulus as well as the highest elongation. The WPC sample containing the untreated wood particles has the insignificant improvement in the mechanical properties.

At the same time, the WPC sample filled with the wood particles treated at 90ºC has enhanced values of mechanical strength and modulus as well as the lowest values of deformation. In comparison with the case of the WPC sample filled with untreated wood particles, its tensile and bending strength values increase by 40% and 19%, respectively, but the deformation decreases 2.3-2.8 times.

The pronounced improvement in the mechanical properties of the WPC sample filled with the wood particles hydrolyzed at 90ºC could be explained by the decrease of their hydrophilicity that promoted the increase of the interfacial adhesion between the polymer matrix and the lignocellulosic filler.

IV. CONCLUSIONS

The obtained results have shown that the acidic treatment of aspen wood sawdust at 90ºC leads to an increase in its hydrophobicity that decreases the wettability and moisture sorption of the obtained wood-polymer composite and increases its mechanical properties.

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REFERENCES

[1] D. Klemm, B. Heublein, H. P. Fink and A. Bohn, "Cellulose: Fascinating biopolymer and sustainable raw material," Angew. Chem., Int. Ed., vol. 44, 2005, pp. 3358-3393.

[2] A. K. Mohanty, M. Misra and L. T. Drzal, "Sustainable Bio-Composites from renewable resources: Opportunities and challanges in the green materials world," J. Polym. Environ., vol. 10, 2002, pp. 19-26.

[3] M. Carus, A. Eder, L. Dammer, H. Korte, L. Scholz, R. Essel and E. Breitmayer, "Wood plastic composites (WPC) and natural fibre composites (NFC): European and Global markets 2012 and future trends," 2014. [Online]. Available: www.bio-based.eu/markets [Accessed: Feb. 18, 2017].

[4] M. N. Rao, R. Sultana and S. H. Kota, *Solid and Hazardous waste management*. Joe Hayton, 2017

[5] C. M. Popescu, "A near infrared spectroscopic study of the structural modifications of lime (Tilia CordataMill.) wood during hydro-thermal treatment," Spectrochim. Acta. A. Mol. Biomol. Spectrosc., vol. 115, 2013, pp. 227-233.

[6] J. O. Nwadiogbu, P. A. C. Okoye, V. I. Ajiwe and N. J. N. Nnaji, "Hydrophobic treatment of corn cob by acetylation: Kinetics and thermodynamics studies," J. Environ. Chem. Eng., vol. 2, 2014, pp. 1699-1704.

[7] W. Z. W. Zahari, R. N. R. L. Badri, H. Ardyananta, D. Kurniawan and F. M. Nor, "Mechanical Properties and Water Absorption Behavior of Polypropylene / Ijuk Fiber Composite by Using Silane Treatment," Proc. Manuf., vol. 2, 2015, pp. 573-57.

[8] G. Shulga, J. Jaunslavietis, J. Ozolins, B. Neiberte, A. Verovkins, S. Vitolina and V. Shakels, "Properties of Recycled Polypropylene Based Composites Incorporating Treated Hardwood Sawdust," AIP Conference Proceedings of the 8th International Conference "Times of Polymers (TOP) & Composites. From Aerospace to Nanotechnology." Ed. A. D'Amore, D. Acierno and L.Grassia. vol. 1736, 020111 (2016); http://dx.doi.org/10.1063/1/1/4949686.

[9] G. Shulga, B. Neiberte, A. Verovkins, S. Vitolina, J. Jaunslavietis, J. Ozolins, "Short fibre filler from wood residue for polymer composite materials," Material Science, vol. 22, 2016, pp. 370-375,

[10] W. Deng, Y. Song, Q. Wang and W. Wang, "Improvement of compatibility and mechanical properties of modified wood fiber/polypropylene composites", Frontiers of Foresty in China, vol. 3, 2008, pp. 243-247.

[11] D. Ndiaye and A. Tidjani, "Effects of coupling agents on thermal behaviour and mechanical properties of wood flour/polypropylene composites," J. Composite Materials, vol. 46, no. 24, 2012. pp.3067-3075.

[12] A.W. Adamson and A. P. Gast, Physical Chemistry of Surfaces. New York: John Wiley & Sons, 1997.

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Intelligent and Adaptive Fuzzy Control System for Energy Efficient Homes

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Abstract. "Smart houses" have widely established their position as a research field during the last decade. Nowadays the technical solutions related to energy resource management are being rapidly developed and integrated into the daily lives of people. The energy resource management systems use sensor networks for receiving and processing information during the realia time. Smart house adaptive and intelligent solutions has advanced towards common environment, which can take care of the inhabitants' well-being in numerous ways. This paper propose to use a context sensitive and proactive fuzzy control system for controlling the automation processes in smart house environment. The designed monitoring system has adaptive and intelligent options, and it can operate using real time information received from sensors. The system is designed to operate fully in the background and can be installed to any exiting working system. This paper describes a central heating boiler control system implemented using the fuzzy control system designed. Author concentrates on the basic operation of such systems and present findings from the design process and initial tests.

Keywords: Energy Efficiency, Fuzzy logic, Sensow network.

I. INTRODUCTION

The number of studies related to intellectual and adaptive system use in the smart home context is increasing daily. Nowadays it is not difficult to imagine a situation when a person could live in a house where all processes are managed by artificial intelligence. Most of the time the smart system of house management system will be able to react correctly to the actions of the human or take proper proactive actions, both based on predesigned model and measured variables. However, at some point the system might make a mistake or a wrong decision which then will have to be modified or customized by the user. The adaptive control system may result in a decision-making structure which might change dynamically adding a new decision or changing the priorities of a decision. Such activities indicate some topical problems:

- how to change the decision-making and model operating scenarios;
- how the system can identify the required scenario which meets the user's needs.

Recieved data recognition is an effective method for providing existing rules and activating context linked actions [1, 5, 11]. Nowadays this is used regarding an intellectually developed environment creation and by using machine learning algorithms it can be utilized in building proactive systems [7]. Some smart home technologies have been built using content recognition technology [4] and neural networks for decision-making [9]. By using context-based smart home technology flexible and adaptive process management can be provided. Context recognition deals with fuzzy quantities of environment, like brightness, temperature, humidity, level, etc.. A person in this system acts as an expert and may affect the performance of the system by using fuzzy variables. Nowadays a lot of neural networks algorithms, which have already been utilized for decision making, can be converted to fuzzy systems to improve its implementation in smart house context. Moreover, by integrating fuzzy systems into smart home management and decision-making processes a more genuine and natural environment can be established.

This article describes the fuzzy control method for heating circuit management, which can adapt to the user's needs by acquiring new operating requirements. In order to use the system, prior training is not required; it can add or remove requirements or modify the existing ones by using the information received from the environment in real time.

II. RELATED WORKS

Today, the main studies which are related to the introduction of Smart environment into people's daily lives are associated with the device, network, software security and user interface development, that will allow the automation of the management processes and the reduction of the energy consumption in systems. Nowadays the discovery of energy consumption is ongoing and most of the producers unfortunately do not define it as main

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priority [2]. The competitiveness of European technologies could strengthen the European position in the global market for energy effective solutions. The EU is making rapid progress towards establishing Europe-wide energy consumption standards; however, most European countries have established and follow their own set of regulations.

Although smart environment system energy consumption effective solutions are currently not available, none represent a complete solution with low cost-performance parameters. The intelligent smart environment systems will raise the level of convenience for the user and reduce working system total energy consumption as result it will reduce system running costs while increasing its quality, thereby increasing competitiveness and profitability of consortium SMEs [10].

When designing automation systems more and more attention has been paid to the Fuzzy system [8] because these systems are well suited for the environment where the dynamic values can change unexpectedly and the next step cannot be predicted or calculated mathematically. Many articles have proven that Fuzzy systems are quite easy to understand and design because they are based on natural language. Control systems that use fuzzy logic in the automation process are generally fast, user friendly and cheap because they do not need much memory and resources to operate. [6]

III. FUNDAMENTALS OF THEORY OF FUZZY LOGIC

Fuzzy set theory provides a major newer paradigm in modeling and reasoning with uncertainty. Though there were several forerunners in science and philosophy, in particular in the areas of multivalued logics and vague concepts, Lotfi A. Zadeh, a professor at University of California at Berkeley was the first to propose a theory of fuzzy sets and an associated logic, namely fuzzy logic [12]. Essentially, a fuzzy set is a set whose members may have degrees of membership between 0 and 1, as opposed to classical sets where each element must have either 0 or 1 as the membership degree—if 0, the element is completely outside the set; if 1, the element is completely in the set. As classical logic is based on classical set theory, fuzzy logic is based on fuzzy set theory.

Major industrial application areas

The first industrial studies related to fuzzy logic using fuzzy control systems were initiated in the 1980s when two Danish engineers L.P. Holmblad and J.J. Østergaard developed a fuzzy controller for automated cement kilns with the option to control the specific burning temperature during the production process. The results were first published in 1982 [3]. The results did not obtain a great interest in Europe, but gained a lot of popularity in Japan where the developed methodology was improved and fuzzy logic was applied in the automation process of the Sendai City subway train management. The developed product gained a lot of support and the technology that was applied was adapted for other similar management systems which were based on the classic On – Off operating principle [5]. This success contributed to the great interest by the industry representatives regarding the feasibility of introducing the Fuzzy logic into the control system automation processes and as a result they were used in industrial control systems as well as in facility heating/ventilation systems.

In the 1990s, the Japanese started to integrate the fuzzy controller in everyday products like washing machines, camcorders, vacuum cleaners as well as transport; as a result, in 1992, a successful technology implementation experience in Japan increased the interest of Europe and the US regarding the fuzzy controller technology and this lead to the fuzzy logic implementation in Europe, in 1993 in the area of information systems.

Fuzzy and linguistic variables.

The fuzzy logic-based decision-making systems use fuzzy sets and fuzzy values. Fuzzy sets and fuzzy size definitions are based on the concept of affiliation functions. In the classical approach, the sets can be defined by using the affiliation functions with two values: value 1 is the affiliation of the object while 0 — the object's irrelevance to the set. While working in the context of fuzzy logic, intermediate values of the affiliation function are permitted, which shows the level of affiliation of an element.

As a result, the fuzzy values can be defined by using a variable set <a, Q, X> where ***a*** is the description of the value, ***Q*** is a universal set which is the definition area of value ***a*** and ***X*** is the fuzzy set that describes the value limits of the variable ***a***.

The most important task in relation to the development of the Fuzzy logic automation system is associated with the processing of the received information and its classification within databases. Profiling allows the identification of the data regularities within a system to enable decision-making. In order to increase the speed of a working system, the database performance features are provided through the individual sub-systems in which the existing knowledge is classified by using three categories – the situation, the action and the result, which reflect the system interaction with the environment.

The fuzzy logic-based decision-making system is based on the variables with fuzzy linguistic values which are effectively used in practice for two reasons:

- When the resource management tasks related to quality assurance are dealt with in the state of uncertainty, it is often crucial to interpret the quality conditions using a certain measure or a degree by which the given condition is executed or not rather than according to the

principle of "completed" / "failed" by checking the strict form of inequality as a means of quality indicator. For example, if the quality indicator must be no less than 0,6, then in the case of the value being 0,568999 the wrong decision could be made, classifying the case as an unsatisfactory result of *quality*.

- Linguistic values are a very good tool for strategic decision-making related to system building. The decision-making procedures are much easier to set and use with the help of the linguistic values of the input variables and the decision-making indicator. For instance, the use of the linguistic variable Water may result in the fuzzy values or set of values: cold, warm, hot.

IV. CONTROLLER MODEL IDENTIFICATION

The article describes the heating boiler control system, which uses three linguistic values relating to space: low, adequate, high and two linguistic values relating to water temperature: hot, cold. Let us look at a set of requirements that uses the input data of the linguistic variables. As a result, the management conditions of the distribution valve by using water temperature and the room temperature are as follows.

IF (room temperature = "high" && water temperature = "hot") THEN close control valve.
IF (room temperature = "low" && water temperature = "hot") THEN open control valve.
IF (room temperature = "adequate") THEN do nothing.
IF (room temperature = "high" && water temperature = "cold") THEN close control valve.
IF (room temperature = "low" && water temperature = "cold") THEN close control valve.

Referring to an expert opinion, the affiliation of the physical values of the temperature will be defined to the set of fuzzy values: "low" = 0,1; "adequate" = 0,5; "high" = 0,9; "cold" = 0,1; "hot" = 0,9.

Using the defined values, the conditional terms will be transformed:

Close control valve min(0,9;0,9);
Open control valve min(0,1;0,9);
Do nothing: 0,5 = 0,5;
Close control valve min(0,9;0,1);
Close control valve min(0,1;0,1);

A valve servo motor ESBE ARA 600 was used in the experiment that ensured the maximum turning step which is equal to 90 degrees. For the actuator to work, 120 seconds are required in order to execute a full cycle. As a result, the procedure "close control valve" means rotating the valve by 90 degrees and the procedure "open control valve" means rotating the valve by -90 degrees. Using the industrially defined analogue management system during the experiments has proven that the system provides inconsistent temperature changes which do not allow stabilizing the temperature of the heating system. (Fig. 1). This is based on the engine performance time (120 sec.) and the time of thermal inertia in the heating system.

To avoid wide temperature variations, the optimal valve rotation angle for every system iteration should be determined by using the formula 1.

$$\alpha = \frac{average\ value * \max value + 0.1 * range_n}{average\ value + \min value} \quad (1)$$

As a result, the data of the experiment have determined that the first rotation step of the iteration = 15,75 degrees. During the experiment, the control system can operate only with integers; this results in the first iteration rotation step being equal to 16 degrees and it is necessary for the execution of the iteration for 22 seconds. Consequently, the remaining operating range of the valve = 74 degrees and the time required for an action is 98 sec.

By completing each iteration cycle, standby time t_{wait} is required and it provides accurate reading of the information by taking into account the inertia change of the heating system temperature using formula 2.

$$t_{wait} = \frac{t_1 + t_2 + \cdots + t_n}{n}, where\ t_{wait} > t_n - t_{n-1} \quad (2)$$

where t_1 is the time between the temperature changes.

In an operating system new physical values of the temperature are defined for the fuzzy variables. Table 1 shows the operating principle of the current method which chooses the optimal valve operating range using the pre-defined conditions by reducing the temperature fluctuations.

Table1.
Valve calibration steps.

Cold	Hot	Adequate	Operating range	Operating step
0,1	0,9	0,5	90	16
0,1	0,75	0,425	75	15
0,15	0,75	0,45	60	11
0,15	0,75	0,45	60	11
0,3	0,75	0,525	45	6
0,3	0,65	0,475	35	5
0,38	0,65	0,515	27	4
0,38	0,59	0,485	21	3
0,42	0,59	0,505	17	3
0,42	0,55	0,485	13	2
0,5	0,55	0,525	5	1
0,5	0,55	0,525	5	1
0,5	0,55	0,525	5	1
0,5	0,55	0,525	5	1

It is known [5] that the thermometric temperature sensors are not able to instantly intercept the temperature changes of the particular environment as the heat exchange between the environment, the thermometric surface happens with finite rate and it takes time for the temperature sensor to read the correct temperature value. Suppose that the temperature sensor with the temperature T0 is placed

in a new environment with a temperature of Θ. As a result, the sensor temperature will change by using the formula 3:

$$T - \theta = (T_0 - \theta)e^{-\frac{\tau}{\lambda}} \quad (3)$$

where Θ – the real temperature of the environment, τ – time, λ – temperature sensor thermal inertia factor.

In order to determine the temperature sensor inertia factor, the activation time of the system is (t = 0). A certain temperature difference has been determined, if the initial temperature difference T_0 and θ is known. Consequently, the adaptive system is able to determine the inertia changes of the temperature by using the Formula 4.

$$n = \frac{T_0 - \theta}{T - \theta} = e^{\frac{\tau}{\lambda}} \quad (4)$$

As a result, using the method for determining the operational temperature range as well as the inertia factor of the temperature sensor, the article describes the algorithm of the adaptive heating valve control system (Fig. 1.):

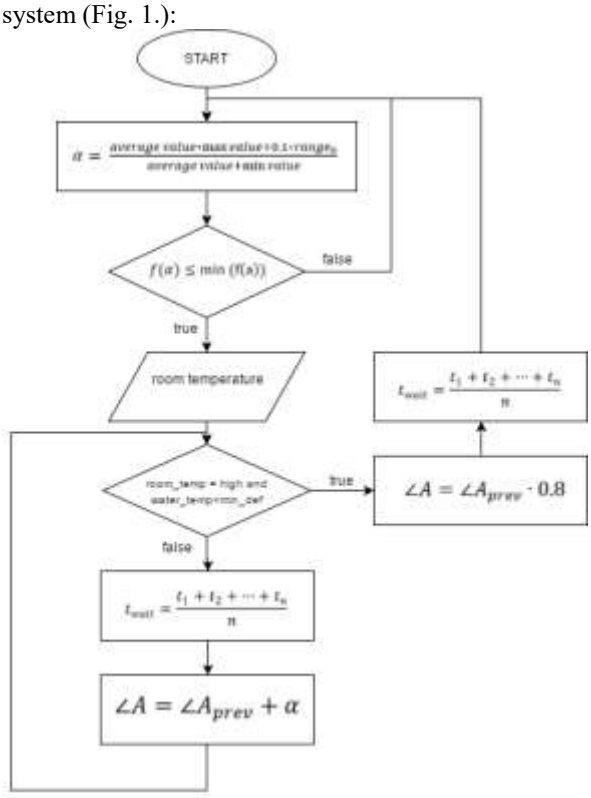

Fig. 1. Algorithm of the adaptive heating valve control system

V. ADAPTIVE SUBSYSTEM EXPLOITATION IN AUTONOMOUS ADAPTIVE CONTROL SYSTEMS.

For an adaptive control system to function, the training cycle and the operational calibration of the starting system for certain tasks and the environment – it is necessary to define a set of requirements and values of the starting system which contains general knowledge of the object and the operating environment. During the initial stage a system is able to meet the basic management principles at the beginning of the life cycle of a system or in case of emergency by using the sensor nodes. It is known that the management of a system is not effective when using only the predefined constant values in comparison with a system that works with the help of the empirical knowledge basis.

In order to create the control system of the initial phase, the article describes a situation where poorly formalized management objects are used. The main task of the system is to provide minimum object management possibilities at the early stage of the system life cycle; as a result, a control system which uses fuzzy logic principles was applied.

The system input data are the peak operating angle is l of the management engine and the maximum full time of the rotation cycle is t_{max}.

The basis of the control module consists of the fuzzy variables F1 .. Fn, dF1..dF2 described in this article characterizing the boiler temperature, room temperature and the linguistic values of the valve position:

$$\text{FN \& dFM} \rightarrow \text{AN*M} \quad (5)$$

where N and M are unclear sets that contain information about the certain room temperature and boiler temperature value range.

In order to select an executable requirement A from the requirement sets the following formula is used:

$$A = \frac{\sum(A_k \cdot P_k)}{\sum P_k}. \quad (6)$$

where A_k – the number of an executable requirement, P_k – the output values of the current requirement.

In cases when the system expert wants to limit the range of decision, the system is assigned with the requirement having the maximum value which will result in the completion of the task that matches the requirement.

VI. CONTROLLER PRACTICAL VALIDATION

Using the Climate change financial instrument as a means of co-financing in the project "The use of renewable energy sources in the household sector", in cooperation with LLC "Chelsea Trade", a private house had been connected to the heating system with a total capacity of 90kW which uses alternative and renewable resources for energy production.

The autonomous heating and hot water preparation system that was installed works, by using a series of temperature, water flow and pressure sensors for central boiler and pump node. The adaptive management of the circuit valve of the heating system was carried out with the aim of reducing the fuel and the electricity consumption during system operation.

To test the methodology described in this article a boiler control module is developed in which the control algorithm was implemented by using the Arduino language. In order to implement all the requirements of the algorithm ArduinoUno microcontroller and the analogue temperature sensor LM335 were used; to visualize the operational processes LCD displays (1602B) were used. The actuator was implemented by using ESBO ARA 600 servomotor which was used to regulate the heating valve.

The time of the experiment

- The first stage – September 2016, with the average outdoor air temperature + 13,2 C°. The heating system was in the standby mode most of the time and the highest consumption of the fuel was used to maintain the boiler combustion process (Fig 2.)

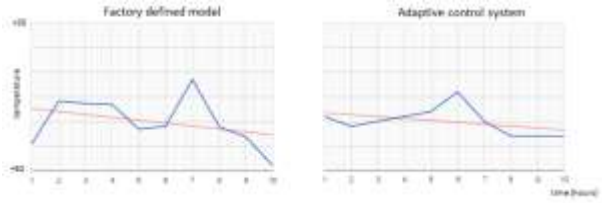

Fig. 2. The first phase of the temperature variation in the heating system.

- The second stage – November 2016, with the average outdoor air temperature + 0,6 C°. The heating system operates using 50% of its nominal capacity (Fig.3).

Fig.3. The second phase of the temperature variation in the heating system.

- The third stage – 7th January, 2017. The average daily air temperature –18,2 C°. The heating system operates using 90% of the nominal capacity (Fig.4).

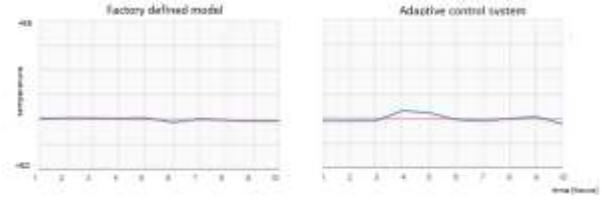

Fig. 4. The third phase of the temperature variation in the heating system

Benchmark value determination

The time t_{et} (min) will be assumed as the reference value – how long the heating system can operate using the Q quantity of fuel. Let us assume that the heating system operates via industrially defined ON-OFF valve control algorithm and the system can be considered as active as long as the room temperature stays within the given border.

As a result, each stage has certain benchmark values of the system performance, which are also taken from the boiler output temperature fluctuations.

Table 2.
Burning boiler fuel consumption

$T_{et1\ (min)}$	$Q_{1\ (kg)}$	kg/min	$T_{et2\ (min)}$	$Q_{2\ (kg)}$	kg/min	$T_{et3\ (min)}$	$Q_{3\ (kg)}$	kg/min
260	16	0,06	133	16	0,12	82	16	0,20
502	32	0,06	250	32	0,13	158	32	0,20
758	48	0,06	378	48	0,13	228	48	0,21
958	64	0,07	508	64	0,13	300	64	0,21
1218	80	0,07	592	80	0,14	398	80	0,20
1470	96	0,07	718	96	0,13	462	96	0,21
1712	112	0,07	873	112	0,13	515	112	0,22

The summary of the experiment results

During the experiment the results confirmed that:

By using the control algorithm of the adaptive heating system mixer described in this article, the overall increase in the system performance expectancy in relation to the benchmark model (Table 2) can be seen, but there are cases when the heating system is operating at a nominal capacity and the mixer valve is opened to 90%; then by using the adaptive valve control algorithm with the calibration tasks the excess energy is consumed (Fig. 5).

Table 2.
Adaptive management system application results.

Q (kg)	t_{et1} (min)	t_{fuzzy1} (min)	t_{et2} (min)	t_{fuzzy2} (min)	t_{et3} (min)	t_{fuzzy3} (min)
16	260	↑ 264	133	↑ 148	82	↑ 83
32	502	↑ 510	250	↑ 268	158	↓ 142
48	758	↑ 762	378	↑ 392	228	↓ 219
64	958	↑ 962	508	↑ 535	300	↓ 298
80	1218	↑ 1224	592	↑ 618	398	↓ 390
96	1470	↑ 1478	718	↑ 738	462	↓ 462
112	1712	↑ 1722	873	↑ 896	515	↓ 505

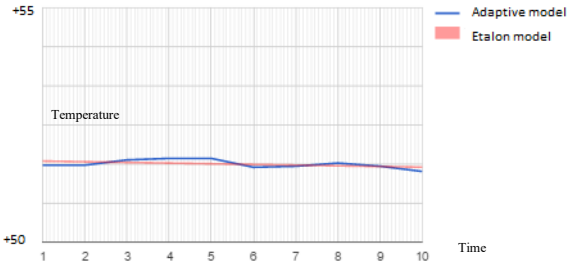

Fig.5. The heating system is operating at a nominal capacity.

VII. CONCLUSIONS

This article has described and practically tested the fuzzy control algorithm for the management of the heating system mixer module for adaptive management that can be adapted to the user's needs while acquiring new operating rules. In order to use the system, it does not need prior training, the training process takes place during the operation of the system by modifying the pre-defined requirements using the information received real-time via the sensors. The article proves that the effectiveness of the control algorithm depends on the

boiler operating temperature and the outside air temperature. In cases when the boiler operates using nominal energy, the control of the operational process increases the consumption of fuel resources wasting the heat energy through heating temperature calibration.

The long-term use of the adaptive control module of a heating system, in systems operating on 40 to 60% of the rated power is obtained by decreasing the consumption of the heating fuel by 8% (~1920 kg/year) by using a 50 kW heating system.

The data obtained will be used for further research by developing intellectual management methodology of the universal heating system.

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REFERENCES

[1] Antonio J. , Juan M. , Baringo L., "Real-Time Demand Response Model", IEEE Transaction on Smart Grid, Vol. 1, No. 3, 2010, pp. 236–242.

[2] Jurenoks A., Dejan J., Sensor Network Information Flow Control Method with Static Coordinator Within Internet of Things in Smart House Environment, Procedia Computer Science vol. 104., pp. 385. - 392. 2017

[3] Holmblad L. P., Ostergaard J. J. (1982) Control of Cement Kiln by Fuzzy Logic, Gupta M. M, Sarchez E, Fuzzy Information and Decision Processes, North Holland, pp. 389-399

[4] Kaila, L., Vainio, A.-M., Vanhala, J., Connecting the smart home, IASTED, Networks and Communication Systems, April 18-20, 2005, pp. 445-450

[5] Kuhn T. R. , "Energizing Efficiency's Potential," The Electricity Journal, vol. 19, pp. 83-87, 2006

[6] LeMay M. , Nelli R. , Gross G., Gunter C. A. , “An integrated architecture for demand response communications and control”, The 41st Annual IEEE Hawaii International Conference on System Sciences (HICSS '08), Waikola, Hawaii, January 2008

[7] Lui T. J. , Stirling W. , Marcy H. O. , “Get Smart”, IEEE Power and Energy Magazine, Volume 8, Issue 3, pp. 66-78, May 2010.

[8] Mäntyjärvi, J., Seppänen, T. Adapting applications in handheld devices using fuzzy context information, Interacting with Computers, vol. 15, issue 4, p. 521-538, August 2003

[9] Sancho J., Sánchez-Soriano J., Chazarra J. A. , Aparicio J. , "Design and implementation of a decision support system for competitive electricity markets," Decision Support Systems, vol. 44, pp. 765-784, 2008

[10] Shahgoshtasbi D., Jamshidi M. , “Energy efficiency in a smart house with an intelligent Neuro-Fuzzy lookup table”, Proc. the 6th IEEE international conference on System of Systems Engineering (SOSE 2011), Albuquerque, NM, USA, 2011

[11] Shahgoshtasbi D., Jamshidi M. , ”Modified Intelligent Energy Management system in a smart house”, Proc. World Automation Congress, Puerto Vallarta, Mexico, 2012.

[12] Zadeh, L.H., 1965. Fuzzy sets. Information and Control, pp: 338-353.

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The Assessment of Climate Change and Watershed Effect on the Heterotrophic Metabolism in the Lake Onego Ecosystem

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Abstract. Lake Onego, as one of the largest water bodies in a humid zone, is the recipient of terrestrial carbon and plays an important role in the global balance of this element. Due to heterotrophic metabolism in the Lake Onego ecosystem, substantial emissions of carbon dioxide from this lake into the atmosphere can be assumed. However, the extent of this phenomenon is still poorly known. As a climate change has led to an increase in water and organic matter flow into the northern water bodies, the carbon balance study of aquatic ecosystems is of particular relevance. The elements of the water balance for the Lake Onego catchment area in the current climate conditions are assessed. Based on satellite images the model of Lake Onego watershed terrestrial ecosystems is used to simulate the flow of organic matter into the lake with different types of vegetation and topography consideration. The assessment of the benthic communities habitat is carried out taking into account the accumulation of organic matter in various parts of Lake Onego.

Keywords: Lake Onego, remote sensing of watershed state, climate change, deepwater benthos.

I. INTRODUCTION

Lake Onego is one of the two greatest lakes in north-west region of Russia. It is cold and deep. The characteristics of the lake according to Atlas "Lake Onego" [1] are as follows: surface area - 9720 km^2; average depth - 30 m; maximum depth - 120 m; volume of water - 295 km^3; drainage basin area - 53100 km^2. There are 152 tributaries of Lake Onego. The lake is characterized by a high heterogeneity. Its main part maintains oligotrophic conditions and high quality of water. Two north-western bays (Petrozavodskaya and Kondopozskaya Bays) are polluted by municipal and industrial waste waters of the towns (Petrozavodsk, Kondopoga and Medvezhyegorsk) and characterized by mesotrophic status. The surface areas of these bays make up about 4% of the lake.

In recent years, a profound transformation of Lake Onego ecosystem is observed. The reduction of deepwater benthos number is recorded in the different regions of the lake [2]. In general, this indicates the reoligotrophisation processes that occur in many reservoirs in the world. However, plankton indicators suggest return of the lakes to the lower trophic status [3, 4, 5]. In Lake Onego the state of plankton communities remains relatively stable [6], while benthos community undergoes dramatic changes.

It is necessary to consider the peculiarities of the ecosystem metabolism to understand the complex processes in the Lake Onego. The ratio of primary production and respiration are indicators of organic matter balance and anthropogenic impact on the water body [7, 8]. It is important to know the amount of organic matter inflowing from the catchment area. This is particularly relevant in relation to climate change, which became the most prominent in the 2000s [9]. The aim of the present study was to analyze the Lake Onego ecosystem transformation, with due regard to the ecosystems metabolism, the impact of the catchment area, and climate change effect.

II. MATERIALS AND METHODS

The data of long-term meteorological observations on Hydrometeorology and Environmental Monitoring Stations of Russian Federal Service network for the period up to 2016 were used for the analysis and evaluation of the variability of the climate characteristics (air temperature).

Phytoplankton photosynthesis was measured using radiocarbon [10] and plankton respiration rate was determined using the light/dark bottle method to detect changes in the oxygen concentration in the sample water [11] after incubation at a temperature corresponding to lake water.

The deepwater benthos in Lake Onego was sampled by dredge with square area 0.025 m^2 according to Guidelines [12, 13].

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DOC export to the lake is estimated as a function of the vegetation cover types within the watershed. Watershed delineation were made using 30 m resolution DEM, vegetation types is a result of Landsat TM/ETM+ imagery classification. Images and DEMs were downloaded from GLCF ftp://ftp.glcf.umd.edu/glcf/Landsat/WRS2

Another approach to information extraction from TM/ETM+ imagery has been applied. It involves transformation of multi-dimensional image space in visible 3D one and localization in this space the segments of main ecosystem types of territory. So, the method can be named "spectral space modeling". Spectral space model is built in LC1-LC2-MSI axis: two first principal components of the image matrix in logarithmic form, and Moisture Stress Index:

$$LC1 = 0.2793 * \ln(R) + 0.7786 * \_ \ln(NIR) + 0.5619 * \ln(SWIR2)$$
$$LC2 = 0.5887 * \ln(R) - 0.6012 * \ln(NIR) + 0.5404 * \ln(SWIR2)$$
$$MSI = SWIR1/NIR$$

where R, NIR, SWIR1, SWIR2 - Landsat ETM+ bands 3, 4, 5, 7 digital numbers, respectively; ln - natural logarithm.

LC1 accounts for general scene brightness, LC2 correlate with quantity of green biomass, but not orthogonal to brightness [14, 15]. So, in physical terms this transformation is similar to Tasseled Cap [16, 17], but it makes space more "compact", understandable and suitable for analyzing. Localization of spectral classes within the model space was made using airphotos, forest inventory maps, landscape transects and other ground knowledge.

III. RESULTS AND DISCUSSION

The last decade there is a sharp decrease of the deepwater benthos number in different areas of Lake Onego. These processes are the most significant in Petrozavodskaya Bay. The total abundance and biomass of benthos at the central station of this bay fell by 6 times in 2010-2016 compared with 1990-1995 (Table 1).

Table I
The abundance and biomass of the deepwater benthos in Petrozavodskaya Bay of Lake Onego in the 1990-2016 (the central station of the bay)

Years	Parameters	Total abundance. thousands of ind/m^2	Total biomass, g/m^2
1990-1995	Average	6.47	15.26
	min	6.13	10.63
	max	7.14	20.95
1996-2000	Average	4.66	9.80
	min	3.69	8.56
	max	5.73	11.73
2001-2005	Average	4.92	18.20
	min	4.39	14.52
	max	5.37	25.82
2006-2010	Average	2.99	6.93
	min	1.22	3.86
	max	5.22	11.00
2011-2016	Average	1.06	2.67
	min	0.44	1.20
	max	1.84	4.24

The main representatives of the benthos are relic crustaceans (Amphipoda), oligochaetes and chironomids. The abundance and biomass of amphipods and oligochaetes reduced during the analyzed period. Parameters of chironomids, which are characterized by low share in the total number and biomass, do not show any tendency to change. Integrated assessment of the benthos total biomass at depths of 10-30 m was done for Petrozavodskaya Bay in different periods of observation. In 2001-2006 total integral biomass of benthos (in terms of organic carbon) at depths of 10-30 m was 524 tons [18]. In 2007-2014 the integral biomass at these depths was 283 tons i.e. it has decreased almost in 2 times [2].

The production and respiration processes in Lake Onega [7] were taken into account to explain the observed situation with a sharp change in the benthic abundance. There is a dramatic difference in the rate of photosynthesis and destruction of organic matter in polluted bays and the central part of the Lake Onego due to the high heterogeneity of the ecosystem. The processes of anthropogenic eutrophication are observed in the north-western bays of Lake Onego (Petrozavodskaya and Kondopozskaya bays). Here there are the maximum values of primary production, especially in the upper parts of the bays: 327±57 mg C/м^3·day in the surface layer in Kondopozskaya Bay; 127±27 mg C/м^3·day in the surface layer in Petrozavodskaya Bay. The values of respiration in these bays are also high: 170±77 и 103±21 mg C/м^3·day in this layer, respectively.

The situation at the deepwater areas of Lake Onego quite differs from the polluted bays. The primary production of organic matter and respiration rates at the central part of lake are characterized by low values. The average values of photosynthesis for profundal lake area is 19.7±1.8 mg C/м^3·day. The intensity of respiration processes in the central parts of the lake is characterized by values 31.0±4.6 mg C/м^3·day. Rates of photosynthesis and destruction are comparable with that of extracellular phytoplankton production. So, all organic matter synthesized during photosynthesis is mineralized in the photic zone.

The integral values of primary production and respiration (in terms of water column) are very different. The respiration rates are higher than production ones 10-12 times. A significant predominance of respiration above the primary production is connected with the heterotrophic type of metabolism of Lake Onego ecosystem due to a large number of allochthonous organic matter which inflow into the reservoir.

Since all of the synthesized (autochthonous) organic matter potentially can be exploited in the surface layers of water, the food base of deepwater benthos of Lake Onego is mainly determined by allochthonous organic matter. The main source of allochthonous organic carbon entering the Lake Onega is the river flow (90-91.5%) due to the high

swamped catchment [20]. A small part of the allochthonous organic carbon enters the lake from the precipitation (3.9-5%) and wastewaters (4.6-5%).

It was of interest to review the dynamics of the carbon inflow with the tributaries in the context of the sharp decline of benthos abundance in Lake Onego. The results of observations on the tributaries of Lake Onego during 1965-2008 were used [19]. In 1965-1986 permanent seasonal observations were carried out on 22 lake tributaries and occasionally at several small rivers. In the 2000s, the monitoring was conducted on 28 tributaries. It was shown that some changes in the organic carbon flows into the lake occurred (Table 2). Thus, the years 2007-2008 were characterized by increased river discharge into the lake. At the same period the total organic carbon concentrations in the water of the main tributaries increased: up 13.4-16.1 mgC/l (1985-2002) to 16.8-18.1 mgC/l (2007-2008). These factors together can determine the increase in organic carbon input with the river waters in 2007-2008 to 1.4-1.6 times as compared to the previous period.

Table II
River discharge into the Lake Onego (V, km3/year) and total organic carbon inflow with the tributaries (TOC, thousands of tons/year) in 1965-2008 (according to the data by [20])

Parameters	1965-1966	1985-1986	2001-2002	2007-2008
V	15.55	12.75	14	17.79
TOC	216	189	214	299*

Note: * - including, 36.7 thousands of tons/year – flow of total organic carbon in previously unstudied tributaries.

However, the accuracy of the organic carbon inflow estimates depends on the completeness of the studied tributaries (see Table 2). In this regard, the organic carbon flow from the catchment area was assessed using satellite images.

Spectral segments of mature and old-growth pine (Pinus sylvestris L.) forests, dominated in the region, are straightening from ecological optimum (moraine ridges - myrtillus type) in directions of two main environment gradients:

a) automorphic - lack of water and nutrition (fluvioglacial sands -> bedrock)
b) hydromorphic - degree of paludification (lacustrian planes)

Thus, the biogeocenotic complexes (Quaternary deposits - soil - vegetation) are identified. Clearly traced in spectral space succession trajectories of forest regeneration (new clear-cut – young - middle age – sub-climax), also associated with the type of Quaternary deposits.

For mire ecosystems spectral classes accurately reflect type of water and mineral nutrition (oligotrophic/mesotrophic). Ambiguous classes (e.g. some types of non-closed canopy stands) decomposition made with use of geomorphometric model and time series imagery, and as a result all basic classes of primary ecosystems, and also various variants and stages of their natural and anthropogenous disturbances, in total a few dozen categories are distinguished (Fig. 1).

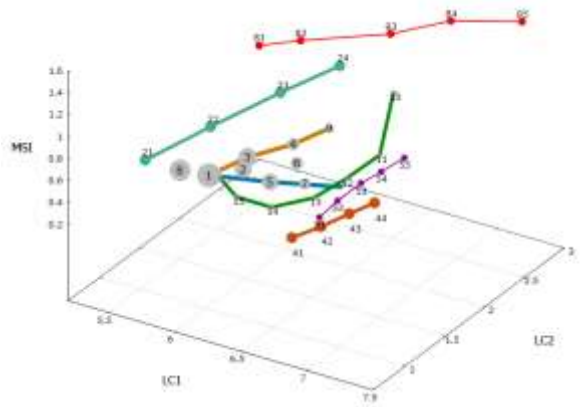

Fig. 1. Spectral space model of the watershed terrstrial ecosystems. Digits represent the centers of spectral classes: 1-2-3-4 – pine forests on authomorfic soils (upland), 8 – spruce forest, 5-6-7 – wetland forests, 21-24 - open mesotrophic mires, 41-44 – open ombrotrophic mires, 10-15 – trajectory of forest regeneration, 51-55 – crops, meadows, 81-85 – non-vegetation (sands, roads, settlements).

At present no in situ data within the Onego lake basin is available, thus the values of DOC export from each type of ecosystem could only be assessed from literature data [21, 22]. Mean values for two main ecosystem classes, upland forests and wetlands, were accepted (Table 3).

Table III
Total watershed loading to the Onego lake

Ecosystem type	Spectral classes (see Fig. 1)	Total area, mln ha	DOC export, $ha^{-1} \cdot yr^{-1}$	Lake input, thousand of $ton \cdot yr^{-1}$
upland forest	1-4, 8, 12-15	3.8	40	152
peatland	5-7, 21-24, 41-44	0.87	70	60.9
			Total	212.9

This approximate estimate shows that about 200 thousand of tons of dissolved organic carbon inflow from the catchment area into Lake Onego in the 1990-2010 per year. This value is sufficiently close to those obtained previously, despite the fact that total organic carbon flow was accounted in the field observations (see Table 2). Thus, it can be argued that the flow of organic carbon from the tributaries into Lake Onego in the 2000s (when there was a change in the benthic communities), at least not decreased. Consequently, the decline of the deepwater benthos abundance in Lake Onego is not connected with the organic carbon inflow from the tributaries.

A possible reason of benthos abundance decreasing at the bottom is the reduction of anthropogenic load in the last 15 years [2]. The wastewaters inflow in Petrozavodskaya Bay in 1990-2005 was 46-51 million of m^3 per year. Since the year 2005, the anthropogenic load on the Petrozavodskaya

bay is 28-33 million of m^3 per year, i.e. it is reduced in 1.5-1.8 times. However, the scale of reduction in benthos abundance (at the central station in Petrozavodskaya Bay - 6 times) are not comparable with the lowering of the wastewater volume.

It should be noted that the most important group of deepwater benthic communities are relic crustaceans, i.e. coldwater organisms. For glacial relic crustaceans optimal temperature ranges are shifted toward lower values [23]. This explains their distribution in reservoirs with greater depths, where the water temperature is kept low in the summer. Perhaps the reason for reduction of benthos abundance, including glacial relict crustaceans, is a climate change. The air temperature data indicate climate change in Karelia. So, for the period from 1989 to present time, the average annual temperature has increased by 1-2 °C as compared to with the previous period [9]. The duration of the ice-free period for Lake Onego increased by 20 days [24].

The average annual air temperature in Petrozavodsk can be presented in terms of deviations from the climatic norm, see Figure 2.

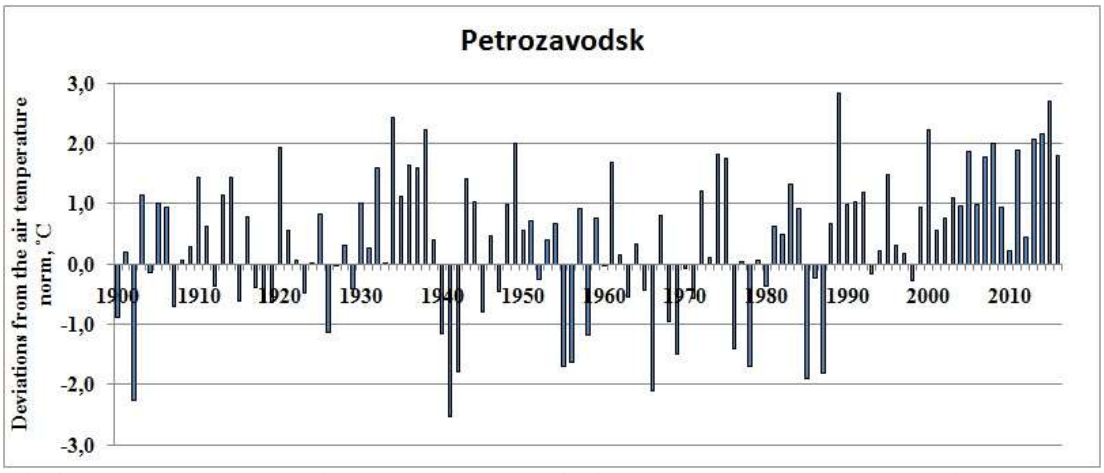

Fig. 2. The deviations of the average annual air temperature (ºC) from the climatic norm (1961-1990), Meteorological station, Petrozavodsk, 1900-2016.

The long-term average annual air temperatures for the 1961-1990 were used as the climate norm. The graph shows the temperature increase since the beginning of the century. In the 1950s the relative cooling was observed, which was replaced in the 1980s by the climate warming. Since 1989, a steady increase of average annual air temperature above normal ones is observed. This trend is also observed for the entire territory of the Republic of Karelia [9, 25, 26]. It should be noted that, although the temperature during the last 20 years exceeds the climatic norm, its further growth is not revealed.

Currently the change of the surface water layer temperature of Lake Onego is studied. It is shown that the shift of water surface temperature through 10°C occurs on earlier date of spring with the rate 1.4-1.7 days/10 years [27]. It is found that the amount of effective for biota water temperatures (above 10°C) increased and the period of "biological summer" became longer as a result of regional climate change over the Lake Onego. However, data on the changes of temperature in the deep layers of the water is absent. The observed reaction of the deepwater benthos determines the relevance of a more detailed investigation of possible temperature regime changes for Lake Onego under conditions of regional climate change.

IV. CONCLUSIONS

Thus, the heterotrophic metabolism of the Lake Onego ecosystem shows the great role of allochthonous organic matter in the functioning of deepwater benthic communities. The field observation of the organic carbon inflow into Lake Onego and assessment of terrestrial organic carbon fluxes based on the analysis of satellite images have shown that the amount of allochthonous organic matter remains relatively constant throughout the 2000s. Possible reasons for a sharp decline of deepwater benthos abundance in Lake Onego in the last decade may be a reduction of anthropogenic load and climate change.

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REFERENCES

[1] *Lake Onego. Atlas* / Editor. Ed. N. N. Filatov. Petrozavodsk: Karelian Research Centre, 2010. (In Russian)

[2] N. Kalinkina, A. Sidorova, T. Polyakova, N. Belkina, N. Berezina, I. Litvinova, *Decline in the deepwater benthic communities abundance in the Onego Lake under multifactor influence* // Principy èkologii. 2016. Vol. 5. № 2. pp. 47–68. (In Russian)

[3] M. M. Tilzer, U. Gaedke, A. Schweizer, B. Beese, T. Wiese, *Interannual variability of phytoplankton productivity and related parameters in Lake Constance: no response to*

decreased phosphorus loading? // Journal of Plankton Research. 1991.Vol. 13. N. 4. pp. 755-777.

[4] D. Straile and W. Geller, *Crustacean zooplankton in Lake Constance from 1920 to 1995: Response to eutrophication and re-oligotrophication* // Advances in Limnology. 1998. V. 53. pp. 255-274.

[5] E.V. Donk, D.O. Hessen, A.M. Verschoor, R.D. Gulati, *Re-oligotrophication by phosphorus reduction and effects on seston qualityin lakes* // Limnologica. 2008. V. 38. pp. 189–202.

[6] E. V. Tekanova and M. T. Syarki, *Peculiarities of phenology of the primary production process in the pelagic zone of Lake Onega* // Biology Bulletin. 2015, Volume 42, Issue 6, pp. 556–562.

[7] Tekanova E.V. and Timakova T.M., *Primary production and destruction of organic matter in Lake Onego* // Status and Problems of Production Hydrobiology. Moscow, 2006. pp. 60-70. (In Russian)

[8] E.V. Tekanova, *The contribution of primary production to organic carbon content in Lake Onego* // Inland water biology. Vol. 5, Issue 4, pp. 328–332.

[9] L. E. Nazarova, *Variability of average long-term air temperature values in Karelia* // Regional Research of Russia. 2014. T. 146, issuance 4. pp. 39-45. (In Russian)

[10] S. I. Kuznetsov and G. A. Dubinina, *Methods of studying aquatic organisms* / Nauka, Moscow, 1989 (in Russian).

[11] G. G. Winberg, *Primary production of water bodies* // Science Academy of BSSR, Minsk 1960 (in Russian).

[12] Guidelines for the collection and processing of materials in hydrobiological research on freshwater reservoirs. Zoobenthos and its products / Ed. G.G. Winberg, G.M. Lavrentiev. - L .: GosNIORKh. 1984. 52 p. (In Russian)

[13] Guidelines for the collection and processing of materials in the conduct of monitoring of biological pollution in the Gulf of Finland. / Ed. A. Alimov, T. Florinskaya (eds), St. Petersburg, 2005 (In Russian)

[14] P. Yu. Litinskiy, *Multispectral imagery classification method based on spectral space modeling* // Proceedings of the Karelian Research Centre of the Russian Academy of Sciences. № 5. Mathematical Modeling and Information Technologies. 2011. pp. 45-54. (In Russian)

[15] P. Yu. Litinskiy, *Geoinformation model of Eastern Fennoscandia Northern taiga ecosystems* // Proceedings of the Karelian Research Centre of the Russian Academy of Sciences. № 1. BIOGEOGRAPHY Series. 2012. pp. 3-15. (In Russian)

[16] R .J. Kauth and G. S. Thomas, *The Tasseled Cap – a graphic description of the spectral-temporal development of agricultural crops as seen by Landsat* // Proceedings on the Symposium on Machine Processing of Remotely Sensed Data, 4b: 41-51, 6 June - 2 July 1976 (West Lafayette, Indiana: LARS, Purdue University).

[17] C. Huang, Yang, L. Wylie, Collin Homer, G. Zylstra, *Derivation of a tasselled cap transformation based on Landsat 7 at-satellite reflectance*. USGS Staff - Published Research. 2002. Paper 621. Conservation Ecology 8 (2): 3.

[18] A.V. Ryabinkin and T. N. Polyakova, *Macrozoobenthos of lake and its role in fish food* // Bioresource of Lake Onego. Petrozavodsk: Karelian Research Centre, 2008. pp. 67-91. (In Russian)

[19] A. V. Sabylina, *External load on the lake* // The largest lake-reservoirs of the North-West European part of Russia: current state and change of ecosystems under climatic and anthropogenic impacts / Editor. Ed. N. N. Filatov. Petrozavodsk: Karelian Research Centre, 2015. pp. 68-72. (In Russian)

[20] A. V. Sabylina, *Organic carbon, total phosphorus and total nitrogen inflow to Lake Onego with stream runoff, and their removal by Svir river waters in 1965-2008* // Proceedings of the Karelian Research Centre of the Russian Academy of Sciences. LIMNOLOGY Series. № 9, 2016. pp. 68-77. (In Russian)

[21] C. D. Canham, M. L. Pace, M. J. Papaik, A. G. B. Primack, K. M. Roy, R. J. Maranger, R. P. Curran, D. M. Spada, *A spatially explicit watershed-scale analysis of dissolved organic carbon in Adirondack lakes*// Ecological applications, 14: 2004 pp. 839–854.

[22] H. A. De Wit, J. L. J. Ledesma, M. N. Futter, *Aquatic DOC export from subarctic Atlantic blanket bog in Norway is controlled by seasalt deposition, temperature and precipitation* // Biogeochemistry 2016, Volume 127, Issue 2, pp. 305–321

[23] L.M. Sushchenya, V.P. Semenchenko, V.V. Vezhnovets, *Biology and production of glacial relict crustaceans* // Science and Technology, 1986. 160 p. (In Russian)

[24] T. Efremova and N. Palshin, R. Zdorovennov, *Long-term characteristics of ice phenology in Karelian lakes* // Estonian Journal of Earth Sciences. 2013. V. 62. № 1. pp. 33–41.

[25] L. E. Nazarova, *Long-term air temperature changes in Karelia* // Geography and Natural Resources. 2008. № 3. pp. 75–79. (In Russian)

[26] L. E. Nazarova, *Characteristics of the dynamics of temperature of Karelia* // Geography and Natural Resources. 2012, № 4. pp. 170–174. (In Russian)

[27] N.N. Filatov, L.A. Rukhovets, L.E. Nazarova, A.P. Georgiev, T.V. Ephraim, N.I. Pal'shin, *Climate change impacts on the ecosystem of lake north of European Russia* // Proceedings of the Russian State Hydrometeorological University. A theoretical research journal. Issue 34. –St. Petersburg: RSHU Publishers, 2014. P. 49-55. (In Russian)

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Water Springs Research in Utena District (Lithuania)

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Abstract. water springs can be researched like the objects of geo heritage, geo diversity, geo tops, nature, drinking water resources, mythology, tourism objects and others. They are important from the scientific, aesthetic, tourism, and cultural points of view. This article aims to analyse water springs as geo tops, geo heritage and drinking water resources. The content of water's chemical structure, cations and anions in spring water will be taken into account. After the water quality analysis in Utena district was made, it was set that the prevailing springs' water is slightly alkaline hard water of relatively low conductivity. The prevailing anions are hydrocarbonates, and the prevailing cations – calcium, sodium, magnesium. The amount of the nitrates does not exceed the limits.

Keywords: Geo heritage, Geo diversity, Geo top, Geo sites, pH, cations and anions.

I. INTRODUCTION

We rarely talk about the destruction of geological and geomorphologic objects because of the same reasons, especially because of agricultural development, construction. The mechanic erosion destroys the hills, deteriorates the soil. It is important to determine the priorities of research and protection. More than twenty years ago, scientists have made a distinction only one category - the geographical extremes. There are the largest, longest, deepest natural objects. Now scientists distinguish much more categories. For example geo diversity, geo hertage, geo sities, geo tops and other. [1] These categories are interrelated. The geo tops were started to analyze latest. Mostly analyzed geo tops in Lithuania are water springs. In this article the main attention will be paid to the water quality analysis from the springs in Utena district.

II. MATERIALS AND METHODS

Firstly, we need to determine what the geo diversity is, what most important objects should be included into the geo tops and geo heritage lists and to determine the level of their protection.

Geo heritage defined in the recommendations of Council of Europe (2004) – it is scientific, cultural, aesthetic, landscape, economic and generic value of natural geological objects that must be preserved to the future generations. Present experience shows that geo heritage can be used for recreation, educational tourism, education and training but the most important its value is scientific. [1]

Geo diversity can be described as the variety of elements of geology — the rocks, minerals, fossils and soils — and the natural landforms and processes that shape them throughout geological time. Geo diversity also recognises the link between people, landscape and their culture. The recognition of the concept of geo diversity represents an opportunity for the geological sciences to raise their profile, and raise awareness of the importance of abiotic parts of ecosystems. Geo diversity is the process of recognising and assessing the value of geological features, collections, sites, monuments, artworks, and landscapes and the application of practices for their care, maintenance and management for the long-term benefit of all. [2]

Beside the state protected geo heritage objects, there is one more geo heritage category – geo tops. They are scientifically and educationally (unique and reference) important geological, geomorphologic, hydrogeological objects and their groups – forms of relief, outcrop, boulders and their accumulations, high yield or increased mineralization ground water springheads, excavations, exposures and others. Very often they have huge aesthetic, tourist, archaeological, historical and cultural value. Most of them already have the status of nature heritage objects, the others are potentially claimed to be protected by the state. Part of the geo tops are in the private property or formed by human. [3]

Since 1995 – geo tops are analysed and registered by Lithuania Geology Service by the Ministry of Environment. They are registered in the Geo tops subsystem of the State geology informative system. In this subsystem it is possible now to find information about 641 geological, geomorphologic, hydro geological and hydrographical natural heritage objects. Geo tops are determined by carrying out state geological mapping, special scientific research, getting information from

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research organisations, individual nature explorers and promoters, and the directions of protected territories. [4]

Every state (municipality) has to „collect“ (register) its explored geo collection made up from geo diversity, geo heritage, geo tops and other reference and unique natural objects. This list will enable to know the available objects, research, protect them and be proud of them. [1]

The mostly researched geo tops in Lithuania are water springs. Springhead or water spring is the place where underground water exudes from the underground naturally. The concentrated spontaneous underground water outfall to the ground surface or under the water happens. It often forms there where the underground water layers are being crossed by the present relief forms (valleys, ravines, lake pits). It can also form due to geological-structural features of the locality, the rock filtration. Most authors of the world classify the sources according to the overflow conditions on the ground surface, duration of action, abundance of water, chemical structure and temperature. The water springs could be rising, falling, permanent, seasonal and temporary, freshwater and mineral and others. According to the origin of the feeding water, the springs can be divided into surface, ground or artesian. [5]

The springs, rising from the compressible watery layers, are characterized as having quite stable chemical structure, yield, temperature, and the quality of the ground water springs often depend on pollution objects or the agricultural or any other activities performed in the surroundings (nutrition area), the yield and the temperature can change in the bigger range. [5]

The quality of the water in the local groundwater system will generally determine the quality of spring water. The quality of water discharged by springs can vary greatly because of factors such as the quality of the water that recharges the aquifer and the type of rocks with which the groundwater is in contact. The rate of flow and the length of the flowpath through the aquifer affects the amount of time the water is in contact with the rock, and thus, the amount of minerals that the water can dissolve. [7]

The water springs are not used for water supply or irrigation in Lithuania. In most cases the water springs‘ water is used by the people living nearby. In order to find out if the spring is suitable for the water supply, firstly the watery layer that feeds the spring must be identified. If the spring is fed by the subsoil waters, it is not suitable for the water supply because it has low abundance of water, it can be easily contaminated or to dry up in certain season. The springs fed by the ground waters are worth our attention. Lithuanian hydrogeologists estimated that it is possible to get over 3 million m^3 fresh drinking water from the underground without making any damage to environment. [5]

Groundwater zone of bicarbonates is spread on the entire country and is used for drinking water supply. Thickness of it is changing from 200 – 400 m at Baltija and Žemaičiai highland, to 50 – 150 m at the Nemunas lowland. Despite differences of chemical composition and mineralization in various aquifers or parts of them, the ions of bicarbonate and calcium prevails. A groundwater of sulfate, chloride–sulfate and chloride hydrochemical zones is used or could be used in future for balneologic and industrial purposes. (Both can be active in future). [6]

III. RESULTS AND DISCUSSION

Lately, a lot of water springs are being researched in the protected territories of Lithuania‘s by Lithuania Geology Service by the Ministry of Environment. So that there would be as less unsearched water springs in other places, the decision to research a few water springs in Utena district was made.

The quality of the water was analysed from 9 water springs in Utena district. The position of the water springs is shown on the map made by Arcgis online programme (Figure 1). There are two springs in one place, called Lydekos in Figure 1 (Didžioji lydeka and Mažoji lydeka).

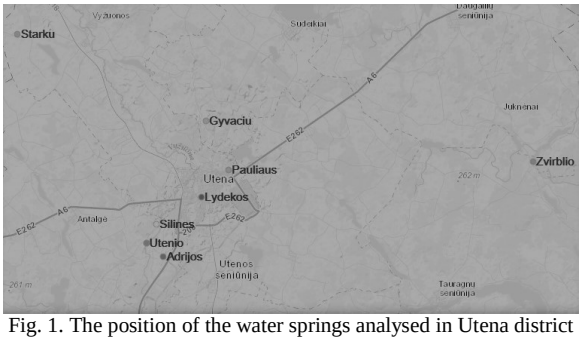


Fig. 1. The position of the water springs analysed in Utena district

The water analysis was carried out in a certified laboratory by Lithuania Geology Service by the Ministry of Environment. The laboratory, while analysing the water, follow the hygiene norm HN 24:2003 of the Republic of Lithuania “Safety and quality requirements for drinking water”. Various water quality indicators were analysed.

Acids and alkalis balance indicator pH (hydrogen ions concentration indicator) influences physical features of water. It varies from the most acid – 0 to the most alkaline – 14. The environment, where pH is equal to 7, is called neutral. While analysing the water springs in Utena district, the hydrogen ions concentration indicator in the water was set Figure 2). In different springs in Utena district pH varies not so much, it is from 7,63 to 8,47 because slightly alkaline water prevails in Lithuania. This chemical water indicator is not regulated in the hygiene norm HN 24:2003 because drinking water is close to

neutral value and does not have influence to people's health.

Under natural conditions the water is not chemically pure (H_2O). The underground water is a multicomponent mineral salts solution in which prevail calcium, magnesium, sodium, potassium cations; chloride sulphate hydro carbonate anions and necessary elements (biologically active microelements), which include in various compounds: fluorine, manganese, iron, iodine, zinc, copper and others. Their concentrations and proportions in the water depend on the variety of the hydrogeological conditions, the initial composition of the rocks, where the water lies. The entirety of the inanimate materials dissolved in the water determines the general natural water mineralization and its chemical composition. [5] They influence the taste and smell of the water.

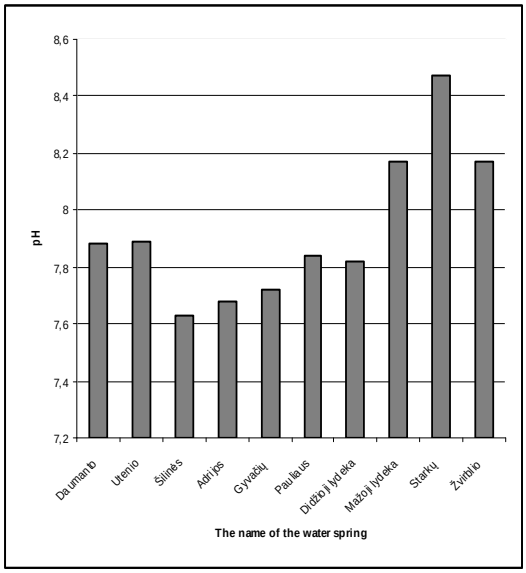


Fig. 2. Hydrogen ion concentration, pH units 20^0C

Distinctive electric conductivity is the physics indicator of water quality. Chemically pure water do not conduct eletricity. Conductivity is provided by the salts ions that are melted in water. HN 24:2003 regulate that distictive electric conductivity would not be over 2500 µS cm^{-1} in 20^o temperature.

In the spring water from Utena district (Figure 3) the distinctive electric conductivity is relatively low – from 520 µS/cm (in Utenis spring) to 1081 µS/cm (in Starkai spring). It means low level of dissolved salt ions.

Hardness in water is determined by entirety of salts in it (calcium and magnesium hydrocarbonates, carbonates, sulphates, chlorides). The salts of water hardness are not harmless to person's health, so it is not regulated.

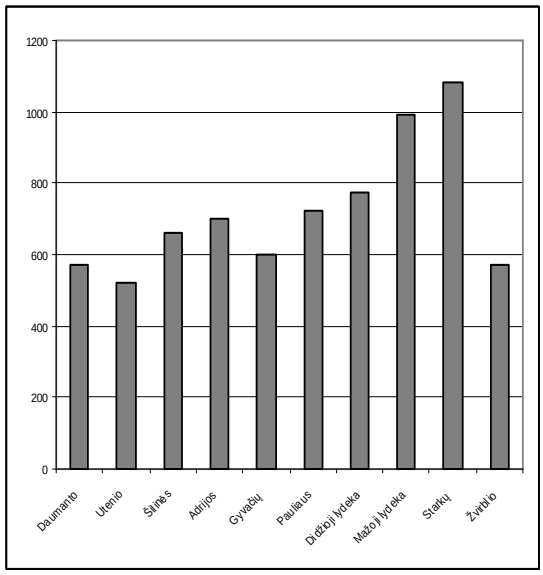


Fig. 3. Distinctive electric conductivity, µS/cm

The water hardness in the springs of Utena district is shown in the Figure 4. Carbonate and non-carbonate hardness make up the general hardness of the water. It is not low, the lowest is in Utenis spring – 5,83 mg-ekv/l, and the highest was set in Starkai spring – 11,93 mg-ekv/l.

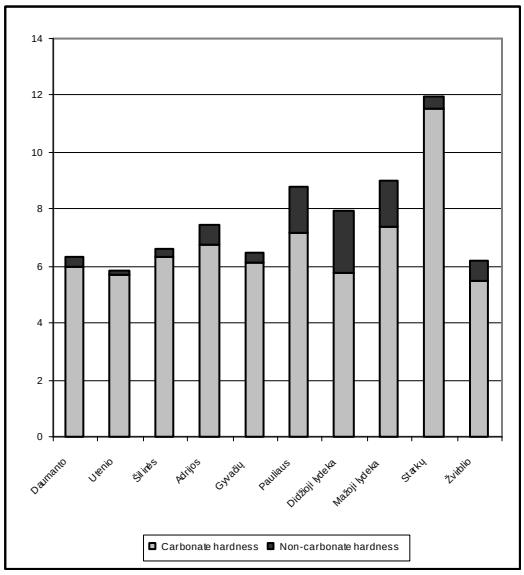
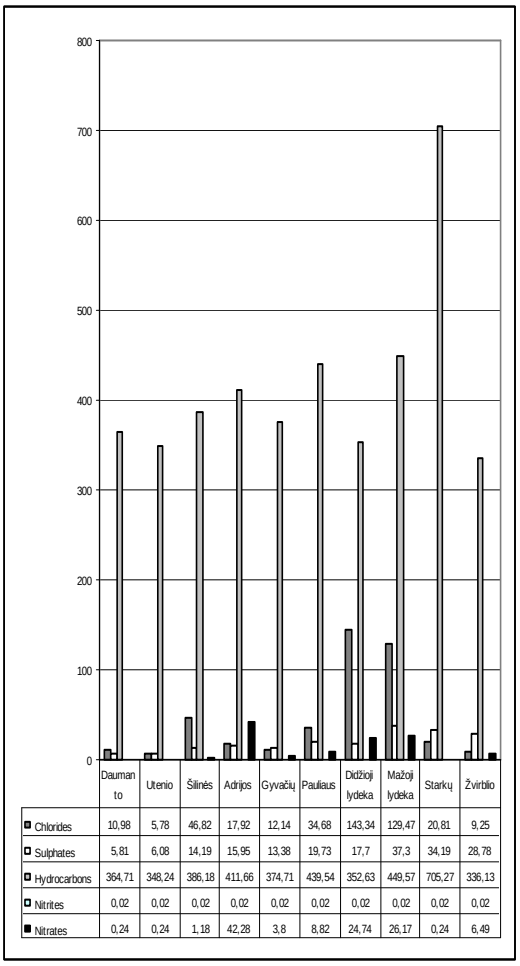


Fig 4. General spring water hardness, mg-ekv/l

The advantage of the carbonate hardness is that it becomes lower when the water is being boiled as it turns into sediment. The highest non-carbonate hardness was set in the springs located in the city.

Sometimes the chemical water's composition is expressed by fake fraction where the meanings of the anions over 10% ekv. in the descending order are written in the numerator, and the meanings of the cations are written in the denominator (over 10% ekv.). [5]

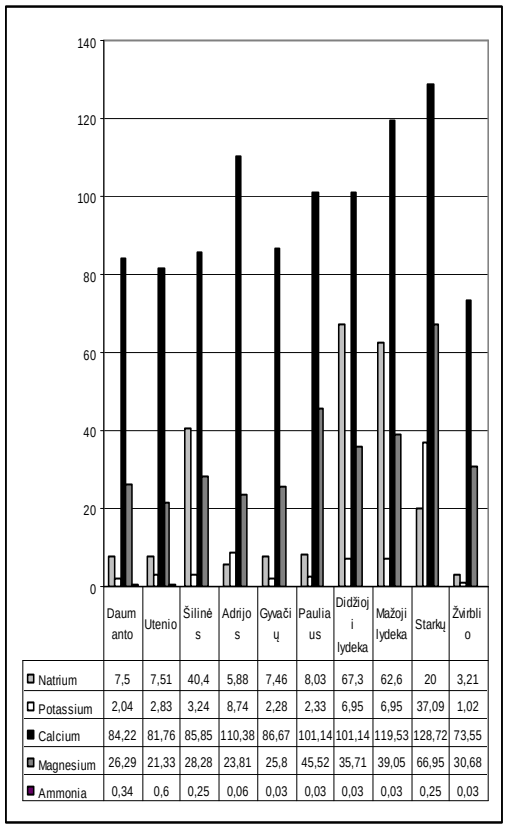


	Daumanto	Utenio	Šilinės	Adrijos	Gyvačių	Paulius	Didžioji lydeka	Mažoji lydeka	Starkų	Žvirblio
Chlorides	10,98	5,78	46,82	17,92	12,14	34,68	143,34	129,47	20,81	9,25
Sulphates	5,81	6,08	14,19	15,95	13,38	19,73	17,7	37,3	34,19	28,78
Hydrocarbons	364,71	348,24	386,18	411,66	374,71	439,54	352,63	449,57	705,27	336,13
Nitrites	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02	0,02
Nitrates	0,24	0,24	1,18	42,28	3,8	8,82	24,74	26,17	0,24	6,49

Fig. 5. The amount of anions, mg/l

So, while performing water quality analysis, the amount of anions and cations is set. In Lithuania hydro carbonate water prevails, and the is obviously proven the analysis of the water from Utena district springs (Figures 5 and 6), where the amount of hydrocarbonates is from 336,13 mg/l (in Zvirblis spring) to 705,27 mg/l (in Starkai spring). HN 24:2003 regulates that the amounts of chlorides and sulphates in the water would not exceed 250 mg/l, and these indicators do not come close to limits (Figure 5).

HN 24:2003 regulates the limit value of nitrates – 50 mg/l. The concentration of nitrate sis very different in Utena district springs. It is influenced by the agricultural activities in the surroundings and the pollution of the drinking water. In two springs (The Great and The small pike) located in Utena centre the amount of the nitrates is close to 25 mg/l, and in one spring (Adrija) it is 42,28 mg/l. In other springs the amount of nitrates is not high. The amount of nitrites is not higher than 0,02 mg/l in the springs of Utena district, while the limit value is 0,5 mg/l.



	Daumanto	Utenio	Šilinės	Adrijos	Gyvačių	Paulius	Didžioji lydeka	Mažoji lydeka	Starkų	Žvirblio
Natrium	7,5	7,51	40,4	5,88	7,46	8,03	67,3	62,6	20	3,21
Potassium	2,04	2,83	3,24	8,74	2,28	2,33	6,95	6,95	37,09	1,02
Calcium	84,22	81,76	85,85	110,38	86,67	101,14	101,14	119,53	128,72	73,55
Magnesium	26,29	21,33	28,28	23,81	25,8	45,52	35,71	39,05	66,95	30,68
Ammonia	0,34	0,6	0,25	0,06	0,03	0,03	0,03	0,03	0,25	0,03

Fig. 6. The amount of cations, mg/l

In the water from Utena district springs calcium, sodium and magnesium cations prevail (Figure 6). HN 24:2003 regulates that two cations have limit values – sodium should not exceed 200 mg/l, and ammonium 0,5 mg/l. The highest level of sodium is in The Great pike's spring – 67,3 mg/l, and the lowest in Zvirblis spring – 3,21 mg/l. Ammonium exceed the limit values only in Utenis spring water (0,6 mg/l).

The water quality in the springs of Utena district is quite good because only ammonium exceed the limit values in one of the springs. The water from Pikes' spring is not recommended to drink but for watering purposes (which is mostly used for now) it is suitable. The water from open springs should be boiled before drinking due to possible microbiological pollution.

IV. CONCLUSIONS

1. Water springs are significant objects of geo heritage, geo diversity, geo tops, nature, drinking water resources and others.
2. In different springs in Utena district water pH varies from 7,63 to 8,47 and is slightly alkaline. The distinctive electric conductivity is relatively low – from 520 µS/cm to 1081 µS/cm. The general hardness of the water is not low, from 5,83 mg-ekv/l to 11,93 mg-ekv/l. The amount of hydro carbonates is from 336,13 mg/l to 705,27 mg/l. The amounts of chlorides and sulphates are not high. In two water springs the amount of the nitrates is close to 25 mg/l, and in one spring it is 42,28 mg/l. The amount of nitrites is not

higher than 0,02 mg/l in the springs of Utena district. The amount of sodium is 3,21 – 67,3 mg/l. Ammonium exceed the limit values only in one water spring(0,6 mg/l), so the water quality in Utena district is quite good.

REFERENCES

[1] *The Importance of Geoheritage and Geo Topo f the charts in Inveronmental studies*, Environment. Technology. Resources. Proceedings of the 10th International Scientific and practical Conference June 18-20, 2015 Volume II, ISSN 1691-5402, ISBN 978-9984-44-172-6

[2] *Geodiversity*. [Online]. Available: http://www.onegeology.org/extra/geodiversity/home.html [Accessed: Feb. 22, 2017].

[3] J. Satkūnas, *Geoheritage Day. Secrets of Sėlių land geoheritage*, (Geologinio paveldo diena. Sėlių žemės geologinio paveldo paslaptys), 2014.

[4] *The new objects of geoheritage*. [Online]. Available: https://www.lgt.lt/index.php?option=com_content&view=category&layout=blog&id=233&Itemid=1223&lang=lt [Accessed: Feb. 15, 2017].

[5] K. Kadūnas at all, *Water springs and sources in Lithuania: Aukstadvaris regional park* (Lietuvos šaltiniai ir versmės: Aukštadvario regioninis parkas), 2012, pp 5-25

[6] *Groundwater*. [Online]. Available: https://www.lgt.lt/index.php?option=com_content&view=article&id=204&Itemid=609&lang=en [Accessed: Feb. 23, 2017]

[7] *Springs - The Water Cycle*. [Online]. Available: https://water.usgs.gov/edu/watercyclesprings.html

[8] [Accessed: Feb. 22, 2017]

Environment. Technology. Resources, Rezekne, Latvia
Proceedings of the 11th International Scientific and Practical Conference. Volume I, 150-155

The sex System of the Population of *Sagittaria Saittifolia* as an Indicator of the Ecological Status of a River

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Abstract. The ecological state of small rivers that define the water regime of the territory, as well as the water supply of larger rivers, the quality of their waters is a matter of a serious concern. The ecosystems of watercourses in urban areas exposed to pollution by industrial and domestic wastes are under the maximum anthropogenic load. Bioindicative methods, which let to assess directly the status of aquatic ecosystems and their individual components, occupy an important place in the system of ecological monitoring of water bodies. Plants respond to toxicants in an aquatic habitat by the abnormality of biosynthesis of chlorophyll, carotenoids and other pigments, change of mineral balance, phytohormones, which leads to a change in their reproductive differentiation.

In this regard, water quality assessment was carried out on the basis of chemical analysis and bioindication concerning Sagittaria sagittifolia populations in the upper and middle stream ways of the river Tyosha flowing through the Nizhny Novgorod region.

The article presents the results of some organoleptic and chemical parameters such as pH level of overall hardness, concentration of nitrates and nitrites, ions of ammonium, phosphates, mercury, concentration of oxygen and carbon dioxide in the water. It was detected that there were exceeding quantities of ammonium ions, nitrite ions, phosphates in the water of all ranges of the river Tyosha, and also high content of iron in the downstreams of the river. The findings suggest that the reproductive structure of arrowhead inflorescences can serve as a bio-indicator of the degree of water pollution. The harder the environmental conditions of the plant habitat in the water body, the more intensive is a shift in the ratio of flowers to the feminine side. It has been shown that due to the deterioration of environmental conditions, the number of compound inflorescences of the arrowhead and the numbers of whorls in them decrease and, on the other hand, there is an increase in the percentage of plants with simple typical inflorescences. A credible shift in the reproductive ratio of arrowhead inflorescences to the female side is spotted on the downstream river station near Lukoyanov and industrial community Shatky, where the complex of environmental factors for its growth is the least favorable. It was established that anthropogenic pollution of the river has a negative effect on the reproductive sphere of Sagittaria sagittifolia, causing a reduction in pollen fertility, which is confirmed by the chemical analysis of water.

On the basis of the studies the assessment of the ecological status of the water in the Tyosha river was given.

Keywords: anthropogenic load, bio-indication, bio-indicator, pollen fertility, sex differentiation, reproductive structure.

I. INTRODUCTION

The ecological state of small rivers in Russia is alarming. Small rivers define the water regime of the territory, as well as the water supply of larger rivers, the quality of their water [6]. A particularly acute situation is connected with watercourses within the city limits, where their ecosystems are polluted by industrial, municipal and rainfall wastes [15]. In the Nizhny Novgorod region, there are more than 9 thousand water bodies, among which small rivers are very important. Many of them are degraded today: they have become shallow; their banks are demined, their water quality is deteriorating. Among the most dangerous pollutants of freshwater reservoirs are oil products, heavy metals, pesticides. The sources of biogens are fertilizers coming from the fields, and wastes from livestock farms [3]. Thus, the relevance of the study of the ecological state of small rivers is obvious.

An important role in assessing the state of the rivers is played by biological control methods that allow a direct estimation of the state of aquatic ecosystems and their individual components. The presence of bio-indicators and their condition help to reveal the changes in the environment. In plants pollutants often transgress the biosynthesis of chlorophyll, carotenoids and other pigments, impact the mineral balance, phytohormones, causing changes in sex differentiation.

The issue of the day is to find adequate test-objects reflecting actual ecological state of the environment. One of these bioindicators is *Sagittaria sagittifolia*. As one of the main environmental

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indicators determining the status of the environment, we have chosen the reproductive ratio. According to modern scientific views gender is not only a means of reproduction, but also an effective tool of the evolution, responsive to directional change in the environment [4]. According to A.G. Sidorsky [13], the reproductive structure of inflorescences of the arrowhead can serve as a bio-indicator of the degree of water pollution. Petroleum products, surfactants in high concentrations lead to a shift in the sex differentiation of plants to the female side and the increase in the percentage of populations of plants with simple typical inflorescences. The greater the ratios of flowers of female type, the harder are the environmental conditions of plant habitats [11].

The aim of this work was to evaluate the water quality using a number of chemical analyzes and bio-indication of *Sagittaria sagittifolia* populations in the upper and middle stream of the river Tyosha, flowing through the southern part of the Nizhny Novgorod region.

II. MATERIALS AND METHODS OF RESEARCH

The object of the research of river water pollution is Old-World arrowhead (*Sagittaria sagittifolia*) - a perennial herbaceous plant. Its underwater leaves are of simple elongated shape, floating ones – elliptical and above-water leaves are shaped like an arrow. The flowers are diclinous, three pieces form an acervulus, have a green trimerous bell and three white with rose base petals. The material was collected at 4 stations of the river Tyosha with a different anthropogenic load (Fig. 1).

Fig. 1. Sketch-map of sample drawing on the river Tyosha (✦ - points of sample drawing)

The first point – is the Tyosha River, downstream of Lukoyanov. The main pollutants of the river in this area are municipal sewage of the city and the pig-breeding complex near the head of the river; the 2nd Point – is the Tyosha River below the industrial community Shatky. Here, the pollutants come from factories, situated upstream: Shatkovsky plant, JSC "Shatkovsky butter factory", Shatkovsky instrument-making factory, a district hospital.

The second point is the Tyosha River near the village Kozhino, located on its left bank. At this station of the river a watermill had been working for a long time. Currently, there is only a construction made of timber, boulders and concrete, which creates rifts of swirling water. The fourth point is the Tyosha River below Arzamas - quite a large industrial city of Nizhny Novgorod region, with the developed sectors of mechanical engineering and instrument making.

The research was carried out in July 2016. The temperature ranged from 18°C to + 25°C, which corresponds to average long-term observations.

The length of the route along the river was 67 km from Lukoyanov (headstream) to the city of Arzamas, including the monitored river range below the city. In each of 4 points we collected 150 plants that were analyzed in respect to the reproductive structure of their inflorescences. Depending on the depth of the water in which the arrowhead grows, it forms different ecological forms: 1) *Sagittaria sagittifolia Forma typical* – a typical form, with roots at a depth of 15 – 30 cm, with three generations of leaves. 2) *Sagittaria sagittifolia Forma natans* – a form with floating leaves, rooted at a depth of 70 – 85 cm 3) *Sagittaria sagittifolia Forma vallisnerifolia* – a form rooted at a depth of 150 - 500 cm, and having only a long ribbon-like tender leaves. 4) *Sagittaria sagittifolia Forma terrestris* – a terraneous form, usually found on the banks of reservoirs. In this environment they develop a large number of aerial leaves, and the first underwater ones are very few. The botanical literature often presents the notion that the Old-World arrowhead inflorescence resembles a simple whorl, in which one or two lower whorls have a pistillate type, and all the rest - the staminate type of flowers. 200 reproductive forms of the arrowhead were described; they have the following features: some plants have one or two bottom whorls with 2 side clusters forming the complex whorl cluster; the number of whorls varies from 1 to 10. There are rare forms of inflorescence, forming androdioecious flowers instead of pistillate flowers. We used the method of counting of the whorls with male and female flowers, described by A.G. Sidorsky [13]. To determine the pollen fertility we used the acetone-carmine method [9]. Hydro-chemical composition of water has been studied at the research points. To control the thermal pollution we measured water temperature. When there is a difference in the measured temperatures in a few degrees (temperature gradients) we can talk about thermal pollution of water bodies [1].

The validity of differences was assessed by Student's criteria.

III. DISCUSSION AND RESULTS

It is known that plants can utilize and involve in their metabolism some amount of toxic compounds accumulated on the water surface. Some of them can be inactivated in plant cells, and a portion - accumulated in certain organs [12]. In the Old-World arrowhead the reproductive structure of inflorescences changes depending on the environmental conditions [14].

From the above-described environmental forms of the arrowhead we found three forms in the areas of the Tyosha river: *Forma typical* about 25.3%, *Forma natans* (70%), *Forma vallisnerifolia* (5.7%). All arrowhead population consisted of specimen of different ages, had inflorescences at different stages of budding, flowering and fruiting. Analysis of the reproductive structure of inflorescences of the Old-World arrowhead revealed a high variability of the plants on this basis. All plants can be divided into groups of specimen with simple and complex whorled cluster (Fig. 2; 3), with staminate, pistillate and mixed whorls (Fig 4; 5).

Fig. 2. simple (а) и compound (б) inflorescences. Fig. 3 Compound inflorescences.

Fig. 4. Stamina whorls.

Fig. 5. Pistillate whorls.

In the course of the research it was found that the number of compound inflorescences of the arrowhead is minimal (1%) at the first point, which is below the source of domestic sewage in Lukoyanov, and wash-outs from the fields (Fig. 6).

There are much more compound inflorescences of this plant (31%) in the area of Shatky – point II. The number of plants with a compound type of inflorescences at the site near Kozhino at point III (which is far from Shatky and especially from Lukoyanov) is 50 times bigger in comparison with Lukoyanov river station. Downstream, the river takes wastes of Arzamas, and environmental conditions again become less favorable for the growth of *Sagittaria sagittifolia*, which manifested itself in a sharp decrease in the number of compound inflorescences – 11% (Fig. 6).

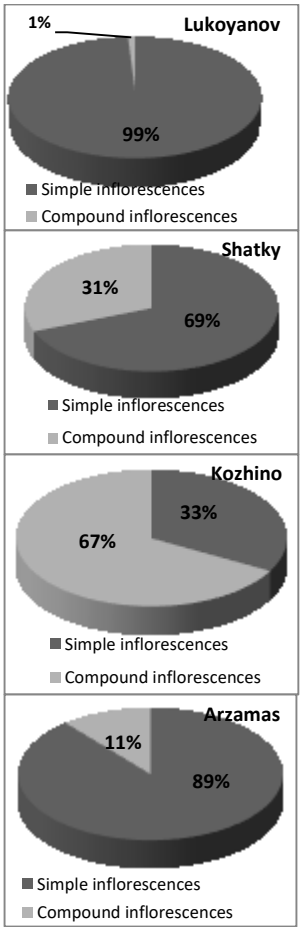

Fig. 6. Dependence of the number of inflorescences of different type on the region of the research

It is likely that the initiation and then bloom of simple inflorescences are faster than that of the compound, which is, apparently, an adaptive property of plants with this type of generative shoot in ecologically unfavorable growing conditions.

In the area of the river near Kozhino – at point III – we recorded the largest number of mixed whorls (with male and female flowers, mainly in the side cluster) - 1.2 specimen, compared to other river stations (Fig. 7).

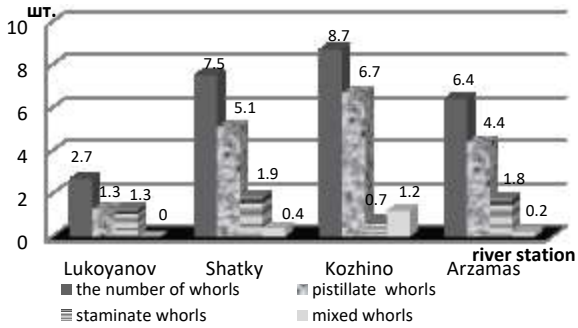

Fig. 7. Dependence of the average number and type of whorls in the arrowhead inflorescences on environmental conditions

Here we saw the maximum number of whorls in inflorescences of the arrowhead (8.7 pcs.), among which we noticed the smallest number of pistillate whorls (0.7 pcs.). A smaller, compared with point III, number of whorls was found at the river station near Shatky (7.5 pcs.), among which there were only 0.4 pc. of the mixed type due to water pollution by local enterprises. The river station below the city of Lukoyanov was characterized by the smallest of all the points of the study number of whorls in the inflorescence (2.7 pcs.), among which there were no mixed, and the number of staminate and pistillate was equal. In point IV, below the city of Arzamas, only 0.2 pc. mixed whorls were noted among inflorescences of the arrowhead.

The results of our research show that due to the worsening conditions of plants' habitat, there is a shift of sex differentiation (ratio of staminate and pistillate flowers) to the female side. This is consistent with the data of other authors [5; 7, 13, 14]. It was found that the maximum number of pistillate flowers is observed on the territory of the river near Lukoyanov – 50.6%, and the minimum – in the area near Kozhino – 14.4%

Table 1
Reproductive Differenciation of Sagittária Sagittifolia at Different Stations of the River. Tyosha

Features	River Station			
	Lukoyanov	Shatky	Kozhino	Arzamas
Overall number of staminate flowers	50.6%	28.6%	14.4%	30.2%
Overall number of pistillate flowers	49.4%	71.4%	85.6%	69.8%
Overall number of pistillate flowers in an inflorescence	4.1 ± 0.2	6.5 ± 0.9	3.7 ± 1.0	5.8 ± 1.6
Average number of pistillate flowers in an inflorescence	4.0 ± 0.3	16.1±3.8	22.2 ± 4.6	13.3 ± 2.8
Ratio (♂/♀) of flowers in an inflorescence	1.0 ± 0.2	2.5±0.3	6.0 ± 1.2	2.3 ± 0.4
Pollen fertility, %	59.0 ± 1.5	61.4±1.6	79.3 ± 1.8	62.0 ± 1.1

The maximum credible shift of the ratio of reproductive forms of arrowhead flowers to the female side is marked at the station of the river near Lukoyanov, where, apparently, the complex of environmental factors for its growth is the least favorable (Table. 1). Here, where there is a small river bed occupancy, a weak current, we found the 1st form of the arrowhead – *Sagittaria sagittifolia Forma typical*.

At the river stations II and IV of the Tyosha we found an approximately equal ratio of male and female flowers (♂/♀) in the inflorescences (2.5 – 2.3), which is almost 2.5 times less compared to station III. Thus, below Lukoyanov, industrial community Shatky and Arzamas there is the feminization of arrowhead populations under the influence of adverse factors of growth.

The most important indicator of functional reproductive differentiation of plants is the viability of pollen, because the conditions of cultivation of plants affect the condition of pollen grains, their viability and fertility [2, 8, 18, 19]. There is a credible difference of pollen grains quality of the arrowhead growing at the studied stations of the river (Table. 1, Fig. 8). The lowest pollen fertility in plants was marked in Lukoyanov downstream at point I, which is 20.3% lower than at point III. At stations II and IV arrowhead pollen also had low fertility, which indicates the adverse growing conditions at points I, II and IV.

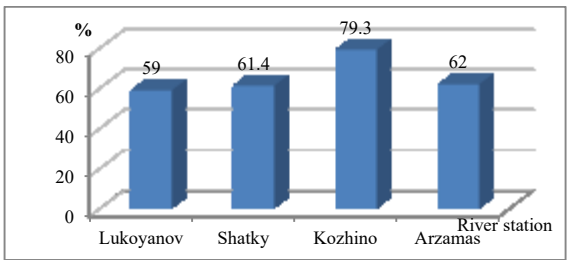

Fig. 8. Pollen fertility, % of *Sagittária sagittifolia* depending on the area of the research

Our bio-indication data are consistent with the hydrochemical analysis of water quality conducted in the laboratory of Arzamas weather station in July 2016. Studies were carried out on the surface water-level of four areas with the use of a variety of quantitative analysis methods: photometric, chromatographic, potentiometric, atomic absorption, titimetric and others. [10]. The data obtained are presented in Table 2.

Table 2
Hydrochemical Analysis of Water Quality of the Studied River Stations of the Tyosha

Exponent	Norm	Research rezults			
		№1 Lukoyanov	№2 Shatky	№3 Kozhino	№4 Arzamas
Temperature difference Δ t°		2 ° C	1.5 ° C	0 ° C	0.5 ° C
Smell in points	2	3	2	1	1
pH	6.5 – 8.5	7.5	7.5	8	8
Total hardness (GH), mg-equ/l	7	5.5	10	24.5	25
Carbonate hardness (KH), mg-equ/l	1.43 – 5.35	5.3	6.5	5.9	6
ammonium (NH_4^+), мг/л	0.5	1.6	1.05	0.65	0.78
Nitrite (NO2-), mg / l	0.2	0.5	0.4	0.2	0.28
dissolved oxygen (O2), mg / l	Not less than 6	8	10	10	10
nitrates (NO3-), mg / l	40	10	1	0.5	0.5
phosphate (PO43-), mg / l	0.05	1	0.6	0.1	0.4
Sulfates mg / l	100.0	723.5	815.6	924.6	954.7
iron (Fe), mg / l	0.1	0.4	0.4	0.1	0.5
carbon dioxide (CO2), mg / l	2 – 10	13	14	10	13
active chlorine (Cl), mg / l	0.00001	0	0	0	0
chromates (Cr6 +), mg / l	0.02	0	0	0	0
Copper mg / l	0.001	0.002	0.004	0.0042	0.0048
Zinc mg / l	0.01	0.01	0.020	0.015	0.019
Mercury mg / l	0.00001	<000001	0.00002	0.00001	0.00008

The most significant change in the organoleptic characteristics of water (the temperature difference (2°C), changes in odor and color of water) are observed at the station of the river near Lukoyanov, indicating that processes caused by eutrophication.

The chemical analysis data indicate a rather high degree of contamination of the river. Hydrogen index of samples was recorded in the normal range (7.5 – 8.0), i.e. water is slightly alkaline which is probably due to the discharge of mine water. Total hardness of water in the Tyosha in the middle stream is high and ranges from 24 – 25 mg / eq. dm3 which is probably due to the natural content of sulfates. In the upstream water hardness is within the norm limits (5.5). Biogenic elements are nitrogen and phosphorus compounds.

At the same time, there are ammonium ions, nitrite ions and phosphates in concentrations exceeding the norm. The concentration of ammonium ions ranged from 0.65 mg / l (1.3 MAC) to 1.5 mg / l (3 MAC) in the area of Lukoyanov. There is a high level of water pollution in the river due to nitrite ions, from 0.28 mg / l (MAC) in Arzamas to 0.5 mg / l (2.5 MAC). Exceeding of the maximum allowable norms of content of nitrate ions in the water was not found. Along with nitrogen, the most characteristic pollutants of the river Tyosha are phosphates. The highest concentration of phosphate (20 MPC) is detected at point number 1. The lowest concentration of phosphate (2 MAC) is noted at point number 3. Phosphate sources are phosphate fertilizers and detergents.

The iron content in the upstream of the river exceeded up to 4 MPC, probably due to iron-bearing clays, and agricultural run-off; in the middle stream the marked level is the MPC. Chromate and chlorine concentration at all areas of the study were below detection limits. The content of heavy metals (copper, zinc and mercury) in water exceeded the maximum allowable parameters: copper 4.2 times, 1.5 – 2 zinc, mercury 2 – 8 times. This may be due to the discharge of waste water from instrument-making plants, electroplating shops, fertilizers washouts from the fields.

IV. CONCLUSION

The study revealed that the number of arrowhead compound inflorescences and the number of whorls in them is reduced due to the deterioration of environmental conditions. The maximum number of this type of generative shoots and the largest number of whorls were found in the area of the Tyosha near Kozhino, and the minimum - in the Lukoyanov area. The maximum credible shift of the ratio of reproductive forms of arrowhead flowers to the female side is marked at the station of the river below Lukoyanov, industrial community Shatky and Arzamas where the complex of environmental factors for its growth is the least favorable.

In the water of the river Tyosha below Lukoyanov there are processes caused by eutrophication. In the water of all the river stations of the Tyosha we detected excess of standards for ammonium ions, nitrite ions, phosphates, sulfates, copper, zinc, mercury, especially in the area of Lukoyanov, Shatky and Arzamas. Iron content exceeds the norm 4 times at the river stations near Lukoyanov and Shatky and 5 times near Arzamas.

On the basis of the research it was found out that in the upstream of the river water is polluted to a greater extent than in its middle stream. To solve the environmental problems of the Tyosha certain activities must be initiated:

1) the discharge of untreated and insufficiently treated wastewater of sewages must be prohibited;

2) control over the observance of the regime of water protection zone of the river and its tributaries;
3) the landscaping of the coastal zone, coastal zone for recreation;
4) monitoring of the ecological state of the river.

REFERENCES

[1] Alekseyev S.V. Ecological practice. / S.V. Alekseyev, N.V. Gruzdev, A.G. Muravyova, E.V. Grushina – Moscow: JC MDS, 1996, – 192 p.

[2] Bessonova V.P. Influence of environmental pollution on male fertility of decorative flower plants / V.P. Bessonova, L.M. Fendyur, T.N. Peresypkina // Bot. journal. – 1997. – V. 82. – № 5. pp. 38 – 45.

[3] Vavilov YU.L. Populational criteria of water quality assessment of small rivers of urban territories with the help of biological test-objects // Populations in space and time: Mat. VIII AllRus. Population seminar – N. Novgorod: NSU named after N.I. Lobachevsky, 2005, pp. 41 – 42.

[4] Geodakyan V.A. Genetic chromosomes: what are they for? (A new concept) // Rep. Academy of Sciencies. 1996. v. 346, №4. pp. 565 – 569.

[5] Zhatkov A.I. Influence of pre-sowing irradiation of corn on the ratio of male and female flowers and productivity of cucumbers and hemp. / A.I. ZHatkov, G.A. Zhatkov // Col. scient. th. Kharkov. SHI, 1984, V. 310. pp. 64 – 68.

[6] Ilyin M.YU. The results of bioindicative studies of small rivers GPBZ «Kerzhenskij» of Nizhny Novgorod region. M.YU. Ilyin, I.A. Kudrin, G.V. SHurganova, T.V. Kuklina // Works of the third international scientific- practical conference of young scientists «Indication of environment status: theory, practice, education», 17 – 19 april 2014, pp. 97 – 100.

[7] Konchina T.A. Combined influence of pre-sowing γ – radiation and the conditions of cultivation on the genetic structure and some biological features of spinach // Dep. In VINITI 07.01., № 1728 – 2001.

[8] Konchina T.A. Opportunities of using the pollen quality of plants in bioindication of water bodies / Actual problems of humanitarian research and science. № 06(65) June 2014. part. 1. pp. 67 – 69.

[9] Pausheva Z.P. Practical work on plant cytology. Moscow: Agropromizdat, 1988. p. 148.

[10] List of standards of water quality of water bodies of fish industry, including MAC of harmful substances in waters of water bodies of fish industries / Printed order of Rusfishing 18 Jan. 2010 . №30 «About the standards of water quality of water bodies of fish industry, including MAC of harmful substances in waters of water bodies.

[11] Polosina T.P. Influence of genetic structure of Old-World arrowhead inflorescence on the viability of pollen // Ecological research and problems of education in European regions of Russia / Mat. AllRus. Scientif. – practic. conf. Arzamas, 5 – 7 Oct. 2000c, 2000. pp. 29 – 31.

[12] Sadchikov A.P. Ecology of coastal aquatic vegetation / AP Sadchikov, MA Kudryashov. NIA-Nature, REFIA, 2004. pp. 27 – 30.

[13] Sidorsky A.G.Evolution of genetic organization in flowering plants - Nizhny Novgorod: Volga-Vyatka Book. Publishing House, 1991, 210 p.

[14] Sidorsky A.G. The use of bio-indicators to assess the ecological status of rivers Nizhny Novgorod region // Ecological-geographical problems of the Volga-Vyatka region – N. Novgorod, 1994, pp.111 – 121.

[15] Tkachev B.P. Small rivers: the current state and environmental problems. Analytical Review. / B.P. Tkachev, V.I. Bulatov - Novosibirsk, 2002, 113 p.

[16] Fedorov A.I. Workshop on ecology and environmental protection. / A.I. Fedorov, A.N. Nicholas – Moscow, humanity ed. VLADOS Centre, 2001, 288 p.

[17] G.V. Shurganova. Water quality assessment of small and medium rivers of the Volga on the basis of the analysis of indicator species of zooplankton / G.V. Shurganova, M.L. Tarbeev, A.V. Golubev, A.A. Tarasova // Water: chemistry and ecology – 2011, №10. pp. 87 – 92.

[18] Cox R. M. Sensitivity of forest plant reproduction to longrange transported air pollutants: the effects of wet deposited acidity and copper on reproduction of Populus tremunloides // New. Phytol. – 1988. – V. 110. – №1. – pp. 33 – 38.

[19] Zhestkova E.Specifics of educational activity antimotivation in future teachers subject to the training period / Assel Bakirovna Akpayeva, Natalia Valentinovna Ivanova, Tatiana Ivanovna Luchina, Elena Viktorovna Minaeva, Elena Alexandrovna Zhestkova // International Review of Management and Marketing. – 2016. - №3. – p.265-259.

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Snow Microwave Reflection at Mobile Phone Frequency Bands

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Abstract. Snow should be accounted in electromagnetic fields' risk assessment, especially in Nordic countries where in winter months snow precipitation and coverage may significantly affect the propagation of microwaves. The risk assessment should be always carried out under worst case scenario conditions, including the reflective properties of the surfaces surrounding the antenna. In this study fresh snow microwave reflectance properties were investigated at the mobile communication bands from 1700 to 2700 MHz.The investigation revealed that reflection loss from snow is more dependent from the frequency than from the thickness of snow coverage. Amongst mobile communication bands, the strongest microwave reflection (reflection loss only 3.2dB) was registered at WiFi2G band. Averaging all the snow thicknesses, the highest reflection loss occurs at GSM1800UL (1710-1785 MHz) and UMTS2100DL (2110-2170 MHz) bands. The least attenuation of reflection occurs in adjacent DECT band.

Keywords: electromagnetic fields, radiofrequency, microwaves, reflection, reflectance, snow, water, mobile phones.

I. INTRODUCTION

Having a proper risk management of electromagnetic fields (EMFs) requires accounting also seasonal factors which may affect the propagation of electromagnetic fields. The microwave reflectance or transmittance of water depends greatly on the frequency, but also on the state of the water. Water allows much less microwave penetration depth as compared to the ice. Water in semi-solid state, such as snow is an important issue of risk management especially in Nordic countries where in winter months snow precipitation and coverage may significantly affect the propagation of microwaves. The important issue is to assess the radiofrequency (RF) radiation levels from the point of human safety: in work environment - the occupational safety and in open places, schools etc. - the public safety. The propagation of radiowaves may be of issue in case of seasonal factors near radiofrequency sources, such as antennas of TV and radio broadcasting, emergency services networks, and mobile communications. Although TV and radio antennas are not so common in the technogenic environment, developments in mobile communications has placed thousands of microwave antennas in the immediate vicinity where people work, live and conduct their everyday activities. Many of these antennas are not tower placed but positioned on the buildings, on the floors and on the rooftops (an example is presented in figures 1 and 2). Where safety of people needs to be considered, it is important to assess the effect of snow to radiowave propagation at close proximity to the radiofrequency source. Assessing RF safety is also relevant with respect to communication signal transmittance, as seasonal factors may attenuate the signal, hindering the communication links operability. Such cases may include TV and radio broadcasting antennas, but even in more cases private and business mobile communications such as walkie-talkies, DECT phones, wireless data, voice and video links. In most cases public communications operability may be substituted with other means of communications, whereas in emergency services and military operations the reliability of means of communication plays a crucial role, hence characterizing the critical effect of seasonal factors on radiowave propagation.

In 2016 new occupational electromagnetic fields' legislation has emerged in European Union member states, consequent to the European Parliament and the Council of the European Union issuing a new directive 2013/35/EU [1], [2]. The new legislation sets new standards for the electromagnetic fields' risk assessment and risk management. Amongst other duties, the obligation of the employer is to reduce the risks from electromagnetic fields to a minimum. This

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entails implementing technical and administrative means to reduce the workers exposure to the electromagnetic fields and to arrange the work in a way where minimal amount of exposure is attained.

In assessing the safety of workers and other people nearby the antennas, the risk assessment is likely to be carried out under conditions without snow interaction with the surrounding surfaces. In unforeseen cases, where snow would affect the reflection properties of the walls, floors and ground plane surrounding the high power transmission antenna, the microwave exposure levels may be significantly elevated. Workers working under the conditions of elevated electromagnetic fields levels are subjected to an increased health and/or safety risk. Therefore, the risk assessment should be always carried out under worst case scenario conditions, including the reflective properties of the surfaces surrounding the antenna.

Fig. 1. An example of a mobile communications base station antenna (marked with a red circle), positioned close to ground and building surfaces on top of the entrance; Tampere University campus, Finland.

As the excess water in and on the building material so could snow alter the interaction of the microwave with the material. The reflective or absorptive properties of the surfaces could be emphasized, resulting in a new electromagnetic wave propagation scenario in the vicinity of the material's surface. Such cases may be present at locations of high power mobile communications and public broadcasting antennas.

In assessing microwave propagation and interaction with materials, basically three types of behavior can be observed: transmission, reflection and absorption. Materials transparent to microwaves have low dielectric loss, hence microwaves pass through it with little or no attenuation. Microwaves reflect back from microwave opaque materials and no transmission occurs. In absorbing materials, high dielectric loss causes microwave absorption within the material, where the level of absorption is dependent on the dielectric loss factor. Absorption is directly related to transmission and reflection, where both are reduced and the microwave energy is absorbed within the material and turned into heat [3]–[5].

Fig. 2. A close-up of a mobile communications base station antenna, positioned close to ground and building surfaces; Tampere University campus, Finland.

Electrically conductive surfaces cause the reflection, where the microwave is reflected from the surface and/or from the inside layers of the material. The capacitive and conductive components of the dielectric response of the material is determined by the dielectric constant and the dielectric loss factor [4].

II. METHOD

In this study fresh snow microwave reflectance properties were investigated. The measurement environmental conditions were: relative humidity 82-87%, air temp. -0.9…-1.1°C; snow temp. -1.5…-1.7°C. The fresh snow (figure 4) was in small fine particles as the testing was performed within 8 hours after snowfall.

In order to conduct the snow measurements, outside temporary laboratory was assembled. The measurement setup included Rohde&Schwarz Universal Protocol Tester CRTU-RU capable of generating and measuring signals up to 2700 MHz, with a maximum output power of 13 dBm. Two standard gain horn antennas were used as presented in figure 3. The Tx antenna transmitted the different radiowave wavelengths, whereas Rx1 received the reflected wave.

From the transmitting horn antenna, the microwave propagates from the horn antenna in a parallel beam, which is called the near-field or also Fresnel zone. Field divergence happens in the so-called far-field or Fraunhöfer zone and the wave intensity decreases by the inverse square law - the amplitude decreases in inverse proportion to distance from the aperture of the horn [6].

The distance of the near field zone (l) in case of rectangular horn opening is determined by the formula by Botsco [7] (formula 1): A is the dimension of the largest side of the rectangle and λ the wavelength. The antennas were distanced in a manner to place the sample to the far field region where the microwave hit the material.

$$l = \frac{A^2}{2\lambda} \tag{1}$$

The snow was placed on a sample holder 60x60 cm in dimension and 40 cm in height, casket made of RF-invisible material (figures 5, 6). The transmitting antenna was placed underneath the tray, as so the reflection receiving antenna Rx1. The setup was surrounded by RF absorbing elements in order to reduce the inbound and outbound radiowaves. The snow was measured at different thicknesses: 2, 5, 10, 15, 20, 25, 30, 35, 40 centimeters.

The snow was not damped, accumulating thickness of snow layers was placed in a light way, approximating the natural fall and packing of snow on the ground.

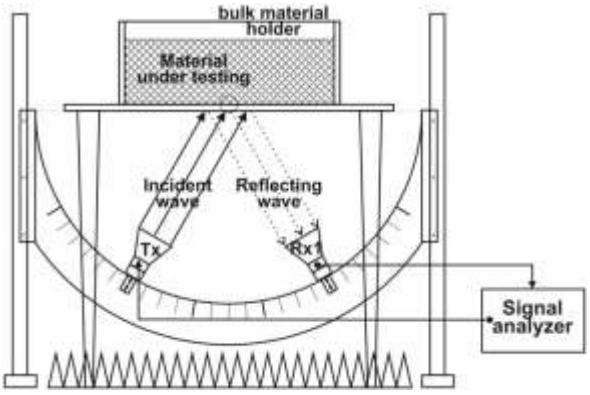

Fig. 3. Measurement setup included irradiator horn antenna Tx and two receiving horn antennas: Rx1 for reflected wave and Rx2 for transmitted wave measurement.

Fig. 4. Sample of fresh snow; ticks indicating 2 mm steps.

Fig. 5. Snow in a sample tray.

Fig. 6. Intersection of snow of 30cm thickness within a sample tray.

Before and after measuring the samples, a calibration procedure was done including measuring full and null reflection microwave levels. Full reflection was determined by placing a sample size aluminum plate to the sample and measuring full reflection with antenna Rx1, whereas null reflection was determined by leaving the sample tray empty and measuring the non-reflected wave level at antenna Rx1. Reflection loss (*RL*) was calculated to each

snow sample as a logarithmic ratio of powers in decibels (dB), which is a ratio of the reflected (P_r) wave to the full reflection (P_i). The measurements were registered in unit of measure powers decibel milliwatts (dBm). Ratio in decibels (dB) is a representation of gain or loss of the material under testing (MUT). Subtracting two powers (dBm) is resulting in their ratio (dB); reflection loss (RL) as presented in formula 2.

$$RL(\text{dB}) = 10 \cdot log_{10}\left(\frac{P_r}{P_i}\right) dB = P_r|dBm - P_i|dBm \quad (2)$$

The measurements covered radiofrequencies from 1700-2700 MHz which accounts most of the mobile communication bands including, GSM1800, DECT, UMTS2100, WIFI2G, LTE2600. It should be noted that in some countries the mobile operators are allowed to use whatever frequency bands they have acquired to whatever protocol they wish to transmit at these frequencies. Therefore, in example the 4G LTE protocol could be encountered in any of the frequency bands. The output power was 10dBm (10mW).

The analysis was conducted for each single frequency point within the span range, accounting reflection loss in decibels (dB) as presented in formula 2. The 0 dB reflection loss would mean total reflection of the radiowave from the sample, whereas 10 dB would characterize the loss of power of tenfold due to the material.

The analysis presents mobile communication band specific average reflection losses for the following bands: GSM1800UL (1710-1785 MHz), GSM1800DL (1805-1880 MHz), DECT (1880-1900 MHz), UMTS2100UL (1920-1980 MHz), UMTS2100DL (2110-2170 MHz), WiFi2G (2400-2484 MHz), LTE2600UL (2500-2570 MHz), LTE2600DL (2620-2690 MHz); the analysis treats mobile communications upload (UL) and download (DL) bands separately, as download links i.e. mobile phone base station antenna frequencies, are of most interest, due to the relatively higher output power as compared to upload units (e.g. mobile phones). LTE800 and GSM900 mobile bands were omitted from the investigation due to the frequency limitations of the current setup.

III. RESULTS

Snow microwave reflection properties were determined on nine different snow thicknesses. Results averaged across the sample, show a noticeable variation in the reflected microwave levels as a result of snow thickness and the frequency.

The extremities of the reflection loss were determined by 1) removing the sample and 2) replacing the sample with a fully reflective Aluminum sheet. The lowest reflection loss was registered 2.6 dB and the highest reflection loss 29.9 dB (figure 7).

The investigation revealed that reflection loss from snow is more dependent from the frequency than from the thickness of snow coverage, whereas the highest variation in reflection loss was registered at WiFi2G band (2400-2484 MHz). The main reflection attenuation effect lies within the structure and dielectric properties of the snow particles, and not so much in the bulk condition of snow.

Figure 9 presents mobile communications band specific reflection loss distributed into fresh snow thicknesses' subgroups. The highest reflection loss occurs at GSM1800UL and UMTS2100DL bands. The least attenuation of reflection occurs in adjacent DECT band. The variation between the lowest reflection and highest reflection of power across the frequency span of 1700-2700 MHz was about 27 dB across all snow thicknesses.

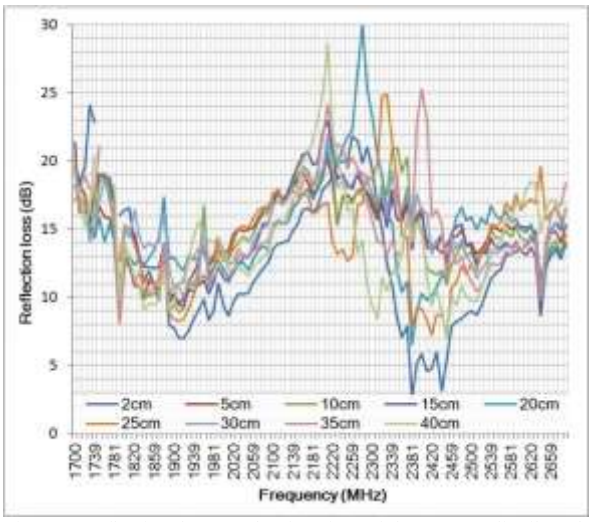

Fig. 7. Reflection loss as the function of frequency, distributed across different fresh snow thicknesses.

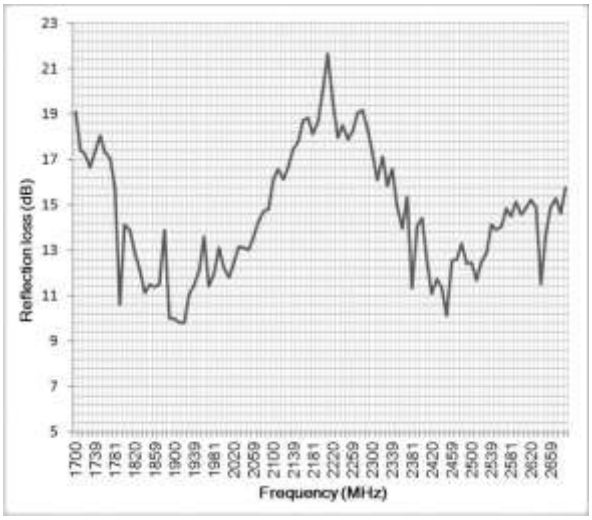

Fig. 8. Averaged reflection loss across all fresh snow thicknesses as a function of frequency.

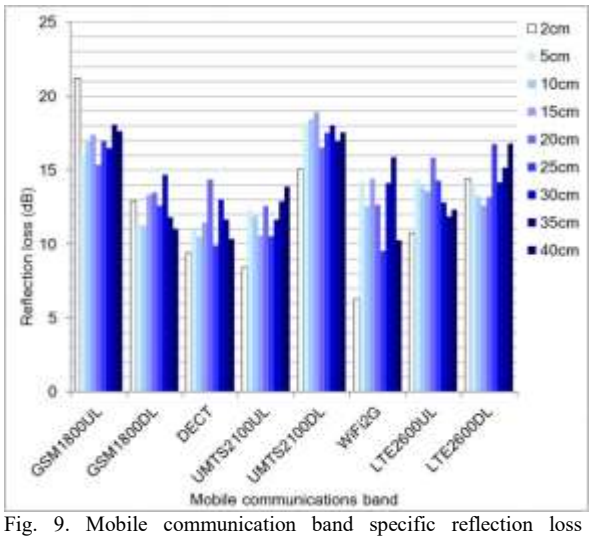

Fig. 9. Mobile communication band specific reflection loss distributed into subgroups of snow thickness of 2 to 40 cm.

Table 1 presents mean and lowest reflection loss per mobile communications band as averaged across different thicknesses of fresh snow (2 to 40 cm). A strong microwave reflection (reflection loss only 3.2dB) was registered at WiFi2G band; also a moderate microwave reflection occurs at DECT and UMTS2100UL bands.

Figure 8 presents a combined reflection loss curve where reflection loss of all snow thicknesses was averaged. At 2.1 to 2.3 GHz frequency span the fresh snow reflection attenuation is most effective.

Table I
Mobile communications band specific reflection loss (dB) of snow

Mobile communications band	Frequency span (MHz)	Snow reflection loss (dB)	
		mean	lowest
GSM1800UL	1710-1785	17.1	14.1
GSM1800DL	1805-1880	12.5	9.0
DECT	1880-1900	11.3	7.7
UMTS2100UL	1920-1980	11.6	7.0
UMTS2100DL	2110-2170	17.5	14.0
WiFi2G	2400-2484	12.2	3.2
LTE2600UL	2500-2570	13.3	8.7
LTE2600DL	2620-2690	12.1	8.7

IV. CONCLUSIONS AND DISCUSSION

Although the total reflection (reflection loss of 0 dB) was not registered during the snow microwave measurements, a large variation in between the lowest and highest reflection loss was determined across the sample. This is a significant indicator of snow alteration of microwave propagation: both the attenuation of the signal and elevation of exposure could occur under different snow coverage conditions.

The results demonstrate that next to building materials, also snow coverage is a considerable factor in assessing microwave propagation near the RF sources. The safety of the workers in working environment and people at public places should be assessed in the electromagnetic fields' risk assessment considering also the seasonal conditions, including the snow coverage of different thicknesses. The current study has demonstrated that snow coverage may significantly affect the microwave exposure level at open spaces where snow precipitation could result in snow coverage in the proximity of RF sources. Assessing the effect of snow coverage on microwave propagation is critical where RF sources, such as mobile phone base station antennas are placed on buildings or other structures made of RF-transparent materials. In such locations the safety of people may have been assessed based on the fact that radiowaves penetrate building materials, hence reflections are minimized. In case of snow precipitation, the resulting amplification of microwaves may create standing waves, where summation of the waves occurs, hence multiplying nearby exposure levels.

The extent of the reflection loss is due to the absorption effect of microwave into water molecules. Future studies should focus on different states of snow, as dependent on the age and weather treatment, the structure of snow could vary significantly, also altering the properties of interaction of snow and the microwave.

REFERENCES

[1] TheEuropean Parliament and the Council, *Directive 2013/35/EU on the minimum health and safety requirements regarding the exposure of workers to the risks arising from physical agents (electromagnetic fields)*, vol. Official J, no. June. 2013, p. L 179/1-21.

[2] Vabariigi Valitsuse määrus 01.04.2016 nr 44, "Töötervishoiu ja tööohutuse nõuded elektromagnetväljadest mõjutatud töökeskkonnale , elektromagnetväljadega kokkupuute piirnormid ja rakendusväärtused ning elektromagnetväljade mõõtmise kord," *Riigi Teat.*, vol. RT I, 07.0, no. 4, 2016.

[3] S. Das, A. K. Mukhopadhyay, S. Datta, and D. Basu, "Prospects of microwave processing: an overview," *Bull. Mater. Sci.*, vol. 32, no. 1, pp. 1–13, 2009.

[4] E. T. Thostenson and T.-W. Chou, "Microwave processing: fundamentals and applications," *Compos. Part A Appl. Sci. Manuf.*, vol. 30, no. 9, pp. 1055–1071, 1999.

[5] D. E. Clark, D. C. Folz, and J. K. West, "Processing materials with microwave energy," *Mater. Sci. Eng. A*, vol. 287, no. 2, pp. 153–158, 2000.

[6] J. Blitz, *Electrical and magnetic methods of non-destructive testing*, vol. 3. Springer Science & Business Media, 2012.

[7] R. J. Botsco, R. W. Cribbs, R. J. King, and R. C. McMaster, "Microwave methods and applications in nondestructive testing," *Nondestruct. Test. Handb.*, vol. 4, 1986.

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Endopolyploidy of Endangered Plant Species Ligularia Sibirica in Different Environments

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Abstract. The goal of this study was to detect endopolyploidy of Ligularia sibirica from populations existed in different ecological conditions. This is important step to elaborate the appropriate protection measures of rare and endangered species, which should be based on understanding of ongoing processes in populations. From this point of view the knowledge of genetic diversity, including endopolyploidy level between and within populations, is crucial. L. sibirica is endangered and protected plant species in Latvia which is included in the protected plants list of EU Habitat directive 92/43/EEK Annexes 2 and 4. Perennial herbaceous plant L. sibirica is one of two species of genus Ligularia in Europe. According to the previous data, this species has been disappeared from all previously known locations in Latvia. However, some new locations were found in central part of the country recently. Determination of edopolyploidy level of L. sibirica was performed by the BD FACSJazz® cell sorter (BD Biosciences, USA) with flow cytometer function. In young leafs nine relative fluorescence DNA peaks from 2C up to 64 C were detected. The most common was 2C peak presented in 93% and 63% of samples from Zušu-Staiņu sulphur spring and Krustkalni Nature reserve populations respectively.

Keywords: Ligularia sibirica, flow cytometry, endopolyploidy, endangered species.

I. INTRODUCTION

Ligularia sibirica (L.) Cass. is endangered herbaceous relict species, with restricted population structure throughout the Europe. In Latvia amount of species localities have dramatically decreased during last century. *L. sibirica* is included in the Annex II of Habitats Directive of the Council of European Communities [1]. Typical habitats of *L. sibirica* are wet meadows, springs and spring mires. Changes on chromosome level, for example endopolyploidy, can reflect adaptation under pressure of different stress conditions. Knowledge of the variation of endopolyloidy of individuals of endangered species is important for understanding of ongoing processes in populations. Endopolyploidy is result of the exponential replication of nuclear DNA in the absence of mitosis mainly due the endoreduplication which occur in 90% of all angiosperms [2]. Plant endopolyploidisation is associated with cell differentiation and metabolic activity and is important for normal organ and tissues growth and development [3, 4]. Endoreduplication consist of repeated endocycles without occurrence of mitosis, and chromosomes segregation. Endopolyploidisation leads to presence of various ploidy levels (2C, 4C, 8C...) in the same organism [3]. Many study have reported endopolyploidy in different organism groups [5] mainly focused on plants [6-11], most of information on endopolyploidisation was obtained using experimental data from *Arabidopsis thaliana* [12]. Endopolyploidy can be modulated by many environmental stress factors, including light [3], nutrient availability [12, 13], temperature [10], heavy metal pollution [14], drought and cold stress [2] by activity changes of different molecular processes. The goal of this study was to determine endopolyploidy occurrence in young leafs of *L. sibirica* from two different habitats.

II. MATERIALS AND METHODS

In 2015, *L. sibirica* young leafs (one from each individual) were collected in two localities of the Vidzeme region of Latvia: Zušu-Staiņu sulphur spring and Krustkalni Nature reserve (Figure 1).

Fig. 1. *Ligularia sibirica* habitats in Latvia, 1 - Zušu-Staiņu sulphur mires, 2 - Krustkalni Nature reserve

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Altogether 51 leafs samples were collected: form 22 specimens in Krustkalni and 29 in Zušu-Staiņu sulphur spring. Leaf were dried and kept till analysis in silica gel. Samples for flow cytometry were prepared with a DNA staining kit (Sysmex Partec, PI Absolute, GmbH, Germany) according to manufacturer protocol with some modifications. For each sample, approximately 50 mg of dry leaf material was excised and placed into a glass Petri dish (60 x 15 mm). Dry material was chopped in 500 µL of +4C° cold extraction buffer. For removal of cell fragments the suspension was filtered through 40 µm filter (Falcon, USA) into a 5 mL polypropylene cytometry tube (Falcon, USA), and 1.5 mL of staining buffer was added. Cells nuclei were stained with 10 µL propidium iodide, and incubated in the dark for 24h at +4C° before analysis by flow cytometry. BD FACSJazz® cell sorter (BD Biosciences, USA) with flow cytometer function was used to detect DNA content (C value) of *L. sibirica*. The device was equipped with 100 µm nozzle and used phosphate-buffered saline (BD PharmingenTM PBS, BD Biosciences, USA) as a sheath fluid. Cell counting events were triggered by forward - scattered signal. The excitation of the cell fluorescence was made by 488 nm Coherent Sapphire Solid State (blue) laser. Before measurements, flow cytometer was calibrated using SpheroTM rainbow calibration particles (3.0 –3.4 µm, BD Biosciences, USA) in phosphate buffered saline (PBS). The calibration was considered as successful if the coefficient of variance (CV) of the calibration particles relative fluorescence did not exceed 3%.

Soil samples from both *L. sibirica* grow habitats were collected for laboratory analysis. The soil samples were taken from the root zone near *L. sibirica* plants to 20 cm depth. For each sample at least five sub-samples were collected and mixed into a single sample. Collected soil samples were air-dried and sieved through 2-mm sieve. To determine the plant available amounts of 3 essential nutrients (N, P, K) the soil samples were extracted with 1 M HCl solution (soil/extract volume ratio1:5). The levels of N, P were analyzed by the colorimetry, and K with the flame photometer (Jenwaey PFP7) [17].

III. RESULTS AND DISCUSSION

Flow cytometry analysis of DNA content in *L. sibirica* young leafs from different environments revealed presence of nine relative fluorescence peaks from 2C up to 64 C (Figure 1). Analysis samples from both localities shown that 83% of them were endopolyploid, only 9 samples had cells with one ploidy level: 5 in Zušu-Staiņu locality (Table 2), and 4 in Krustkalni (Table 3). In Zuši-Staiņu locality 93% of the young leafs were found to have 2C DNA content, 34.5% were 4C, 44% were 8C and 34.5% were found to have 16C DNA content. In contrast, in Krustkalni, 2C DNA content was observed only in 63% of samples. Because cell development process in young leafs are still in progress, determination of dominant C value in specimen was performed to prevent G2 phase influence on evaluation of endopopyploidy level. Paying attention to 4C, 8C, 16C, 32C and 64C DNA content peaks that represent DNA amplification by several endocycles in endoreduplication process, in both populations percentage of dominant C value are approximately equal, except 8C which frequency is about 17% higher in Zuši-Staiņu population. Percentage of 64C DNA nucleus among all samples was very low, represented by only 4%. 3C and 10C DNA peaks were observed in only several specimens, and 10C peak were found only in Zuši-Staiņu population. From the point of view of different environments, Zušu-Staiņu population exhibit much higher nutrient degree (Table 1).

Table 1.
Soil Nutrient Composition In Investigated Localities

Locality	Nr. of soil sample	N	P	K
Zušu-Staiņu	1.	250	174	104
	2.	220	92	127
	3.	183	126	135
	4.	88	61	116
	5.	54	22	55
	Mean:	159	95	107.4
Krustkalni	1.	101	65	145
	2.	71	52	47
	3.	85	47	89
	4.	71	41	88
	5.	65	29	65
	6.	76	41	55
	Mean:	78.2	45.8	81.5

Data showed that low contamination of nitrogen is crucial for *L. sibirica* population existence and growth [15], thus high level of nitrogen and other nutrients can be observed as stress factor with negative effect to population existence. It is also possible that nutrients availability just like other environmental factors can affect endopolyploidy level [13, 16]. It is also known, that high levels of endopolyploidy occur in cells with increased secretory function [2]. In this case, it is possible that *L. sibirica* individuals from Zušu-Staiņu habitat undergo adaptation increasing endopolyploidy in their leaf cells during plant development.

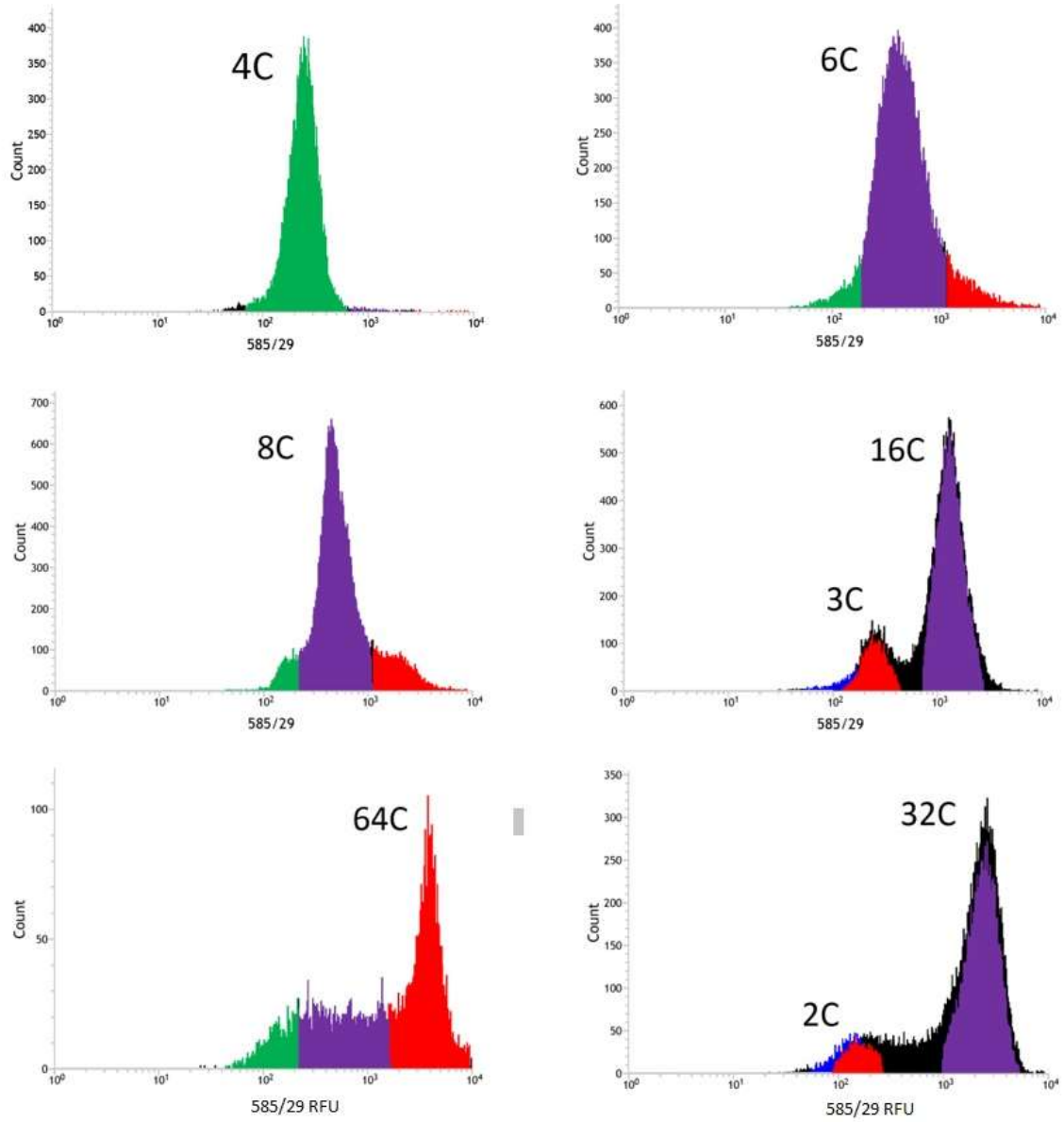

Fig. 2. Density plot showing the relative fluorescence of Ligularia sibirica nuclei staining with PI. Abscissa: RFU (relative fluorescence units) in logarithmic scale at 585 nm; ordinate: number of nuclei.

Table 2.
C Value Peaks of Ligularia Sibirica from Krustkalni Nature Reserve

Nr.	C value	Dominant C value
1	2C + 32C	32C
2	2C + 16C	2C, 16C
3	3C + 16C	3C, 16C
4	2C + 4C + 16C+ >16C	16C
5	2C + 4C + 8C + 16C	8C
6	2C + 32C	32C
7	2C + 32C+ >32C	32C
8	2C + 32C	32C
9	2C + 16C	16C
10	2C + 64C + > 64C	64C

Table 3.
C Value Peaks of Ligularia Sibirica from Zušu-Staiņu Sulphur Spring

11	2C + 4C	2C, 4C
12	4C + 8C	4C
13	4C + 16C	16C
14	2C+ 8C+ 16C	16C
15	4C + 16C + >16C	16C
16	8C	8C
17	2C + 8C	2C, 8C
18	2C + 8C + >8C	2C, 8C
19	4C	4C
20	2C + 32C + >32C	32C
21	2C	2C
22	2C	2C

Nr.	C value	Dominan C value
1	2C + 4C + 8C	2C, 8C
2	2C + 8C	2C, 8C
3	2C+ 4C + 16C	16C
4	2C + 4C + 16C + 32C	32C
5	2C +8C	8C
6	2C +8C	8C
7	4C	4C
8	2C + 8C + >8C	2C, 8C
9	2C + 10C + 16C	10C
10	2C + 8C + 10C	8C, 10C
11	2C + 32C	32C
12	2C + 4C + 8C	8C
13	2C + 8C+ 10C	10C
14	2C + 16C + >16C	16C
15	2C + 16C	2C
16	2C + 8C + 16C	16C
17	2C + 4C	4C
18	2C +8C+ 16C	2C, 8C
19	2C + 8C +> 16C	8C
20	2C + 4C + 64C	64C
21	2C+ 4C	4C
22	2C + 4C + 8C + 10C	4C, 8C
23	2C + 8C	8C
24	2C + 4C + >16C	2C
25	6C	6C
26	2C + 8C + 10C + 16C	10C
27	2C	2C
28	2C	2C
29	2C	2C

IV. CONCLUSION

Flow cytometry was successfully used to determine endoplolyploidy level in *Ligularia sibirica* populations from different localities. Zušu-Staiņu sulphur spring population showing higher level of nutrient contamination what probably is associated with nearness of farmland, revealed especially high percentage of 8C, but not in higher C value peaks. Both populations exhibit different endopolyploidy specifity what is related to pressure of different stress factors. Thus, it can be concluded that nutrient contamination is not the only factor affecting endopolyploidisation in *L. sibirica* young leafs.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] Council of European Communities (1992) Council Directive 92/43/EEC of 21 May on the conservation of natural habitats and of wild fauna and flora. Off J Eur Communities 35. pp. 7–50.

[2] Scholes D.R., Paige K.N. Plasticity in ploidy: a generalized response to stress. Trends in Plant Science, 20 (3). 2015, pp. 165-175.

[3] Maluszynska J., Kolano B., Sas-Nowosielska H. Endopolyploidy in plants. In: Leitch I.J., Greilhuber J., Doležel J., Wendel J.F. (eds). 2013, Plant Genome Diversity, Vol 2. Physical structure, behaviour and evolution of plant genome.

[4] Barow M., Meister A.. Endopolyploidy in seed plants is differently correlated to systematics, organ, life strategy and genome size. Plant, Cell Environ 26. 2003, pp. 571-584.

[5] Lee H.O., Davidson J.M. Duronio R.J. Endoreplication: polyploidy with purpose. Genes & Dev. 23. 2009, pp. 2461-2477.

[6] Yang M., Loh C.S. Systemic endopolyploidy in *Spathoglottis plicata* (Orchidaceae) development. BMC Cell Biol, 5. 2004, pp. 33.

[7] Straková N., Kocová V., Kolarčik V., Mártonfi P. Endopolyploidy in organs of *Trifolium pratense* L. in different ontogenetic stages. Caryologia, 67. 2014, pp. 116–123.

[8] Agulló-Antón M.Á., Olmos E., Pérez-Pérez J.M., Acosta M. Evaluation of ploidy level and endoreduplication in carnation (*Dianthus* spp.). Plant Sci, 201–202. 2013, pp. 1–11.

[9] Trávníček P., Ponert J., Urfus T., Jersáková J., Vrána J., Hřibová E., Doležel J., Suda J. Challenges off low-cytometric estimation of nuclear genome size in Orchids, a plant group with both whole-genome and progressively partial endoreplication. Cytom, Part A, 87. 2015, pp. 958–966.

[10] Bertin N. Analysis of the tomato fruit growth response to temperature and plant fruit load in relation to cell division, cell expansion and DNA endoreduplication. Ann Bot. 95. 2005, pp. 439-447.

[11] Kolano B., Siwinska D., Maluszynska J. Endopolyploidy patterns during development of *Chenopodium quinoa*. Acta Biol Cracov 51(2). 2005, pp. 85-92.

[12] Jovtchev G., Barow M., Meister A., Schubert I. Impact of environmental and endogenous on endopolyploidization in angiosperms. Environmental and Experimental Botany, 60. 2007, pp. 404-411.

[13] Barow M. Endopolyploidy in seed plants. Bioessays 28. 2006, pp. 271-281.

[14] Biskup A., Izmailow R. Endosperm development in seeds of *Echium vulgare* L. (*Boraginaceae*) from polluted sites. Acta Bot. Cracov. Ser. Bot. 46. 2004, pp. 39-44.

[15] Heinken-Šmídová A., Münzbergová Z. Population dynamics of the endangered, long-lived perennial species, *Ligularia sibirica.* Folia Geobot. 47. 2012, pp. 193-214.

[16] Kocová V., Straková N., Kolarčik V., Rákai A., Mártonfi P. Endoreduplication as a part of flower ontogony in *Trifolium pratense* cultivars. Bot. Stud., 57. 2016, pp. 34.

[17] Rinkis G., Ramane H., Kunicka, T. Methods of soil and plant analysis. Zinātne, Riga (in Russian). 1987.

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Methodological and Psychological Aspects of Education for Sustainable Development in Russia with Regard to International Cooperation

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Abstract. In 2004 the European Economic Commission developed the Strategy of Education for Sustainable Development (ESD). The aim of the strategy is the promotion of education for sustainable development and its inclusion in the system of formal and informal education. The authors propose the measures for the acceleration of ESD distribution at the international level because international cooperation in education can be considered as a contribution of countries to the implementation of global transition to sustainable development. The authors' concept of the phenomenon of ecological consciousness and the conditions of its formation are considered. The main problems of ESD efficiency are defined and criteria for its evaluation are offered. Integral features of the personality as an indispensable component of ESD are described.

Keywords: ecological consciousness, ecological culture, education for sustainable development, environmental awareness.

I. INTRODUCTION

Nowadays sustainable development (SD) in education is generally understood as the further stage of ecological education [1].

It is known that in 2014 the European Economic Commission developed the Strategy of Education for Sustainable Development (ESD) [2]. The main objectives of the strategy are as follows:

- assistance to sustainable development by formal and informal training;
- education of teachers who afterwards include questions of SD in the courses delivered;
- strengthening international cooperation in the field of SD.

It is supposed that the specialists who have acquired principles of sustainable development will perform their professional activities according to them. To achieve this goal, personal and professional qualities of a future specialist should be based on three obligatory components. They are:

- the amount and level of proficiency in the generalized knowledge and ideas of surrounding natural and social reality, necessary for forward and balanced development of the "person-society-nature" system;
- the availability of competences in acceptance of professional solutions on the basis of complete product life cycle or activities. This period covers production and conversion of raw materials in a product, sale, use and servicing of a product and comes to an end with placement of production wastes and consumption taking into account transport flows during the whole cycle (ISO 14040 and 1441 standards);
- the created consciousness reflecting valuable line items of the personality based on ideology of sustainable development.

It is obvious that the methodology of ESD is in direct dependence on the level of consciousness of a future specialist, on how this level corresponds to those moral and valuable reference points which are set by the principles of sustainable development [3].

In this paper an attempt to give objective characteristics of the phenomenon of a human person that corresponds to the present stage of the Russian society development is made.

II. MATERIALS AND METHODS

The initial position for characterizing consciousness of sustainable development is such a system of attitudes of the subject towards objective reality which 1) is based on a noosferizm [4] relying on a post-nonclassical paradigm of science and society development; 2) allows to use synergy

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approach in activity; 3) creates high motivational activity on overcoming anthropogenous crises through development when a new, higher level of dynamic balance with the environment is established; 4) considers culture as a factor which compensates constantly increasing tool and technological capabilities and supports internal control over manifestation of society and each person's aggression. It is culture that assimilates experience of anthropogenous catastrophic crashes and develops effective management models of social and natural processes [5].

The level of consciousness of a person is determined by the environment in which he lives, feels, creates or destroys.

The two components of the environment – socio-cultural and educational – are considered to be the most important for a future specialist. At the same time, objects, relations, traditions, established values, rules and regulations, symbols cultivated and supported by all members of society (or by its absolute majority) refer to the socio-cultural environment.

Researches show [6] that a real situation in the Russian society, the technological level of production processes, socially snugged rules of conduct, ordinary ideas of relations of a person with the environment correspond to psychology of so-called "industrial or technocratic society" in Russia. It means that ecological content of the acts made to a natural environment is not actualized by people.

Consumer meanings are more urgent. Anthropocentrism is shown in the attitudes towards other living beings. Possibilities of satisfaction of communication requirement with the nature are connected with the expansive appropriating behaviour forms. Two mutually exclusive bases very often get on in the identity of the modern person: he may be, hypothetically, "the most active friend of the nature" in off-duty hours and, at the same time, at work, being submitted to logic of production process, may cause ecological damage. According to some data [7], the level of development of the intellectual and strong-willed parts of consciousness for sustainable development in Russia is yielded by more than twice to the average level of economically developed countries.

In general, at this stage the social and economic situation and the level of public consciousness testify that problems of SD don't become essential and necessary for most of Russians and, consequently, for students. At the same time, Russia declared the commitment to the ideas and principles of SD but not to the detriment of the national interests [8].

What is ESD methodology? For its development it is necessary to outline a circle of the main problems in its development, a theoretical basis and criteria for evaluation of its efficiency. We will briefly describe each of the designated line items.

The main problems of efficiency of ESD are seen in the following:

1) The problem of a ratio of components of education.

At present, geographical and ecological components prevail in ESD. A lot of questions are put in a considerable number of training courses, but significantly less number of answers is given.

These questions are:

- what should the world order be like?
- in what way to prevent emergence and distribution of terrorism?
- what are universal criteria of society of reasonable consumption?
- what is the interrelation of democracy and development in countries with different culture?

At the same time, economic (quality of life, SD indicators, etc.), socio-political (environmental policy at the global, regional, local levels), social-and-ecological (world outlook SD bases, ethics of life, behavior of reasonable consumption, etc.) components remain insufficiently worked out.

2) Elitism problem.

Unfortunately, questions of sustainable development and values inherent in it concern and are significant for very limited number of students so far.

3) The problem of mentality and traditions is closely connected with the aforesaid problem.

Formation of sustainable development isn't valuable as it has no pragmatic component. At the same time, our students prefer to get a specific education which can give them means of livelihood in future. Such is a mental feature of our students. The ideas of sustainable development, "social justice" haven't been personal values for them yet.

4) Customer's problem.

In Russian economy there is no order for a position of a specialist in sustainable development so far. The modern period of development is characterized by the fact that the need for specialists in engineering environment protection increases. It is necessary to recognize that engineering environment protection and education for sustainable development are not identical concepts. Students of ecology, finishing education in a higher education institution, generally own knowledge and skills of the technologies of purification of air and water, calculated parameters connected with impact on the environment (waste, physical factors, etc.), the regulatory base of technogenic impact, etc. Meanwhile, it is necessary to consider complete product life cycle or activities in the SD course. This cycle covers production and conversion of fossil raw materials, conversion of raw materials in a product, sale, use and servicing of a product, placement of production wastes and consumption taking into account transport flows during the whole cycle [9].

5) Shortcomings of theoretical bases of sustainable development.

These shortcomings result in difficulties of development and promotion of SD training courses.

The most essential shortcomings of SD theory development are:

- the lack of the single theory of stability of the biosphere;
- the lack of the theory of justice;
- uncertainty of a ratio of the concepts "stability-variability";
- shortcomings of the applied development indicators;
- the availability of a general relativistic approach.

6) Insufficiency of coordination of education for sustainable development at the international level.

This problem is characterized by:

- the lack of a databank of SD education at the international level;
- the recognition of diplomas on SD by higher education institutions of different countries;
- the lack of the unified criteria for a quality evaluation of SD training courses [10].

III. RESULTS AND DISCUSSION

What are criteria to estimate education for sustainable development?

It is possible to make an attempt to estimate quality of educational programs via ESD indicators which can be the following:

- to what extent development of education in the field of sustainable development is supported politically and organizationally by official structures;
- how sustainable development through formal, informal and unofficial studying is supported;
- competence of teachers in the field of sustainable development that is necessary for training;
- the availability of adequate training materials;
- the support of researches in the field of sustainable development and promotion of education in this field;
- coordination of education for sustainable development at the international level, its structure, function and the principles of interaction;
- strengthening of cooperation at all levels by training in the field of sustainable development at the regional level;
- the integration of the SD ideas into disciplines of educational standards on various specialties. At the same time the closest attention should be paid to engineering specialties as specialists in production and technology render the greatest anthropogenous load on the environment by their professional activity.

This list can be continued.

How can acceleration of process of ESD distribution be achieved in the nearest future?

Firstly, it is necessary to realize accurately: at present it is impossible to persuade all members of the society, and, above all, its future active members - modern students - to share and profess the principles of sustainable development in their professional and everyday life. Purposeful search of that part of youth to which the declared principles are closest and clear is necessary. These may be graduates of specialized classes or profile educational institutions with an ecological orientation.

Secondly, teaching and educational process should be organized on the conscious and comprehensive analysis of the ideas and principles of sustainable development taking into account, on the one hand, strategic objectives of all mankind – to survive and keep the habitat for future generations, and, on the other hand, to provide for Russia the worthy place in future.

Thirdly, professional activity training should be arranged on the basis of resource and energy-saving technologies with forming the system of professional thinking based on the idea that environmental problems of the entity or activity should be solved in a pollution source, but not "at the end of a pipe". It means transfer of the center of gravity from reactive to preventive approaches [11].

What result of such methodological approach to sustainable development in education can be seen?

It is slow, but steady increase of such members of society who realize and understand that salvation of mankind (however pathosly it may sound) is in the change of the concept of life of each person. It should bring real dividends in combination with reasonable environmental policy of the state. According to the theory of the social diffusion applicable to distribution of new habits and regulations of life, the presence of 10-12% of members of society is enough in order that these changes could begin. After achievement of a threshold of 30% these changes become irreversible.

The task of the present stage is to achieve a 12% result.

To build the educational process in the logic of sustainable development at Pskov State University, the socio-pedagogical system of forming students' ecological culture has been designed and implemented for a number of years. The process of this culture formation is a syncretic phenomenon, therefore it is prolonged for the entire period of study at the university and represents the synthesis of the following activities of a future specialist: 1) the initiation of information that constitutes the essence of sustainable development on the basis of experience an assimilation of cross-cultural values of an ecological orientation for the formation of a primary basic worldview; 2) the adoption of sustainable development principles in the process of general

professional training; 3) the formation of professional competences on the basis of the implementation of academic professional activities. All these elements are included into scientific and educational project activities in professional and social aspects. This is how the lifestyle is formed that is understood as the integral formation of the personality based on the environmental consciousness and ecological style of thinking [12].

IV. CONCLUSION

International cooperation in education for the benefit of sustainable development qualitatively influences the development of education in this area in Russia in general and in certain regions (especially if these regions are the territories of the adjacent states, and environmental problems of these states have general history and roots). The cooperation in the field of education can be considered as a component of the contribution of countries to the implementation of processes of global transition to sustainable development.

As we know, much work on forming an education system for sustainable development is conducted in the world. In developed countries the result of this process is an impressive development of its institutional bases and the state support ensuring.

This experience is especially interesting to the countries with the developing and transitional economy. Experience of developed countries in the sphere of ecological education for sustainable development can push economically unstable states to creation and development of the system of environmental protection, to active promotion of the ideas of sustainable development among the population, to distribution of effective measures for achievement of safe activity and balance of economy and ecology which is the basic criterion of sustainable development [13].

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REFERENCES

[1] N. I. Kuzhanova, *Forming of ecological culture of students at the higher technical school.* Pskov: POIPKRO, 2004, 292 p.

[2] N. P. Komendantova-Amann, “Awareness of need for sustainable development as one of the most important values of society”, Culture Horizons: SPb: SPbSPU publishing house, 2005.

[3] T. V. Ivanova, “Ecological values in public consciousness,“ Psychology Questions, Vol.3, 2009.

[4] A. I. Subetto, *Noosferizm*. SPb, 2001. 591 p.

[5] N. I. Kuzhanova, “The importance of ecological consciousness in the strategy of education for sustainable development”, Economic Innovations, Vol. 53.Odessa, 2013, pp. 129-139.

[6] I. V. Kryazh, “Psychosemantic research of ordinary ecological representations”, Psychology Questions, Vol.1, 1998.

[7] V. V. Bakharev, *Ecological culture as factor of sustainable development of society*. Ulyanovsk: ULGU publishing house, 1999, 593 p.

[8] N. I. Kuzhanova, “Cross-border cooperation in the field of ecological education”, Environmental, economic and socio-cultural preconditions of cross-border cooperation in the Baltic region”, Proceedings, Pskov, 2012, pp. 12-23.

[9] M. R. Kononenko, “Foreign experience of education in the field of ecological management and its use in RGGMU”, Actual issues of teaching a university course "Ecological management". SPb: RGTMU publishing house, 2003, 242 p.

[10] S. D. Deryabo and V. A. Yasvin, *Ecological pedagogics and psychology.* Rostov-on - Don, 2008, 348 p.

[11] E. V. Girusova, *Ecology and economy of nature use.* M: UNITY, 2007, 591 p.

[12] N. I. Kuzhanova, “To the question of methodology of education for sustainable development in Russia based on international experience”, Proceedings, Pskov, 2013, pp. 37-41.

[13] Lars Ryden, Pawel Migula, and Magnus Anderson, *Environmental Science*. Uppsala:The Baltic University Press, 2003.

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Pickling Experimental Study on Preparation of Diesel Oil with Pyrolysis Oil from Waste Rubber

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Abstract. The research has been done for removing asphaltene by pickling process of diesel oil from pyrolysis oil self-made by waste rubber in this paper, and the study showed that pickling effect of concentrated sulfuric acid was better than concentrated hydrochloric acid. The best pickling effect was found when the concentration of sulfuric acid was 18.4mol/L, acid to oil ratio, namely, the amount of concentration of sulfuric acid to the amount of diesel oil ratio, was 25%. This experiment proved that removing asphaltene by pickling process using concentrated sulfuric acid was remarkable.

Keywords: asphaltene, pyrolysis, diesel oil, pickling.

I. INTRODUCTION

With the rapid development of pyrolysis technology in recent years, the fate of waste rubber happened changed greatly. Seen from the relevant literature, the preparation of diesel oil using pyrolysis oil from waste rubber was feasible, and some characteristics of the diesel oil was better than 0# diesel oil, which means that waste rubber have better utilization way[1,2,3,4].

However, the high level of asphaltene within the diesel oil can have an adverse impact on the diesel oil quality [2, 5, 6, 7]. Consequently pickling, an effective way to remove asphaltene, was crucial, and then the following factors need to be studied. Firstly, we need to confirm the dominant acid type. After by means of single factor experiments, the influencing factors like acid concentration, acid-to-oil ratio, stirring rate and immersion time were researched. Finally, we point out the optimum conditions of pickling process.

II. MATERIALS AND EQUIPMENT

Materials

Self-made pyrolysis oil (It came from waste rubber pyrolysis using High temperature pyrolysis furnace. Nitrogen gas as carrier gas, the flow of 50 mL/min; Pyrolysis temperature of 450 degrees centigrade for 10 min [5, 8, 9, 10, 11].)

Reagents

Concentrated hydrochloric acid (AR); Concentrated sulfuric acid (AR); Sodium carbonate anhydrous (AR); Atlapulgite; Benzoic acid (AR).

Equipment

High temperature pyrolysis furnace (OTF-1200X); Universal furnace (DL-1); Circulating water type multipurpose vacuum pump (SHB-III); Blast dryer (DGX-9143B); Analytical balance (CP214); Six asynchronous automatic lifting agitator (JJ-6A); Constant temperature water bath oscillator (DKZ-2); Liquid gun (WD-2108); Microcomputer oxygen bomb calorimeter (XRY-1B).

Process

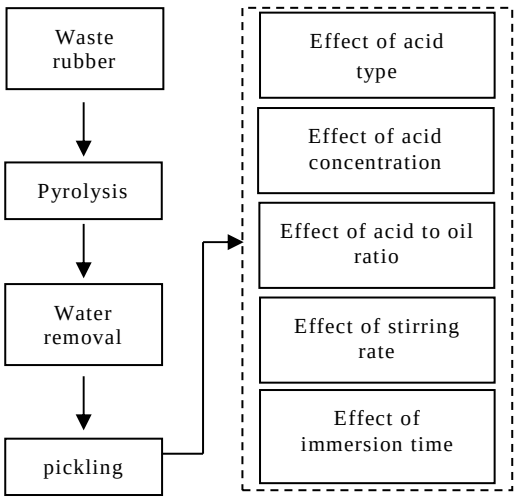

Fig.1. Pickling experiment flow graph

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Methods

The diesel oil sample was given calorific value test by microcomputer oxygen bomb calorimeter before and after the experiments in order to verify the effect of pickling [12, 13, 14, 15].

The experimental data was analyzed by using data fitting from SPSS (Statistical Product and Service Solutions) [14, 16, 17].

III. RESULTS AND ANALYSIS

Effects of acid type

Figure 2 shows effect of asphaltene removal using two kinds of concentrated acid. A1 and A2, B1 and B2 are parallel sample of adding concentrated hydrochloric acid and adding concentrated sulfuric acid, respectively. It's not hard to see that under the same acid dosage, effect of asphaltene removal using concentrated sulfuric acid was superior to concentrated hydrochloric acid, and was twice concentrated hydrochloric acid. The color of diesel oil treated by concentrated sulfuric acid was brighter than concentrated hydrochloric acid (see figure 3, 4), for the asphaltene removal rate using concentrated sulfuric acid was higher than concentrated hydrochloric acid.

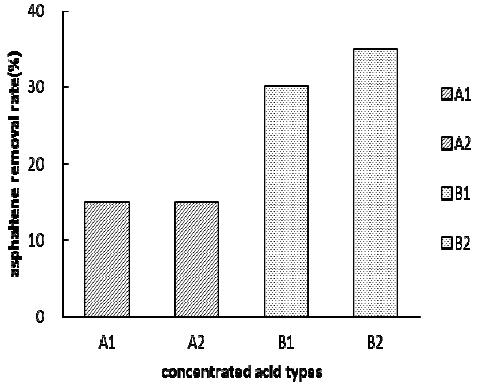

Fig.2. Effect of different concentrated acids on asphaltene removal

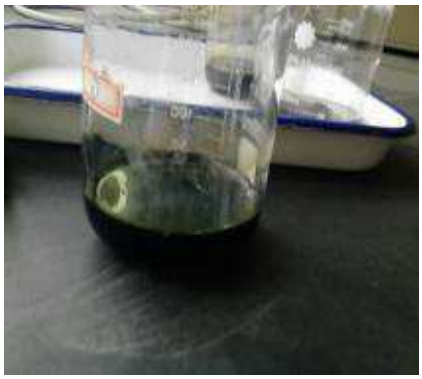

Fig.3. Adding concentrated hydrochloric acid

Fig. 4. Adding concentrated sulfuric acid

Effect of acid concentration

As shown in Table 1, asphaltene removal rate increases continuously with sulfuric acid concentration increases. It's worth mentioning that asphaltene removal rate has a sharp raise when the concentration of sulfuric acid was 18.4mol/L. More importantly, Sulfuric acid with a concentration of 18.4mol/L not only realizes the highest asphaltenes removal rate, but also no additional increase of moisture content within diesel oil.

Table 1.
Effect of different sulfuric acid concentration on asphaltene removal

sulfuric acid concentration (mol/L)	1	2	5	10	18.4
asphaltene removal rate(%)	0.1	0.3	0.75	0.8	5

Effect of acid-to-oil ratio

Asphaltene removal rate as shown in Table 2, effect of different amount of sulfuric acid to remove asphalt was different, but the removal efficiency was higher than 5%. In addition, effect of asphaltene removal was the best when acid-to-oil radio of 25%, the color of the diesel oil becomes bright, and the chroma of diesel oil was reduced to 5 degrees, close to the national standard.

Table 2.
Effect of different acid-to-oil ratio on asphaltene removal

Sulfuric acid-to-oil ratio(%)	10	15	20	25	30
asphaltene removal rate(%)	7	10	6.5	30	5.3

It can be seen from Figure 5 that the color of the middle sample was brighter than any others, the closest to the color of 0 # diesel oil.

Fig.5. The different oil samples of acid

Effect of stirring rate

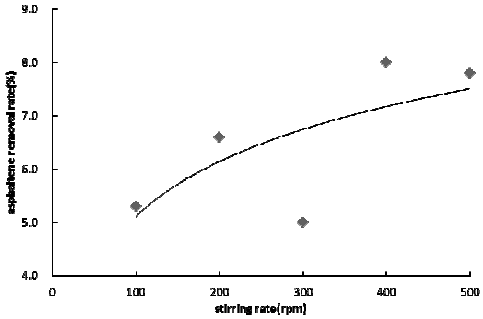

Fig.6. Effect of different rotational speeds on asphaltene removal

Asphaltene removal rate as shown in Figure 6, on the condition that the same concentration and amount of sulfuric acid, the amount of asphaltene removal increases along with the increasing of rotational speed. In the figure 6, deviation tendency of the third point may be caused by improper operation. In addition, when the rotational speed increases to 400 rpm or more, the amount of asphaltene removal increases slowly, even remain flat.

Effect of immersion time

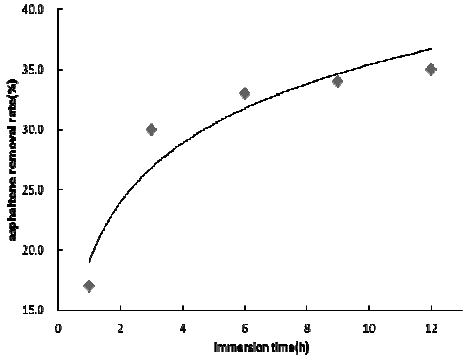

Fig.7. Effect of immersion time on asphaltene removal

With the immersion time increasing, effect of asphaltene removal was obvious. From Figuie 7, when the immersion time was 0h to 6h, effect of asphaltene removal was the most obvious; after 10h, the amount of asphaltene no longer increase, that was to say 10h was the limited time of asphaltene removal.

Table 3.
Calorific value of the diesel oil sample before and after the Pickling experiments

Experimental condition	After the Experiment Unit:kJ/kg	Before the Experiment Unit:kJ/kg
Optimal acid concentration	32067	27376
Optimal acid-to-oil ratio	36424	
Optimal stirring rate	31157	
Optimal immersion time	36173	

As shown in Table 3, the calorific value of the diesel oil after pickling was generally higher than before pickling, and then the calorific value of 0# diesel oil was measured 40128kJ/kg. Thus it can be seen that the effect of pickling was remarkable, the calorific value of diesel oil sample increased more than 30%.

IV. CONCLUSIONS

Effect of asphaltene removal using concentrated sulfuric acid was superior to concentrated hydrochloric acid.

During the pickling, the optimal concentration of sulfuric acid was 18.4mol/L.

On the condition of acid-to-oil rate of 20%, the chroma of diesel oil was reduced to 5 degrees.

The stirring rate of 200-400 rpm, effect of asphaltene removal was the best.

The optimal immersion time of asphaltene removal was 10h.

REFERENCES

[1] Jiang Yong, Liu Xiaolong, Liu Baoqing. Development of pyrolysis equipment for waste tires [J]. Chemical industry exhibition.2002,21 (9): 681.
[2] Liu Tong. Study on pyrolysis of waste rubber: 5-6.
[3] Zhang Siwen. Utilization of waste tires in developed countries: Volume twenty-second, fourth, 8-9.
[4] Huang Li Ben, Gu Yusheng, Huang Jing. Powder rubber. Chemical Industry Press, 33-38.
[5] Han Fei, Li Zhikun. Recycling technology of waste tires in Japan, Beijing: 45.
[6] Kang Peiyu. Study on the treatment of industrial sludge by low energy plasma incineration technology. North China Municipal Engineering Design and Research Institute, Tianjin.
[7] Li Rulin. Current situation and development countermeasure of waste tire recycling industry in China, Beijing: 2003,3.
[8] The Ministry of Chemical Industry Ministry of personnel education, the Ministry of chemical industry education and training center. Renewable rubber production mechanism, process and quality inspection. Beijing: Chemical Industry Press.
[9] Sun Hongyou. Production of diesel oil by pyrolysis of waste oil [J], technology and market, 2001, 9.
[10] Guan Xiaoyan, Kong Fanzhong, Yang Jingfang, Zhang Wei. Heat treatment of metals in twenty-eighth volumes for >2003 twelfth, 50-53.
[11] Cheng Weimin. Waste oil refining diesel oil project design review. Tractors and agricultural vehicles > June 2012 thirty-ninth volume sixth.

[12] Zhao Fenglan, Yan Jienian. Study on asphaltene inhibitors and clear agent. University of Petroleum (Beijing) EOR Research Center, University of Petroleum (Beijing) Institute of petroleum engineering. Oilfield chemistry, volume twenty-first, fourth, 311-312.
[13] Dong Liming, Yuen Wo Ping. Intensive land use [J]. China land science, 2000.
[14] Wang Yunqiang, Li Li, and. Research progress of biodiesel preparation technology [J]. Anhui agricultural science, 2010.
[15] Li Lilin, Du Wei, et al., et al. Preparation of biodiesel by lipase catalyzed by lipase in a new reaction medium [J]. Journal of process engineering, 2006 (in Chinese).
[16] Lv Dan, Du Wei, and. Study on the application of free lipase NS81006 in the preparation of biodiesel from oil containing acid [J]. Chinese Journal of advanced chemical engineering, 2010.
[17] Wang Chang, Huang Xiaoming, et al. Development and application of biodiesel [J]. Chemical industry and engineering, 2008 (in Chinese).

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Evaluation of Efficient Consumer Response (ECR) Processes in Retail Companies in the Baltic States

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Abstract. The primary goal of retail operations similar to any other business is to make a profit by satisfying consumer needs. To achieve the goal and ensure competitiveness retail enterprises need to carry out their operations as efficiently as possible by applying the latest, most modern work organisation methods. Work efficiency can be achieved by reducing supply chain costs which in turn can be achieved through successful cooperation among all the parties involved. Efficient Consumer Response (ECR) is not just a new approach to process organisation in retail trade but affects all business processes as a whole taking them to a totally new and much higher level, thereby ensuring an increase in customer satisfaction and loyalty levels. The aim of the present research is to review the latest scientific literature on ECR, understand its working principles and carry out a survey of experts in order to ascertain the level of application of ECR in retail enterprises in the Baltic States and put forward recommendations for the enhancement of application of ECR.

Keywords: customer satisfaction, loyalty, relationship management, retail trade.

I. INTRODUCTION

Despite the overall growth of the retail trade sector, internal competition within the respective sectors is increasing. Therefore it is very important to find opportunities on how to successfully survive and develop in circumstances of intense competition. The consumer is the one who makes the choice and the satisfaction of the consumer needs is the primary goal of retail trade. The consumer's choice is based on the good (assortment and quality), price and place. The consumer would also like the service to meet their expectations and to receive the necessary information. In the modern information era it is easy for consumers to gain information about the best offer on the market and retail enterprises have to come up with solutions to be leaders in the fight to attract consumers and maintain long term relationships with them. According to existing research [1] the cost of attracting new customers is 5 – 10 times more expensive than selling to your existing ones and existing customers spend 67% more money than new customers. Therefore it is essential that retail enterprises work out a system that would create desire in existing customers to carry out repeat purchases and continue their relationship. One of the systems offered for ensuring efficient operations in retail trade is ECR (*Efficient Consumer Response)*. An American marketing management firm has researched that the benefit of introduction of ECR would be a reduction of retail prices by 10.8% [13]. It is expected that manufacturers receive 54% of the savings and distributers and retailers could receive the remaining 46% [8].

The research reviewed the use of most popular efficient consumer response (ECR) principles in retail trade. ECR system elements are never a finished process but an enhancement tool for enterprises.

The aim of the research is to assess the level of use of ECR systems and development perspectives in retail enterprises as an effective tool for increasing its competitiveness.

The following tasks were set for achieving the aim:

1. Study the theoretical base of ECR.
2. Characterise the retail trade sector in the Baltic States and the prerequisites for implementing ECR in retail trade.
3. Determine the level of use of ECR and its possibilities in Baltic retail enterprises.

Research limits: 9 Baltic state experts in the retail trade were surveyed in order to identify the trends in the Baltic States and put forward the conditions for building and strengthening customer relationship management. The following limits were set due to the information necessary in the enterprise for ensuring customer relationship management: customer relationship management was researched primarily from the point of view of methodological aspects and the opinions of retail trade experts. Research period: 1st September 2014 to 1st September 2016.

The following research methods were used: monograph or descriptive method, logical – constructivist method – comparison of theoretical

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materials with empirical results; the experts' survey was processed using SPSS – to ascertain the level of use of ECR in retail enterprises in the Baltic States.

The methodological base of the research is based on works of foreign authors (*Best R.; Doyle J.; Evans M. etc.*) and publications in periodicals that provide an overview of trends in the field of customer relationship management and the novelties in the field.

II. RESULTS AND DISCUSSION

Many specialists, researchers and managers nowadays have come to the conclusion that under intense competitive circumstances one of the most significant success factors of enterprises is customer satisfaction with the range of products and services offered and their loyalty to products/brand/enterprise. In fact, a favourable attitude and loyalty are the basis for creating the enterprise's customer capital. However, to achieve the desired level of customer satisfaction and loyalty, the enterprise's relationships with its customers must be managed. Analysing the process of formation of satisfaction and loyalty the following correlations can be observed (refer figure 1).

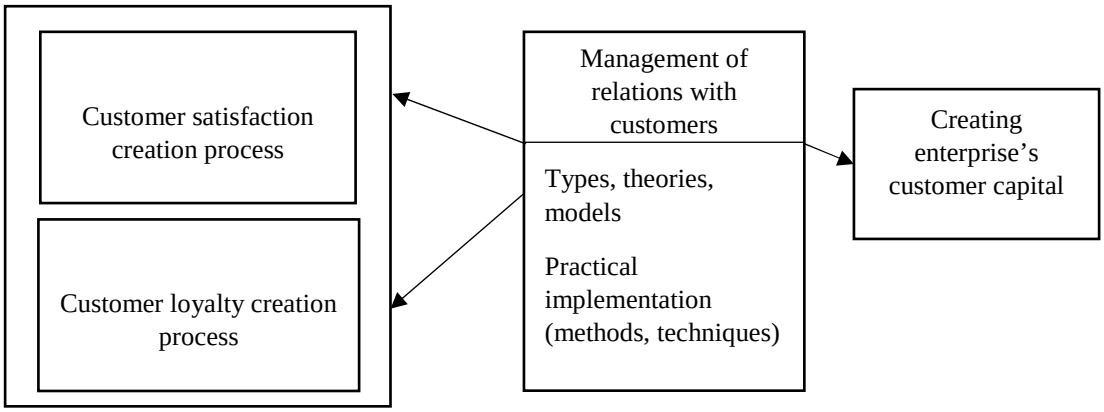

Fig. 1. Managing relationship with customers in connection with customer satisfaction and loyalty creation processes

Analysing several publications and other sources in the field of management of customer relationships [15; 9; 3; 12; 20; 10; 2 u's.], the authors have concluded that four systems researched in theory and applied in practice need to be highlighted:

1) Loyalty Programme – LP;
2) Consumer Relationship Management – CRM;
3) Efficient Consumer Response – ECR;
4) Relationship Marketing Management – RMM.

Retail enterprises use several management systems in practice but with evolution, each newly developed system includes both positive and tested elements of previous systems and new elements. This process is illustrated in figure 2.

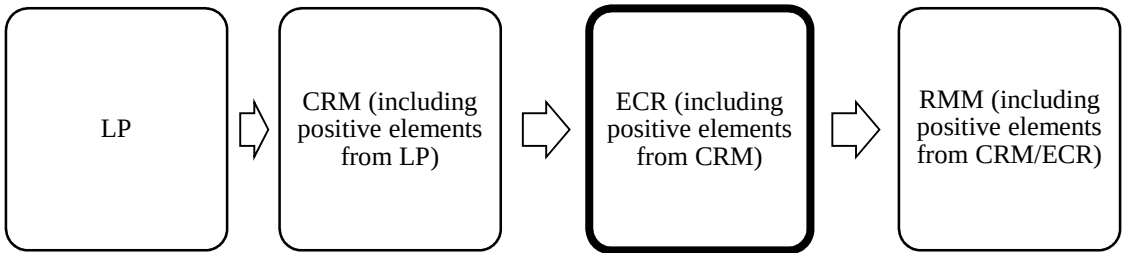

Fig. 2. Evolution of customer relationship management systems in retail trade

LP is used by many enterprises worldwide.

Characterising the advantages and drawbacks of LP one should distinguish its objectively inherent content and subjective implementation that do not always correspond to the demands. For example, both descriptions of positive as well as negative experiences can be found in scientific publications on this field [12; 20; 3; 10 etc.]. In this case the focus is on the subjective implementation of LP options, however the authors also point out some of its objective drawbacks:

- LP content, structure and types in fact relate only to the purchase/ sales process of products/brands even though the customer satisfaction/loyalty creation process which is the basis of customer relationship management is related to pre purchase and post purchase processes as well (refer figures 1.);

- LP in fact does not impact the basic factors of customer satisfaction and loyalty (refer figures 1.);
- LP does not correspond to the dynamics of the customer satisfaction and loyalty creation process;
- Relatively less attention is paid to marketing research – modelling consumer behaviour, market segmentation etc.

These drawbacks to some extent may be overcome by using CRM, which on the one hand includes the positive elements from LP (customer segmentation, differentiation, stimulation, communication with them etc.), but on the other hand is the next stage in the field of creating and managing customer relationships.

Consumer relationship management (CRM) systems were followed by ECR (*Efficient Consumer Response*) which means „efficient response to meet consumer needs". Analysis of results of publications in the field of ECR [5; 17; 11; 16; 18 etc.) allow us to conclude that despite the insignificant differences all the authors consider that ECR is „cooperation between retailers/distributors and manufacturers with the aim of satisfying customer needs and promoting prevention of irrational costs in the supply chain from the manufacturer to the consumer".

ECR became popular in developed countries in the mid 90's of the 20th century and the grounds for its creation was the increasing competition in world markets, rapid information technology development, creation and development of international trade organisations, necessity for optimisation of the distribution channel and growing consumer need for high value and high quality products and service quality. Researchers have underlined that it is the mutual trust between all the partners involved in the product supply process which is a prerequisite for achieving positive ECR results [5]. ECR is long term relationship with the respective stakeholders in the product supply process that foresees the management and resolution of disputes in a timely manner in order to achieve an overall positive result [18].

While agreeing to the statements of the abovementioned researchers regarding ECR one should however consider that it is unreasonable to plan and implement this relationship management system with consumers in practice separately and independently from the introduction of CRM in retail trade. In essence ECR is modernised and updated CRM as it serves the same purpose – managing relationships with consumers to satisfy their needs for products and increase their loyalty level. It is clear that close cooperation between manufacturers and retailers is necessary in this field. Improvement in product quality may mean nothing if retail enterprises are unable to ensure high quality service to their customers (CRM system function) and their loyalty indicators would go down due to the above reason. Summarising the information gathered it could be concluded that the efficient use of CRM and ECR systems are the basis for creation of consumer relationship management systems in retail enterprises.

ECR is more emphasised by Italian researchers [4], who highlight four important ECR blocks that comprise cooperation between manufacturers and retailers in the respective fields (refer table 1).

Table 1
Keys elements and fields of cooperation with suppliers in ECR systems

ECR			
Demand management	**Supply management**	**Integrating demand and supply**	**Use of information technology**
Needs and demands Value creation for customers Optimisation of product assortment Communication optimisation Launching new products on the market	Identifying supply strategies and possibilities Supply standards and indicators Supply corresponding to demand Supply corresponding to demand from the "price-quality" perspective Supply efficiency	Planning and forecasting manufacturer and retailer cooperation Measuring effectiveness of cooperation	Identification standards Information technology and communication standards Harmonising and synchronising databases

One could agree to the conclusions of the „*ECR Baltic"* research that in case of efficient use of the system the following four parties could benefit from it: society, consumers, retailers and manufacturers [7].

The main benefits for the society from ECR:

- quick response to consumer needs;
- preventing loss and reducing costs in the product supply chain;
- ensuring high quality customer service.

Benefits for the consumer:

- Greater choice and more convenient purchase according to consumer needs;
- Ensuring product sufficiency;
- Ensuring product variety.

Benefits for retailers:

- Greater consumer trust and satisfaction with the service quality;
- wider possibilities of market research;
- enhancing relationships with suppliers;
- increasing efficiency of the supply chain.

Benefits for manufacturers:

- Increasing production efficiency;

Coordinating market demand with retailers;
Ensuring product sufficiency;
Ensuring product/brand positioning in the market;
Long term trading relations.

ECR foresees the creation of product assortment through product category management. Product category management assess assortment not as separate product sets but divides them into categories based on consumer needs and psychological aspects of product purchase [11]. Each retail enterprise works out its own product categories based on consumer needs and therefore consumer research and segmentation is necessary to ascertain and understand the target audience for each category and the perception of specific retail outlet (location, ambience etc.).

ECR in essence is based on CRM principles but has been appended with methods of cooperation between enterprises of the manufacturing and retail sector with the aim of ensuring satisfaction of consumer needs and reduction of supply chain costs. ECR also comprises such customer service approach as product category management which is rapidly developing in European countries.

Since regaining independence, retail trade in Latvia in particular and the Baltic States in general has developed with changing effects. For many years the sector has been one of the largest contributors to GDP. During the global economic crisis, retail was one of the economic sectors to experience the largest downturn. Since 2011, retail has developed similar to the economy as a whole. While retail is generally influenced by internal events, it is also indirectly affected by external factors. The Russian-Ukrainian conflict and the related sanctions, as well as the weak growth within the European Union (EU) leave negative impact on consumer behaviour and stimulate savings, thus hindering the total consumption.

To gain understanding on the situation in the Baltic State retail sector, the shadow economy index (SEI), which provides the best description of the industry situation was analysed (refer Figure 3).

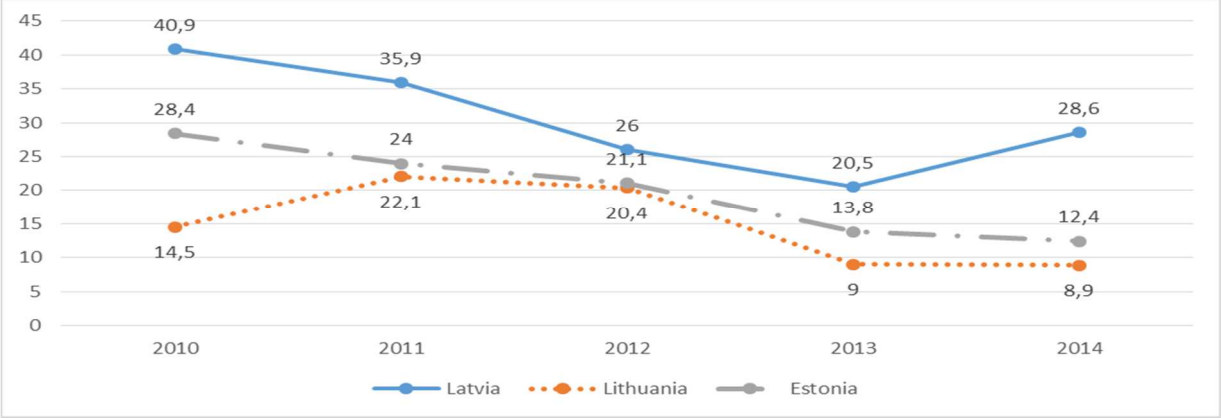

Fig. 3. Shadow economy in the Baltic State retail sector 2010 – 2014 (% of GDP) (According to the data by Putnins, Sauka) [14]

As seen in Figure 3, Latvia is the leader among the Baltic States regarding shadow economy in the retail sector. While there was a positive trend from 2010 to 2013 with SEI decreasing by 20.4 percentage points, the indicator increased by 8.1 percentage points in 2014. It should be noted that the index was only 12.4% in Estonian retail sector in 2014. As well, for Estonia and Lithuania the index shows constant decrease trend. This means that companies can reach their goals applying legal and transparent business methods, incl. in the field of consumer relationship management.

For the evaluation of how entrepreneurs use consumer relationship management principles in retail enterprises in the Baltic States, it is vital to understand the current level and future prospects of CRM application. For this purpose, an expert survey was carried out. Taking into account the experts' knowledge level and connection to the relevant questions, 9 experts were selected –leading specialists of trade associations of the Baltic States, who evaluated the situation in their country in general, as well as the representatives of retail chains located in all three Baltic States, who evaluated the situation in their respective companies.

Table 2
The use of ECR, incl. product category management in retail enterprises or enterprises on the whole in the Baltic States, key indicators for expert assessment

Level of use of CRM	Mean	Standard error of Mean	Median	Mode	Standard deviation	Skewness	Range	Maximum	Sum
Level of cooperation of product category managers with suppliers of the same category products	5.33	0.78	5.00	4.00	2.35	5,5	4.89	9.00	48.00
Product category managers use information from CRM databases	3.22	0.70	3.00	2.00	2.11	4.44	7.27	8.00	29.00
Product category managers are responsible for sales of products in the category	5.78	0.76	6.00	6.00	2.28	5.19	4.38	9.00	52.00
Product category managers determine pricing for products in the category	5.00	0.85	4.00	9.00	2.55	6,5	5.67	9.00	45.00
Product category managers are responsible for promotion of products in the category	4.78	0.88	4.00	4.00	2.64	6.94	6.13	9.00	43.00
Product category managers consult salesmen of products in the category	3.22	0.68	3.00	2.00	2.05	4.19	7.06	7.00	29.00
Accessibility of product category managers to information regarding customer satisfaction	4.67	0.82	5.00	8.00	2.45	6.00	5.83	8.00	42.00
Possibilities of product category mangers to respond to changes in consumer needs	4.56	0.82	4.00	4.00	2.46	6.03	5.99	8.00	41.00

As can be seen the use of ECR databases by product category managers is rather poor (3.22 – mean regarding use of ECR databases, incl. 5.33 for cooperation with suppliers; 4.67 – regarding customer satisfaction). Product category management is at a high level in some individual enterprises. Mo = 8 and Mo = 9 indicate the use of information regarding prices and customer satisfaction from ECR databases by product category managers. Approximately similar assessment, that is an insufficient level, (refer figure 2) indicates that the product category management should be enhanced as a whole and not just its separate elements. Moreover, the process should definitely be integrated with the ECR database. Otherwise, product category management will not be closely linked to the specific characteristics of the target audience, communication modes and consumer needs.

III. CONCLUSIONS

1. The retail trade sector in the Baltic States has developed at the same pace as the economy on the whole since the regaining of independence. Reviewing the situation according to the shadow economy index (SEI) Latvia is the leader among Baltic States in the retail trade sector (28.5 % in 2014). The SEI is only 12.4% for Estonia in 2014 and 8.9% for Lithuania. Moreover, the SEI index is constantly decreasing for Estonia and Lithuania. This means that companies can reach their goals through legal and transparent business methods, incl. in the field of management of consumer relationships.
2. Consumer relationship management systems are constantly evolving in retail trade both in theory and in practice (refer figure 2.). At present there is the development of CRM and ECR systems in retail trade. CRM is a company's operational strategy to attract, differentiate, serve and maintain consumers by understanding their needs and satisfying them, developing long term cooperation based on creating and maintaining consumer databases. ECR system elements and fields are being integrated into CRM systems.
3. The experts' survey indicates that the level of use of ECR in retail enterprises in the Baltic States is insufficient from the consumer needs satisfaction and loyalty creation perspective and therefore the systems need to be improved and developed taking into account the specifics of the target audience.

4. In relation to the development of CRM/ECR systems in retail enterprises it is necessary to invest into and develop the product category management approach using CRM/ECR databases and coordinating it with other marketing and promotional activities.
5. In depth research has not been carried out in Latvia as yet on the benefits of ECR and its use that would convince retail enterprises to use it in a full-fledged manner.
6. Retail enterprises should use assortment management by category in their operations to ensure consumer satisfaction and loyalty as well as high quality service.

REFERENCES

[1] Anderson, J. L., Jolly, L. D., Fairhurst, A. E. (2007). Customer relationship management in retailing: a content analysis of retail trade journals. Journal of Retailing and Consumers services, November, 14(6).

[2] Best, R. (2005). Market based management. 4th ed., Prentice Hall.

[3] Butcher, S., Stephan, A. (2002). Customer Clubs on Loyalty Programmes. Abingdon, Oxsn, GBR: Gower Publishing Limited.

[4] Butsonera, A., Martini, P., Zavattini, G., Santona, A. (2014). Psychometric properties of an Italian version of the experiences in chose relationships – revised (ECR-R) scale. Psychological Reports, ISSN: 0033-2941, Jun, vol. 114 issue 3, pp. 785–81.

[5] Dyer, J. H., Harbir, S. (1998). The Relational View: Cooperative Strategy and Sources of interorganizational Competitive Advantage. Academy of management Review, 23 (4), pp. 660–679.

[6] Doyle, P., Stern, P. (2006). Marketing management and strategy, 4th ed. Prentice Hall, pp. 401–432.

[7] ECR Baltic (b.g.). Retrieved 08.08.2015 from http://www.ecr-baltic.org/en/about-ecr/efektiva-pateretaju-vajadzibu-novertesana-ecr/

[8] ECR Europe (b.g.). Retrieved 05.07.2016 from http://www.ecrnet.org/01-about/01-about1-2.html.

[9] Evans, M. (2012). Consumer Behaviour. Hoboken, NJ, Willy.

[10] Harker, M. J. (1999). Relationship Marketing defined. MCB University Press, Bradford, pp. 13–20.

[11] Hofstetter, J. (2006). Accessing the contribution to ECR. ECR journal, vol. 6 issue 1, pp. 20–29.

[12] Kotler, P., Keller, K. L. (2006). Marketing management. 12th ed., Prentice Hall, pp. 196–197.

[13] Kurt Salmon Associates (1993), Efficient Consumer Response — Enhancing Consumer Value in the Grocery Industry. Washington, DC: Food Marketing Institute.

[14] Putniņš, T.J. & Sauka A., (2015). Ēnu ekonomikas indekss Baltijas valstīs 2009 – 2014. Rīga: SSE Riga Ilgtspējīga biznesa centrs, 47 lpp.

[15] Reisheld, F. (2003). The One Number You Need to grow. Harvard Business Review, December.

[16] Salmon, K. (1993). Efficient Consumer Response-Enhancing Consumer Value in the Grocery industry. Washington DC, Food Marketing Institute.

[17] Seifert, D. (2001). Efficient Consumer Response. Hampp, Mering.

[18] Smith, P. R., Zook, Z. (2011). Marketing Communication. 5th ed. Kogan Page, PA, pp.

[19] Teece, D. J., Gary, P., Amy, S. (1997). Dynamic Capabilities and Strategic Management. Strategic Management Journal, 18(7), pp. 509–533.

[20] Toedt, M. (2015). The contribution of customer relationship management to sales performance in the hotel business. Summary of Doctoral Thesis, University of Latvia, Riga.

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Nature Park as a Resource for Nature Based Tourism

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Abstract. The aim of this comparative article is to show the differences between the visitors' purposes and habits in two national parks: Gauja National Park (GNP) in Latvia and Kasu Bramhananda Reddy National Park (KBR) in Hyderabad, Telangana in India. As well as that, the article aims at highlighting differences in the functional use of the national parks and their locations in the urban and rural context. The study has used the secondary data analysis, such as the analysis and overview of the literature, previously conducted studies and information sources, visitors' surveys in the national parks, and the exploration of the park areas for the evaluation of tourism infrastructure. The results of the study show distinct differences in the national park functions, target groups and their needs. The main target group in KBR is local inhabitants of the million city, and the national park basically fulfils the function of a city park –it is a green area for passive and active (jogging) leisure rather than a nature tourism offer. GNP has three target groups: the local population for a healthy leisure time, domestic visitors and foreign visitors for nature and cultural purposes. Thus, KBR status as a national park is misleading for the international traveller. In the future research it is planned to compare GNP with a national park in India which is located outside the urban environment, carrying out an in-depth study of visitors' opinion on the purpose and elements of infrastructure.

Keywords: nature based tourism; purpose; motivation; national parks; infrastructure.

I. INTRODUCTION

There are different types of tourism; some are very closely connected with national parks. Parks play a major role in leisure and recreation of the population of urban areas. According to the World Health Statistics 2014, 54% of the world's population live in urban areas [7]. In the last almost 50 years there has been an increase in urban population of 20% with a tendency and forecast to continue the growth of more than 1% per year in the future. There are distinct differences among countries regarding the urban and rural population; the urban population in India is 31%, in Latvia 68%, in Malawi 16%, in Nepal 17%, in Nauru and Monaco 100%, in Iceland 94% [8]. National parks are relevant for nature tourism and eco-tourism. However, these data show that national parks are significant also for the domestic tourism and recreation with the main purpose of leisure for the population in urban areas with a high level of population concentration. In addition, these areas are generating potential for the international tourism.

The World Tourism Organisation of United Nations (UNWTO) reported that the number of *international tourists has seen a steady growth from 25 million* in 1950 to 1,235 million in 2016. The UNWTO has predicted it to reach 1.8 billion by 2030 according *to the newly released long-term forecast called Tourism Towards 2030 by the UNWTO* [22]. The fact that 53% of the total trips in 2016 were for leisure, recreation and holidays indicates the continuing importance of the proper management of recreational areas, especially of wilderness and parks [10], [22]. It points to the necessity of sustainable tourism planning and management, particularly in national parks.

According to the Guidelines of the International Union for Conservation of Nature (IUCN), a protected area is defined as "a clearly defined geographical space, recognized, dedicated and managed, through legal or other effective means, to achieve the long-term conservation of nature with associated ecosystem services and cultural values". The term covers a wide variety of designated areas, namely wilderness areas, nature reserves, national

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parks or protected landscapes that can be land, inland, coastal, water or marine areas, or their combination. There are different aims, objectives and restrictions to every IUCN protection category. However, all categories have the common principle of conserving biodiversity and maintaining diversity of landscape or habitat [20].

National parks are among the major resources and attractions for the nature based tourism, and the national park label is the most well-known for tourists and visitors from the categories of protected areas [14], [17], [15]. Nature based tourism is an important segment of the international and domestic tourism industry throughout the world, which has been expanding rapidly over the past decades, and further growth is expected in the future [12]. Nature based tourism is expected to have a continuous growth from an estimated 7% of the global tourism in 2007 to as much as 25% by 2020 [2]. Nature based tourism is the fastest growing branch of tourism both in Europe and in India as the demand for it has been rising at a steady pace [18]. Tourism in national parks contributes towards the conservation of flora and fauna as well as provides local livelihoods, since it is often promoted as a win-win scenario in which tourists have an enjoyable experience [1] - [3].

Natural heritage has two forms: the tangible, which is mostly known as the geological forms (cliffs, stones), flora, fauna, ecological processes, and the intangible [16]. In times when the number of visitors in national parks is increasing throughout the world, the most significant task is to develop and strengthen the intangible natural heritage by providing services and information posters about the symbiosis of humans and nature. Hall shows broader dimensions of the impacts of tourism, including socio-environmental impacts i.e. landscape change [4]. Landscape is the backbone element in the protected areas in Latvia, also Gauja National Park. On the contrary, in national parks in India the most crucial task is to protect and save specific species of fauna, for example the tiger *(Panthera tigris).* Goosling and Hall have made an overview of the scale of tourism analysis clearly showing that the landscape analysis has not been studied sufficiently on a broader scale than the regional [4].

According to Weaver et al [5], there are various types of tourism activities in the nature based tourism. These activities are different from other types of tourism because of the position of the natural environment, or for the reason it is completely based on the natural element of the place. Davidson [16] has mentioned characteristics and attributes of natural landscapes, for example the “natural quit”. The nature based tourism offers a wide variety of activities for tourists such as fitness, viewing, snow and ice related, outdoor and also adventure activities like hiking, mountain climbing, rock climbing, rafting, boating, swimming, kayaking, wildlife watching, bird watching, sightseeing, camping, skiing, air-ballooning, etc. [9].

II. MATERIALS AND METHODS

For conducting the research the authors used semi-structured interviews from different organizations in India and Latvia, and visitors’ surveys mainly in Gauja National Park (GNP) in Latvia, but in a sample volume also in Kasu Bramhananda Reddy National Park (KBR) in India. Visitors’ survey in the GNP was conducted between June and October 2015 in the Latvian and English languages. The visitors’ survey could be interpreted as a structured interview – a qualitative method based on a large number of questions. The total number of respondents in GNP was n=147, including 74% local residents and 26% foreign visitors. The respondents were surveyed in different locations of GNP objects, transport hubs, choosing different days of the week and weather conditions, times of the day and special public events. A sample visitor survey (n=15) was conducted in KBR in February 2014.

For conclusions data triangulation and observation methods were used in both countries by both authors. As well as that, the review of literature studies was carried out. The main limitation of the research is that the statistical data of the number of visitors in both national parks is not available and collected.

Background information on the selected national parks

The authors have chosen two case studies, one from Latvia and the other from Hyderabad, India. The article explores different aspects of tourism, particularly tourism resources, activities, nature and type of visitors of the protected areas: the primary case study is Gauja National Park in Latvia; the secondary or complementary case study is Kasu Bramhananda Reddy National Park, Hyderabad, Telangana in India. The essential strategy behind selecting both parks is that both national parks are located in close proximity to and/or in the city, and the visitor activities are also similar in both parks. The objective of the paper is to find out the difference between two national parks in Latvia and India in terms of tourism resources, motivation of visitors, activities in the parks, and challenges and issues relating to tourism management.

Latvia is a country on the Eastern coast of the Baltic Sea with four different and unique seasons: spring, summer, autumn and winter. Latvia is a small country in terms of population with less than two million people in 2016. Latvia has the external European Union border with Russia and Belarus. Most incoming international tourists arrive from Lithuania, Estonia, Russia, Finland and Germany. [11]. In Latvia there are four national parks, which are located in different regions of the country. Gauja National Park (GNP) is the oldest national park in

Latvia located close to the capital city Rīga. The major and dominant part of the national park is the old valley of the Gauja River. The natural values are geological objects such as caves, cliffs, stones and a high biodiversity of fauna (170 bird species), mammals, flora, cultural heritage objects such as castles, manors and urban planning monuments. The ancient valley of the Gauja River is one of the most significant areas for bat hibernation (including rare bat species) in Latvia. 52 mammal species can be found in GNP, ten of them are included the list of specially protected species [6]. GNP is divided into five zones: strict reserve, nature reserve, cultural historical, landscape protection (the largest area) and neutral.

In 2012 the stakeholders of Gauja National Park established a long-term cooperation in the form of a tourism cluster involving owners of tourism objects, tourism service providers and private, public and educational/research institutions [10]. The goal of the tourism cluster strategy is to achieve the increase in foreign overnight travellers by 20% in 2020 in comparison with 2012. The visitor, educational awareness and tourism information centres are located inside the national park operated by Nature Conservation Agency of the Republic of Latvia or by local municipalities. The centres are providing tourism and nature interpretation materials on the websites of the centres as well as physically printed materials in the centres, posters and stands in the national park.

In India the majority of protected areas are in the category of national parks. A national park is an area, notified and constituted by the state government for the purpose of its ecological, faunal, floral, geomorphological, or zoological association or importance, needed for protecting and propagating or developing wildlife therein or its environment ENVIS (2017). There are 103 national parks in India covering an area of 40,500 km2, which is 1.23% of the geographical area of the country [19]. The KBR is located in the centre of the city of Hyderabad in South India.

The KBR is located in the centre of the city – within a densely populated residential and commercial area in the metropolitan city of Hyderabad. The national park is not only a "green lung" for the residents of Hyderabad, but it also acts as a carbon sink and is a vestige of a vast flora, fauna and natural granite rock formations, which represents the Deccan Plateau. The total area of the park is 142.50 ha (1.42 sq km). There is no open or forest area around KBR National Park and only a width of 25m to 35m of Hyderabad Metropolitan Development Authority Walkway is available as an open space around the national park [21]. The primary vegetation of the park is that of a tropical dry deciduous type with over 600 plant species and 140 species of birds and 30 different varieties of butterflies and reptiles. Some of the animals making their home in the park include: pangolin, small Indian civet, peacock, jungle cat and porcupines. There are few water bodies present in the park providing the needed moisture for the plants and quenching the thirst of birds and small animals. Open forest and dense scrub dominates the area covering about 45% of the land, while grasslands and dense forest cover 20% and 12% respectively. For convenience, the national park that was earlier used by the citizens of Hyderabad for morning walks and leisure was demarcated into two well defined zones, namely – the Conservation Zone (spanning 88.5ha) and the Visitors Zone (54.0ha) by the State Forest Department. Entry into the former zone is strictly regulated, while the latter zone is open for public on nominal charge. This land was earlier under the control of Nizams of the erstwhile Hyderabad State. The national park has a palace that is the property of the Nizam and is guarded meticulously by a contingent of private security force. The park also has numerous dwelling and non-dwelling units within its boundaries that cover an area of 24,356.02m^2 [13].

III. DISCUSSIONS AND RESULTS

The comparison of both national parks is provided in Table 1.

Table 1.
Comparision of Two Nationals Parks

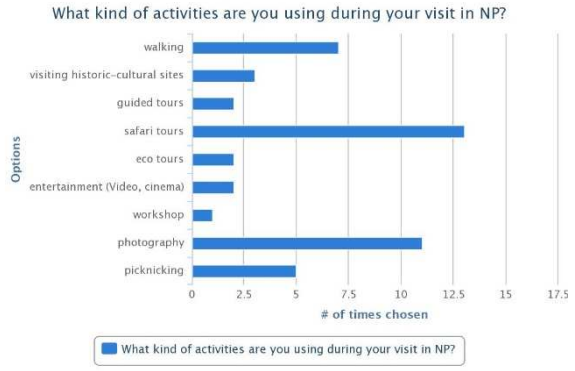
Component	India KBR National Park	Latvia Gauja National Park
Location	Located in the urban area, Hyderabad (around 12 million inhabitants).	Located in both the urban and rural area, includes four towns: Sigulda, Cēsis, Līgatne and a gateway to Valmiera city. 100 000 people live in GNP.
Landscape (Geographical-land and water)	There are a few water bodies and natural granite rock formations, which represent the Deccan Plateau.	The main value of GNP is the River Gauja and its valley. There are a few lakes, smaller rivers and sandstone and limestone cliffs, caves.
Biodiversity	The primary vegetation of the park is that of a tropical dry deciduous type with over 600 plant species, 140 species of birds and 30 different varieties of butterflies and reptiles. Some of the animals making their home in the park include: pangolin, small Indian civet, peacock, jungle cat and porcupines.	52 species of mammals, 170 bird species and almost 900 plants.
Management of Tourism	In the national park tourism is managed by the forest department. No intervention from Tourism department.	Local municipalities are running tourism information centres, in some places there are visitor-environment awareness centres operated by Nature Conservation Agency.

		An NGO – a tourism cluster has been established involving 60 stakeholders.
Tourism in the Park	• Only day visitors (There is no option for the overnight stay inside the park) • Mostly local or nearby community uses the park • Mainly used for walking/jogging in the morning and evening by the elite and rich people, and mostly crowded. • Entry fee goes directly to the forest department • Foreign and other domestic tourists (other than Hyderabad) are very few in number • Outside the park there are various food outlets managed by the chain or corporate outlets catering for the visitors • Many small scale street vendors are getting economic benefit by selling energy drinks, fruits and various soft beverages to the visitors who have come for jogging. • No proper visitor statistics	• Popular destination for domestic visitors for one day • Management focus on the increase of length of the stay for domestic and international visitors in GNP • The number of foreign visitors is increasing year by year • There is no entrance fee in GNP, but a fee is charged in specific objects, for example, in a wind mill, archaeological park. • Private sector provides catering services and accommodation in the park mainly operated by independent companies. • Craftsmen are active to provide souvenirs and also to demonstrate skills in interactive workshops for visitors. • No proper visitor statistics
Timings	Entry fee for KBR Park is Rs20/- for adults and Rs10/- for children (approximately 28 and 16 cents) and it is open 5:30 to 10 am in the morning and 4 or 4:30 to 7 pm in the evening.	No.

Local and foreign visitors' survey in GNP in Latvia showed that visitors appreciate untouched nature, especially the foreign guests. 64.3% of the surveyed foreign visitors find it essential and very important that GNP is a special protection area and has the Natura 2000 label.

For the interest of the administration of GNP, the Latvian respondents also had to answer a question on their support for sports events in the territory of GNP. 82.8% of all respondents supported the idea, but 9.2% did not support it. Meanwhile, 8% of the polled people did not have an answer to this question.

In the survey in KBR National Park visitors were asked questions related to the reasons and habits of visiting the park. The results of KBR National Park Sample Survey show that the main motivation to visit the national park is animal watching (33%) and ecotourism experience (25%), but some visitors are less interested in bird-watching and come for just recreation (12.5%). The most popular activity in the national park is safari tours (28.3%), followed by photography (23.9%) while the least popular is workshops (2.2%) (see Fig.1).



The most often used services and facilities in the national parks are washrooms, catering and information offices. According to Maslow pyramid, the first two facilities mentioned meet the requirement in human basic needs. These are followed by the parking facility and the souvenir service.

Regarding the trail marking, in GNP the answers were different. The national park visitors' survey in India indicated that 42% do not find walking trail marking important, there are probably the two main reasons for it: the majority of visitors choose safari tours, and as the survey results showed short and medium-length hiking trails up to 3km are preferred. In contrast, the trail markings and direction signs are of vital importance in GNP where the tourism infrastructure - marked trails, information signs – is well developed. In some cases in GNP, the reference is made to the lack of information in English.

Most respondents spent between two and six hours in the national parks. Of course, during face-to-face interviews the respondents drew attention to the type of the visited national park. We can fully agree that the time visitors spent in the national parks correlates with the qualities of the particular park and the provided tourism infrastructure.

IV. CONCLUSION

To sum up, this experience of conducting a survey in Hyderabad in India and in Latvia gave the authors a new competence on how to carry out a survey in different countries taking into account intercultural aspects, the choice of words for defining questions and the communication with locals.

Visitors have different expectations during the visits to the national parks. In India the main focus is on watching animals, while in Latvia a greater emphasis is put on walking in nature, underlining the overall importance of the landscape during the park experience. According to visitors' expectations, the tourism infrastructure should be improved in both

Latvian and Indian national parks, if the park management and tourism destination organizations in the national parks want to position them as a nature tourism offer both in the local and international market. In case of India, there is a particular need to develop tourism information infrastructure (direction signs, maps with routes, sights, interpretive information, including on the landscape and plants, not only animals).

The comparison of nature based tourism in two national parks in Latvia and India highlighted the different approaches of the use of national parks according to visitor purpose, motivation and the nature resources in the national parks; as well as that, the management system of tourism and nature conservation is different not only between the countries, but also within a country.

National parks have a great potential in the tourism offer. Tourism in GNP develops rapidly and it should be taken into account for sustainable tourism planning, directing the flow of visitors to the lesser-known attractions. In case of India, there are unused opportunities in the wider national park positioning in tourism appreciating the national park as a totality of natural and cultural values. There is also a urgent need to change the impression and mindset of the visitors about the national parks, as if they are mainly and particular for popular animal watching, and this can be done through various awareness programs.

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REFERENCES

[1] A. Stronza, W. Durham, "Ecotourism and conservation in the Americas", Cambridge, MA: CAB International, 2008.

[2] M. Honey, *Ecotourism: Who owns paradise? (2nd ed.).* Washington, DC: Island Press, 2008.

[3] J.Higham, *Critical issues in eco-tourism: Understanding a complex tourist phenomenon*, Oxford: Elsevier. 2007.

[4] C.M. Hall, *Tourism Planning Policies, Processes and Relationships.* 2nd edition. Pearson Education Limited: England, 2008.

[5] D. Weaver, B. Faulkner, L. Lawton, L. "Nature-based tourism in Australia and beyond: Australia and beyond: a preliminary investigation", Work-in-progress, CRC for Sustainable Tourism, 1999.

[6] V. Pilāts. Biodiversity in Gauja National Park. Sigulda, Gauja National Park Administration, Tech.Rep. 2007.

[7] World Health Statistics (WHS) 2016. World Health Organisation.

[8] World Health Statistics (WHS) World Health Organisation. Tech.Rep. PP.155-165, 2013.

[9] R. Mirzaei, "Modelling the Socioeconomic and Environmental Impacts of Nature-Based Tourism to the Host Communities and their Support for Tourism. Perceptions of Local Population: Mazandaran, North of Iran," Licentiate thesis, University of Giessen, 2013.

[10] A. Livina, Dz. Atstaja, Dz., "Understanding the Philosophy and Performance of Tourism and Leisure in Protected Areas for transition to a Green Economy", in *Tourism in the Green Economy*, (ed. Reddy, M.,V., Wilkes, K.), Routledge, 2015.

[11] I. Druva-Druvaskalne, A. Līviņa, A. "Tourism in Latvia: from fragmented resorts of Russian empire to a national brand on international level", in *European Tourism Planning and Organisation Systems* Volume II. (ed Costa, C., Panyik, E., Buhalis, D.) Channel View, 2015.

[12] F. Giongo, J.Bosco, G.N. Wallace, *A Study of Visitor Management in the World's National Parks and Protected Areas.* Colorado State University, Fort Collins, Colorado City, USA. 1993.

[13] C. Srinivasulu, B. Srinivasulu, A.Rajesh, C. Rao, V. Nagulu. "Non-volant small mammals of Kasu Brahmananda Reddy National Park, Andhra Pradesh", *Zoos' Print Journal*, 19 (6), pp.1495-1497, 2004.

[14] J. Deng, B. King, B., & T.Bauer, T. "Evaluating natural attractions for tourism", *Annals of tourism research*, 29(2), pp. 422-438. 2002.

[15] I. Druva-Druvaskalne, A. Līviņa, "Assessment of environmental aspects in rural tourism in two areas of the North Vidzeme Biosphere Reserve", in: Economic, social and cultural aspects in biodiversity conservation (eds. Opermanis, O., Whitelaw, G.), Press of University of Latvia. pp.19-30, 2008

[16] L. Davidson, "On Nature`s Terms: preserving the Practice of traditional Backcountry Recreation in New Zealand`s National Parks". In: Intangible natural Heritage New Perspectives on Natural Objects. Ed. Dorfman, E. Routledge, 2012.

[17] S.Wall Reinius, P.Fredman, "Protected areas as attraction", Annals of Tourism Research, Vol. 34, no 4, pp. 839-854, 2007.

[18] P. Fredman and L. Tyrväinen, L. "Frontiers in Nature-Based Tourism", *Scandinavian Journal of Hospitality and Tourism*, 10 (3), pp.177-189, 2010.

[19] ENVIS. Centre on Wildlife & Protected Areas. National Wildlife Database. [Online]. April, 2017. Available: http://wiienvis.nic.in/Database/npa_8231.aspx

[20] N. Dudley, "IUCN Guidelines for Applying Protected Area Management Categories", 2008. Available at http://data.iucn.org/dbtw-wpd/edocs/paps-016.pdf

[21] Moef. Minutes of the 7th expert committee, 2017. Available: http://www.moef.gov.in/sites/default/files/MINUTES%20OF%2017TH%20EXPERT%20COMMITTEE.pdf

[22] UNWTO. "Tourism statistics" [Online], 2017, Available: http://www2.unwto.org

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Sustainable Value Creation in Latvia, Lithuania and Estonia: Comparative Analysis of Economic Return from the Use of Economic, Social and Environmental Resources

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Abstract. Baltic neighbouring countries Latvia, Lithuania and Estonia all over the world are considered as brotherly nations that have similar historical events and political economic system. However, for the period of 25 years after gaining their independence from the Soviet Union in 1990, these countries have been implementing different socio-economic development models. It can be concluded on the achieved development results by the world recognized and widely used index indicators as Human Development Index (HDI), Global Competitiveness Index (GCI), Doing Business Index (DBI), revealing a trend that Estonia according to the socio-economic indicators is a step ahead of both Latvia and Lithuania. However, the above-mentioned indices calculation does not include the environmental indicators (HDI report includes Environmental Sustainability subindex, which is calculated separately) that cannot take account of national sustainable development which is becoming increasingly important under the conditions of global resource scarcity. The aim of the research is to determine sustainability of Latvia, Lithuania and Estonia, using the Sustainable Value (SV) approach, calculating how efficiently and with what return (Country's Gross Domestic Product) their economic, social and environmental resources are consumed. SV is a value-based assessment that measures contributions to sustainability in monetary terms while being able to use non-monetary environmental and social input variables. Calculating SV of Latvia, Lithuania and Estonia, the author has used 10 indicators of 2014 that cover the economic, social and environmental dimensions of sustainability, using the average efficiency of these countries as benchmark. As a result the author concluded that, overall, Latvia and Lithuania have almost equal footing with the Return to Cost Ratio (RCR) results, respectively 1.41 and 1.32 (>1 means that resources are used more efficiently than the benchmark), while Estonia's RCR value is 0.52 (<1 means that resources are used less efficiently than the benchmark), which can be explained by differences in national economic structure and the energy independence. The study also showed that there are substantial differences among the countries in economic return from each individual resource use.

Keywords: sustainable development, Sustainable Value, Gross Domestic Product, Latvia, Lithuania, Estonia.

I. INTRODUCTION

In 1990, after regaining the independence from the Soviet Union, Latvia, Lithuania and Estonia faced big challenges in terms of both the economic transition from centrally planned economic to a market economy model as well as the political stability, providing necessary resources for existence and functioning of the countries. For 25 years these countries were implementing different development models. We can evaluate their achievements of the development by the world recognized and widely used index of indicators, for example, according to the HDI in 2015, Estonia rates in the 30th place in the world, Lithuania - 37, Latvia – 46 [1], according to the GCI in the period of the year 2016/2017, Estonia ranks in the 30th place in the world, Lithuania - 35, Latvia - 49 [2], according to the DBI in 2017, Estonia ranks in the 12th place in the world, Latvia - 14, Lithuania - 21 [3]. According to socio-economic indicators, it is evident that Estonia is ahead both Latvia and Lithuania. However, the environmental indicators are not included in the above-mentioned index calculation, which means that when analyzing these indices, we can't evaluate the sustainability of the countries, importance of which is increasing due to the global resource scarcity.

The aim of the research is to provide the analysis of the sustainability performance of Latvia, Lithuania and Estonia in 2014 in monetary terms using the Sustainable Value [4, 5]. Sustainable Value combines economic return with the use of economic, environmental and social burdens and therefore relates the challenge of economic growth to the challenges of environmental and social stewardship. All other existing assessment approaches are burden-based. Sustainable Value is based on the assumption

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that value is created when a resource is used more efficiently than by an alternative use [6].

In 1972 members of the Club of Rome – a group of thinkers in politics, business and science – published disturbing scenarios suggesting that unbounded growth of population, pollution and depletion of natural resources would cause the collapse of physical growth on Earth [7].

Nowadays there are a number of researches implemented in economic science and its interdisciplinary sciences, such as environmental economics, green economics, ecological economics, bio-economics and in other environmental social sciences, proving that the economic growth leaves a negative impact on the environment [8, 9, 10, 11, 12, 13].

The implications of global warming and environmental despoliation have increased the clamor for sustainable development – economic development that seeks to meet current needs without compromising the ability to meet future needs [14].

In 1987 the World Commission on Environment and Development issued an influential report, Our Common Future (the Brundtland Report), which stressed the interdependence of ecological and economic systems, and made a strong plea for the principles of sustainable development. According to the definition by Brundtland Commission (1987), the sustainable development is a "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" [15].

In 2015 the United Nations General Assembly adopted the 2030 Agenda for Sustainable Development and 17 Sustainable Development Goals as a universal and transformative development strategy. The 2030 Agenda commits the global community to "achieving sustainable development in its three dimensions – economic, social and environmental – in a balanced and integrated manner" [16]. The interaction of the economic, social and environmental dimensions and their relevance to sustainable development is shown in the Figure 1.

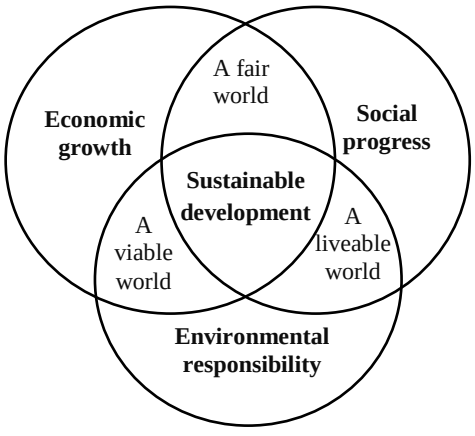

Fig. 1. Standard dimensions of sustainable development [17]

After analysing the Figure1, it can be concluded that in order to achieve sustainable development, it is crucial to harmonize three core sustainable development's elements: economic growth, social progress and environmental responsibility. These elements are interconnected and all are crucial for the well-being of individuals and societies in fair, liveable and viable world.

The relationship between economic growth and the sustainable development is complex. Economic growth involves the combination of different types of capital to produce goods and services. The maintenance of all types of capital is essential for the sustainability of economic growth. The most known capitals are identified by the "Forum for the Future", i.e. manufactured, financial, social, human and natural capital (see Figure 2).

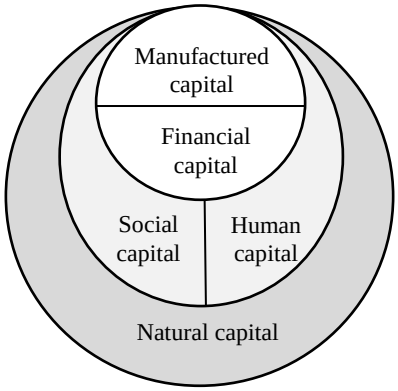

Fig. 2. The five capitals model [18]

The five capitals model of sustainable development was developed by "Forum for the Future" in the 1990's. The model is used to show stocks and flows of resources as they relate to a sustainable society and economy. The purpose of this model is to illustrate the interconnectedness of various types of capital and the dynamic process through which organizations around the world can begin to achieve a balance between their environmental, social and economic needs [18, 19].

Most views of sustainability are concerned with the resource stock left for future generations. Goodwin (2003) suggests that for sustainability, the total stock of the five capitals should be maintained although the depletion of one type can be compensated for by the increase in others [19].

In nowadays, in the century of high-tech, economic growth can avoid the environmental pollution and over- consumption of the resources; especially this can be implemented in the countries with high incomes. It is facilitated by *the composition effect*, when the economic structure changes from secondary (or manufacturing) sector to tertiary (or service) sector, and *the technical effect*, when technological development and investment in the infrastructure can make the burden on the environment less, nevertheless in both cases the key

role is allotted to a stronger environmental policy [20, 21, 22, 23].

It is possible to calculate how efficiently and with what return economic, social and environmental resources of the country (or industry) are consumed, providing the country's (or company's) economic growth. The Sustainable Value approach is used for the purpose to measure the country's (or company's) sustainability performance [4, 5].

II. MATERIALS AND METHODS

The Sustainable Value (SV) approach was developed by Figge and Hahn [4, 5] and used both widely on a corporate level [24, 25], as well as on a macro level [6, 26, 27]. SV uses the return that is created with a resource as the basis for sustainability assessment.

SV approach advantage is that it measures contributions to sustainability in monetary terms, taking into account economic, social and environment dimensions of sustainability, while being able to use nonmonetary environmental and social input variables. SV shows the value that is created or lost through the use of a set of different resources by a country (or company). SV is based on a fundamental insight of financial economics: to create value, a country (or company) must use resources more efficiently than other countries (or companies). SV can take into account all kinds of resources as long as they are necessary for production, scarce and can be measured in absolute quantitative terms. In practice the choice of indicators is limited by availability [27, 28].

SV shows how much more return was created by giving a set of resources to the country (or company) rather than to the benchmark. SV does not claim that the benchmark is sustainable. Instead SV expresses in monetary terms the degree of sustainability relative to this benchmark. If the benchmark consists of future target efficiency, SV shows how well companies or countries perform today relative to this desired state. In the financial markets it is often argued that opportunity cost thinking in a market economy will drive up the efficiency of resource use, which is socially desirable. A more efficient use of a resource is linked to more value creation. To create positive SV a resource must earn its opportunity cost, i.e. it must at least match the return of an alternative use. If a country (or company) creates SV does not only depend on the efficiency of the country (or company) but also on the benchmark that is chosen. SV shows which resources are used in a value-creating way and which are not. SV does not take into account qualitative aspects of sustainability which cannot be quantified in a meaningful way [27, 28].

Five questions help to define the individual SV application [28]:

(1) *Which object?* This first decision question covers what the assessment objects are, i.e. what is being assessed. In this research these are 3 countries of the Baltic Sea region, i.e. Latvia, Lithuania and Estonia.

(2) *Which benchmark?* SV is created when the assessment object, as defined in the previous step, earns its opportunity cost, i.e. has a higher efficiency than the benchmark. This decision defines the benchmark that the assessment objects are compared to. In this research the average efficiency of Latvia, Lithuania and Estonia as the benchmark was applied.

(3) *Which resources?* The SV approach can cover economic, environmental and social resources. The present study considers enterprises' assets, liabilities and equity (total EUR, at the end of the year) [29, 30, 31] *as economic resources*; carbon dioxide CO_2 emissions (tonnes) [32], nitrogen oxides NO_x emissions (tonnes) [33], sulphur oxides SO_x emissions (tonnes) [34], emissions of non-methane volatile organic compounds (NMVOC) (tonnes) [35], methane CH_4 emissions (tonnes) [36], generation of waste (tonnes) [37], annual freshwater withdrawals (total m^3) [38] *as environmental resources*; number of employed persons (aged 15-74) [39, 40, 41] and number of work accidents (total, severity 4 days or over) [42] *as social resources*.

(4) *Which return?* In this study author uses Gross Domestic Product (GDP) based on purchasing-power-parity (PPP) valuation of country GDP converted into current international dollars as the return figure [43]. This corresponds to the products and services produced by economic entities of the respective country and helps to avoid inflation and different purchasing power across these countries.

(5) *Which period?* Data used in the calculation of SV is regarding the year 2014. All necessary data were available up to this year at the moment of preparing this research.

(6) *Which data sources?* Data sources for the analysis were publicly available databases. GDP data was taken from International Monetary Fund as the most reliable economic and financial statistical data. Environmental resources' use data was taken from Eurostat and World Bank. Economic and social resources' use data was taken from the National Statistical Committees of Latvia, Lithuania and Estonia and from Eurostat.

SV can be calculated in five steps [27, 28, 44]:

a) *Defining resource efficiencies for countries.* Resource efficiencies can be calculated using (1):

$$e_{ij}^{t} = \frac{GDP_j^t}{u_{ij}^t} \quad (1)$$

where e_{ij}^{t} – efficiency of the resource *i* use in country *j* in year *t*; GDP_j^t – GDP of the country *j* in year *t*; u_{ij}^t – the resource *i* use of the country *j* in year *t*.

b) *Determining benchmark resource efficiencies.* The average resource efficiencies in the region are used as the benchmark. In this regard the benchmark

efficiency of resource *i* use in year *t* (eb_i^t) can be determined by (2):

$$eb_i^t = \sum_j \frac{GDP_j^t}{u_{ij}^t} \quad (2)$$

c) *Calculating opportunity costs*. Opportunity costs show how much return would be created, if the resources were used not by the country economy, but by the benchmark. Opportunity costs for resource *i* of the country *j* in year *t* (oc_{ij}^t) can be calculated using (3):

$$oc_{ij}^t = eb_i^t \times u_{ij}^t \quad (3)$$

d) *Determining value contributions*. On the basis of opportunity costs and GDP of each country can calculate the contribution of each resource in SV in each year using (4):

$$C_{ij}^t = GDP_j^t - oc_{ij}^t \quad (4)$$

where C_{ij}^t – the contribution of resource *i* to SV of country *j* in year *t*.

e) *Defining SV*. This indicator is calculated using (5) formula as an average of all contributions for a specific country:

$$SV_j^t = \frac{\sum_i C_{ij}^t}{n} \quad (5)$$

where SV_j^t – SV of the country *j* in year *t*; n – the quantity of resources considered.

SV like GDP itself depends on the size of economy. In order to compare different countries the size of a country's economy should be taken into account [45]. Figge and Hahn (2005) suggest using the *Return to Cost Ratio* (RCR) that expresses how much more efficiently than the benchmark a country uses its resources [46]. RCR puts the country's return in relation to the return the benchmark would have created with the same set of resources (opportunity costs). It can be calculated by the (6):

$$RCR_j^t = \frac{GDP_j^t}{GDP_j^t - SV_j^t} \quad (6)$$

where RCR_j^t – the RCR for the country *j* in year *t*.

RCR > 1 indicates that the country yields more efficiently than the benchmark region on average. RCR <1 indicates that the country yields less efficiently than the benchmark region on average. Countries create SV when they use their set of resources more efficiently than a benchmark [28, 46].

III. RESULTS AND DISCUSSION

This section analyzes the sustainable performance of Latvia, Lithuania and Estonia in 2014 using the SV methodology described above. The performance of each country was compared to a benchmark. The benchmark determines opportunity costs and plays therefore a crucial role. Benchmark reflects the average efficiency of the entire region.

Table1 summarizes the selected economic, social and environmental indicators' values, as well it includes the calculated common SV and RCR for the countries, as well as calculated RCR according to each resource consumed.

As we can see in the Table 1, positive SV is for Latvia and Lithuania, both countries have RCR value 1.41 and 1.32 respectively, which means, that both Latvia and Lithuania use resources more efficiently than the benchmark, i.e. efficiency of resource use is higher than average efficiency of three countries. The same can't be said about Estonia, having negative indicator of SV and value of RCR 0.52, which is less than 1, indicating that Estonia uses resources less efficiently than the benchmark.

Analyzing the efficiency of the each used resource among the three countries, it can be concluded that relatively high score of Latvia is achieved by using several resources more efficiently than the benchmark region on average, for example, the use of the sulphur oxides (SO_x) emissions resource is six times effective than the benchmark region on average with RCR = 6.63, as well as the use of the resource generation of waste and annual freshwater withdrawal is 3 times effective than the benchmark region on average with RCR = 3.42 and RCR = 3.10 respectively. In Lithuania, the most efficient resource use is generation of waste with RCR = 2.39, but in Estonia - NMVOC emissions with RCR = 1.56. All these used resources belong to *environmental dimension* of sustainable development.

Analyzing the used resource with RCR <1, it can be concluded that, despite the lower results of RCR = 1.32, nearly all resources are used more efficiently in Lithuania, because it has only one value RCR <1 out of the ten of analysed resources, i.e. methane emissions (CH_4) with RCR = 0.92 (*environmental dimension* of sustainable development).

Latvia, despite reaching the highest value of RCR = 1.41, uses three out of ten resources less efficiently than the benchmark region on average with RCR <1, they are enterprises' assets, liabilities and equity with RCR = 0.97 (*economic dimension* of sustainable development) emissions of non-methane volatile organic compounds (NMVOC) with RCR = 0.88 (*environmental dimension* of sustainable development) and number of employed persons with RCR = 0.94 (*social dimension* of sustainable development).

Whereas low RCR = 0.52 of Estonia is justified by the fact that the majority, respectively, seven out of ten resources are used less efficiently than the benchmark region on average, including enterprises' assets, liabilities and equity with RCR = 0.67 (*economic dimension* of sustainable development), carbon dioxide emissions (CO_2) with RCR = 0.48, nitrogen oxides emissions (NO_x) with RCR = 0.78, sulfur oxides emissions (SO_x) with RCR = 0.31, generation of waste with RCR = 0.31 and annual

freshwater withdrawal with RCR = 0,34 (all of them belong the *environmental dimension* of the sustainable development) and number of work accidents with RCR = 0.39 (*social dimension* of sustainable development).

Table I
All indicators data and calculation results of SV and RCR for Latvia, Lithuania and Estonia

Indicator/Country	**Latvia**	**RCR of resource using**	**Lithuania**	**RCR of resource using**	**Estonia**	**RCR of resource using**
GDP based on PPP valuation of country GDP (current international dollar)	48 362 000 000	-	79 933 000 000	-	36 784 000 000	-
Enterprises' assets, liabilities and equity (total, at the end of the year, EUR)	56 506 900 000	0,97	67 947 179 000	1,33	62 643 109 200	0,67
CO_2 emissions (tonnes)	6 670 663	1,76	14 853 526	1,31	18 539 395	0,48
NO_X emissions (tonnes)	37 968	1,10	63 554	1,08	40 783	0,78
SO_X emissions (tonnes)	2 723	6,63	14 948	1,99	43 917	0,31
NMVOC emissions (tonnes)	33 743	0,88	53 392	0,92	14 488	1,56
CH_4 emissions (tonnes)	78 510	*0,93*	131 732	0,92	39 256	1,42
Generation of waste (tonnes)	2 621 495	3,42	6 200 450	2,39	21 804 040	0,31
Annual freshwater withdrawals (total, cubic metres)	248 000 000	3,10	631 000 000	2,01	1 742 000 000	0,34
Number of employed persons (aged 15-74)	884 600	0,94	1 319 000	1,04	624 800	1,01
Number of work accidents (total, severity 4 days or over)	1 725	1,89	3 120	1,73	6 288	0,39
Sustainable Value of a country	**14 121 918 755,12**		**19 408 305 382,67**		**-33 530 224 137,80**	
Return to Cost Ratio of a country	**1,41**		**1,32**		**0,52**	

The obtained data suggests that the primary role of sustainable performance for Latvia, Lithuania and Estonia is a direct environmental dimension for sustainable development. It can be also based on the fact that the environmental dimension indicators are the one which are in the majority in this analysis. Due to the limited volume of the article, the author will focus further on the environmental dimension impact on the sustainable development of Latvia, Lithuania and Estonia.

Significantly low result of Estonia is justified by the relatively high national energy independence if compared to the situation in Latvia and Lithuania. Still in the 1990's energy dependence[1] was considerable in the tree countries: the total energy dependence was around 45% for Estonia, 70% for Lithuania and 90% for Latvia [47]. Estonia was only about 45% dependent on foreign energy supply in 1990, because it relied mainly on local resources – oil shale, wood and peat. The reserves of these local resources, especially oil shale, have been large enough to supply the country's energy needs [48].

In 2014, Estonia's gross inland energy consumption consisted of 66.9% solid fuels, 16.4% crude oil and petroleum products, 12.8% renewables and 6.5% natural gas (author's calculation is based on [49]). Estonia distinguishes from other analysed countries with high diversification of energy mix and very high waste intensity as local energy source oil shale has very high ash content. It uses its oil shale reserves for the production of electricity and to less extent heat. According to a report published by the European Commission in 2011 86.1% of Estonia's electricity was produced form oil shale [50]. The production of electricity from burning oil shale generates high levels of CO_2, SO_2 and NO_x emissions [51].

Despite the fact that over the past 25 years, Estonia has decreased the emissions of SO_2 and NO_x significantly mainly because of decreased consumption of electricity, the power stations in Estonia have renovated some energy blocks, which has significantly reduced the oil shale consumption and SO_2 emissions, however in industrial towns of North-East Estonia (the location of oil shale chemical plants) the level of pollution does not comply with the stricter environmental standards on emissions set out in the EU [51, 52]. The most important measure to reduce oil shale mining is increasing the efficiency of energy production and consumption. Oil shale mining can be reduced by modernising the existing production facilities and bringing them into compliance with environmental requirements, as well as by introducing renewable and other alternative energy source [52].

The record amount generation of waste [2] for Europe in Estonia also directly depends on the specialization in the production of energy; more than 80% of all waste is generated by the industrial sector,

[1] Energy dependency shows the extent to which an economy relies upon imports in order to meet its energy needs. The indicator is calculated as net imports divided by the sum of gross inland energy consumption plus bunkers.

[2] Estonia generates an average of 16 tonnes of waste per capita (including industrial waste) each year [52].

with 76% of total waste comprising waste generated by the oil shale industry and energy sector. The major part of hazardous waste (approx. 98%) is generated by the oil shale and energy sectors. While large amounts of waste indicate that natural resources are not used efficiently, the harmfulness and toxicity of waste reflects its impact on the environment and human health [52]

In 2014 Latvia's gross inland energy consumption consisted of 36.2% renewables – the highest renewable energy share (RES) in the EU-28, 24.3% natural gas, 32.2% crude oil and petroleum products and 1.3% solid fuels (author's calculation is based on [49]). In 2011 RES has a dominant share in the country's gross electricity generation – 54.9%, mainly being generated by hydro power plants. The other half of electricity is being generated by natural gas – 45.1% [50].

Lithuania was quite independent until the closure of its Nuclear Power Plant in 2009 due to European safety standards (Lithuania had to close Chernobyl type reactor). Now Lithuania has to import most of its energy needs [47]. Lithuanian gross inland consumption in 2014 consisted mainly of natural gas and oil products (30.8% and 36.5% respectively), renewable 19.1% and solid fuels 3.5% (author's calculation is based on [49]).

Therefore author can conclude that Latvia and Lithuania, in order to promote its economic growth, use mostly energy sources, which are safe to environment, therefore there is lower economic growth burden on the environment in these countries and this is the main factor which ensures that the calculated SV for Latvia and Lithuania is higher.

VI. CONCLUSION

In the second half of the XX century, along with the world's common growth of IKP, the question regarding the connection between the economic growth and sustainable development became essential. The economic growth is based on the increase of the total consumption, which activates the overall supply and thereby accelerates the rate of economic growth, which results as material well-being of people, under the condition that country carries out fair socio-economic policy. However, the economic growth brings along the use of financial (or economic), social and natural resources. And sometimes the use of these resources is not properly considered and is ineffective, which means that such economic growth is a threat to the sustainable development of the country.

The sustainable development is being defined as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs". This means that we have to take into a consideration the fact that we didn't inherit the Earth from our ancestors, but borrowed it from our children. Therefore, the integration of the three dimensions of sustainable development is not merely an aspiration, it is vital for the survival of societies, ecosystems and economies.

The research analyses the Sustainable Value of Latvia, Lithuania and Estonia, revealing the value that is created or lost through the use of a set of different resources by a country, making a comparison to the benchmark. The average efficiency of Latvia, Lithuania and Estonia as the benchmark was applied in this research. The resources for the calculation were chosen according to economic, social and environmental dimensions of sustainable development. The results of the calculation revealed the fact that among three countries, Latvia and Lithuania has positive SV and RCR indicator is > 1, which means that both Latvia and Lithuania use resources more efficiently than the benchmark, i.e. efficiency of the use of the resources is higher than average efficiency of three countries. Whereas SV indicator of the Estonia is negative and RCR value is < 1, which means that Estonia uses resources less efficiently than the benchmark. The result of Estonia differs because of the fact that among the three countries Estonia is the most energy-independent, although this independence is based on the oil shale extraction and the use of it for producing electricity, which is harmful to the environment and significantly pollutes the environment.

Therefore the author concludes that the relatively higher socio-economic development of Estonia is achieved by exhaustion of the natural resources and is on the contrary to the world's sustainable development prerequisites.

REFERENCES

[1] S. Jahan, *Human Development Report 2015. Work for Human Development*. United Nation Development Programme, 2015.

[2] K. Schwab and X. Sala-i-Martin, *The Global Competitiveness Report 2016-2017*. World Economic Forum, 2016.

[3] *Doing Business 2017. Equal Opportunity for All*. International Bank for Reconstruction and Development / The World Bank, 2016.

[4] F. Figge, "Environmental Value Added - a New Approach to Measuring Eco-Efficiency", Z. Angew. *Umweltforsch*, 14, pp.184-197, 2001.

[5] F Figge and T. Hahn, "Sustainable value added - measuring corporate contributions to sustainability beyond eco-efficiency," *Ecological Economics*, 48, pp.173-187, 2004.

[6] S. Manzhynski, N. Siniak, A. Zróbek-Rózanska, S. Zróbek, "Sustainability performance in the Baltic Sea Region", *Land Use Policy*, 57, pp.489-498, 2016.

[7] D. H. Meadows, D. L. Meadows, J. Randers, W. W. Behrens III, *The Limits to Growth. A Report for the Club of Rome's Project on the Predicament of Mankind*. New York: Universe Books, 1972.

[8] L. Fei, S. Dong, L. Xue, L. Q. Liang, W. Yang, "Energy consumption-economic growth relationship and carbon dioxide emissions in China," *Energy Policy*, Volume 39, Issue 2, pp. 568–574, 2011.

[9] K. Alkhathlan and M. Javid, "Energy consumption, carbon emissions and economic growth in Saudi Arabia: an aggregate and disaggregate analysis," *Energy Policy*, Volume 62, pp.1525–1532, 2013.

[10] E. A. Rosa and A. Diekmann, T. Dietz, C. Jaeger, *Human Footprints on the Global Environment: Threats to Sustainability*. London: The MIT Press, 2010.

[11] A. K. Jorgenson, "Carbon Dioxide Emissions in Central and Eastern European Nations, 1992-2005: A Test of Ecologically Unequal Exchange Theory," *Human Ecology*, Rev. 18, pp. 105-114, 2011.

[12] A. Jorgenson and B. Clark, V. Giedraitis, "The temporal (in)stability of the carbon dioxide emissions/economic development relationship in Central and Eastern European nations," *Society and Natural Resources*, Vol. 25, pp.1182-1192, 2012.

[13] A. Jorgenson and B. Clark, "Societies consuming nature: a panel study of the ecological footprints of nations 1960–2003," *Social Science Research*, Vol. 40, pp. 226–244, 2011.

[14] P. Knox, J. Agnew, L. McCarthy, *The Geography of the World Economy, 6th edition*. London: Routledge, 2014.

[15] World Commission on Environment and Development, *Our Common Future (The Brundtland Report).* Oxford /New York: Oxford University Press, 1987. [Online]. Available: www.un-documents.net/our-common-future.pdf. [Accessed: December 15, 2016].

[16] *Transforming our world: the 2030 Agenda for Sustainable Development*, United Nations General Assembly, 21 October 2015. [Online]. Available: http://www.un.org/ga/search/view_doc.asp?symbol=A/RES/70/1&Lang=E. [Accessed: December 15, 2016].

[17] *Science for Environment Policy, Indicators for Sustainable Cities, in-depth Report 12*. Produced for the European Commission DG Environment by the Science Communication Unit, UWE, Bristol, 2015. [Online]. Available: http://ec.europa.eu/environment/integration/research/newsalert/pdf/indicators_for_sustainable_cities_IR12_en.pdf. [Accessed: January 7, 2017].

[18] Forum for the Future, *The Five Capitals*, 2016. [Online]. Available: https://www.forumforthefuture.org/project/five-capitals/overview. [Accessed: January 7, 2017].

[19] N. R. Goodwin, *Five Kinds of Capital: Useful Concepts for Sustainable Development*. Global Development and Environment Institute, Working Paper No. 03-07, 2003. [Online]. Available: http://www.ase.tufts.edu/gdae/publications/working_papers/03-07sustainabledevelopment.pdf. [Accessed: January 7, 2017].

[20] J. Birkeland, *Positive Development: From Vicious Circles to Virtuous Cycles Through Built Environment Design*. Earthscan Ltd., 2008.

[21] T. Everett, M. Ishwaran, G. P. Ansaloni, A. Rubin, *Economic Growth and the Environment*. Defra Evidence and Analysis Series. Paper 2, Department for Environment Food and Rural Affairs, 2010. [Online]. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/69195/pb13390-economic-growth-100305.pdf. [Accessed: January 7, 2017].

[22] P. Ekins, *Economic Growth and Environmental Sustainability: The Prospects for Green Growth*. London: Routledge, 2000.

[23] K. Scott, J. Barrett, G. Baiocchi, J. Minx, *Meeting the UK climate change challenge: The contribution of resource efficiency*. WRAP Project EVA128. Report prepared by Stockholm Environment Institute and University of Durham Business School, Waste & Resources Action Programme, 2009. [Online]. Available: http://www.wrap.org.uk/sites/files/wrap/Final%20Report%20EVA128_SEI%20(1)%20JB%20SC%20JB3.pdf. [Accessed: January 7, 2017].

[24] T. Hahn, F. Figge, R. Barkemeyer, "Sustainable value creation among companies in the manufacturing sector," *International Journal of Environmental Technology and Management*, 8, pp. 496-512, 2007.

[25] T. Hahn, F. Figge, R. Barkemeyer, A. Liesen, F. Müller, *Sustainable Value in Automobile Manufacturing: an Analysis of the Sustainability Performance of the Automobile Manufacturers Worldwide, 3rd ed*. Sustainable Value Ltd., 2013. [Online]. Available: http://sustainablevalue.com/downloads/sustainablevalueinautomobilemanufacturing3rded.pdf . [Accessed: December 15, 2016].

[26] F. Ang, S. Van Passel, E. Mathijs, "An aggregate resource efficiency perspective on sustainability: a sustainable value application to the EU-15 countries," *Ecological Economics*, 71, pp. 99-110, 2011.

[27] S. Manzhynski, F. Figge, L. Hassel, "Sustainable Value creation of nine countries of the Baltic region. Value, changes and drivers," *Journal of Cleaner Production*, 108, pp. 637-646, 2015.

[28] *Sustainable Value of European Industry: A Value-Based Analysis of the Environmental Performance of European Manufacturing Companies. Full Version*. The ADVANCE project, 2006. [Online]. Available: http://www.advance-project.org/downloads/advancesurveyfullversion.pdf. [Accessed: December 15, 2016].

[29] Latvijas Republikas Centrālās Statistikas pārvalde, *Komersantu (komercsabiedrību) finansiālie rādītāji gada beigās*, UFG01, 2014. [Online]. Available: http://data.csb.gov.lv/pxweb/lv/ekfin/ekfin__ikgad__uznemfin/UF0010_euro.px/?rxid=cdcb978c-22b0-416a-aacc-aa650d3e2ce0. [Accessed: December 15, 2016].

[30] Lietuvos statistikos departamentas, *Total assets of enterprises*, 2014. [Online]. Available: http://osp.stat.gov.lt/en/statistiniu-rodikliu-analize?portletFormName=visualization&hash=96c74c44-6ee9-40cb-9306-5461b5c37c5b. [Accessed: December 15, 2016].

[31] Statistics Estonia, *Enterprises' assets, liabilities and equity by economic activity (EMTAK 2008) and number of persons employed*, FS009, 2014. [Online]. Available: http://pub.stat.ee/px-web.2001/Dialog/varval.asp?ma=FS009&ti=ENTERPRISES%27+ASSETS%2C+LIABILITIES+AND+EQUITY+BY+ECONOMIC+ACTIVITY+%28EMTAK+2008%29+AND+NUMBER+OF+PERSONS+EMPLOYED&path=../I_Databas/Economy/09Financial_statistics_of_enterprises/02Enterprises_assets/02Annual_statistics/&lang=1. [Accessed: December 15, 2016].

[32] Eurostat, *Air emissions accounts by NACE Rev. 2 activity. Carbon dioxide*, 2014. [Online]. Available: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do. [Accessed: December 15, 2016].

[33] Eurostat, *Air emissions accounts by NACE Rev. 2 activity. Nitrogen oxides*, 2014. [Online]. Available: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do. [Accessed: December 15, 2016].

[34] Eurostat, *Air emissions accounts by NACE Rev. 2 activity. Sulphur oxides*, 2014. [Online]. Available: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do. [Accessed: December 15, 2016].

[35] Eurostat, *Air emissions accounts by NACE Rev. 2 activity. Non-methane volatile organic compounds*, 2014. [Online]. Available: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do. [Accessed: December 15, 2016].

[36] Eurostat, *Air emissions accounts by NACE Rev. 2 activity. Methane*, 2014. [Online]. Available: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do. [Accessed: December 15, 2016].

[37] Eurostat, *Generation of waste by waste category*, 2014. [Online]. Available: http://ec.europa.eu/eurostat/tgm/table.do?tab=table&init=1&plugin=1&pcode=ten00108&language=en. [Accessed: December 15, 2016].

[38] World Bank. *Annual freshwater withdrawals, total (billion cubic meters)*, 2014. [Online]. Available: http://data.worldbank.org/indicator/ER.H2O.FWTL.K3. [Accessed: December 15, 2016].

[39] Latvijas Republikas Centrālās Statistikas pārvalde, *Nodarbinātie pa vecuma grupām un pēc dzimuma*, NBG07, 2014. [Online]. Available: http://data.csb.gov.lv/pxweb/lv/Sociala/Sociala__ikgad__nodarb/NB0070.px/?rxid=cdcb978c-22b0-416a-aacc-aa650d3e2ce0. [Accessed: December 15, 2016].

[40] Lietuvos statistikos departamentas, *Employed persons*, 2014. [Online]. Available: http://osp.stat.gov.lt/web/guest/

statistiniu-rodikliu-analize?portletFormName=visualization&hash=34b4b212-89cf-4844-b4f0-16a2864eec68. [Accessed: December 15, 2016].

[41] Statistics Estonia, *Employed persons by full/part-time job in main job*, ML220, 2014. [Online]. Available: http://www.stat.ee/37204?highlight=employed,persons. [Accessed: December 15, 2016].

[42] Eurostat, *Accidents at work by sex, age, severity, NACE Rev. 2 activity and workstation*, 2014. [Online]. Available: http://appsso.eurostat.ec.europa.eu/nui/submitViewTableAction.do. [Accessed: December 15, 2016].

[43] International Monetary Fund, *Gross domestic product based on purchasing-power-parity (PPP) valuation of country GDP*, 2014. [Online]. Available: http://www.imf.org/external/pubs/ft/weo/2015/02/weodata/weorept.aspx?sy=2013&ey=2020&scsm=1&ssd=1&sort=country&ds=.&br=1&pr1.x=84&pr1.y=8&c=946%2C939%2C941&s=NGDPD%2CPPPGDP%2CLE&grp=0&a=#download. [Accessed: December 15, 2016].

[44] A. Liesen, F. Müller, F. Figge, T. Hahn, *Sustainable Value Creation by Chemical Companies*. Sustainable Value Research, 2009. [Online]. Available: http://www.sustainablevalue.com/downloads/sustainablevalucecreationbychemicalcompanies.pdf. [Accessed: December 15, 2016].

[45] R. J. Baumgartner, "Corporate sustainability performance: methods and illustrative example," *The International Journal of Sustainable Development and Planning*, 3 (2), pp. 117–131, 2008.

[46] F. Figge, T. Hahn, "The cost of sustainability capital and the creation of sustainable value by companies," *Journal of Industrial Ecology*, 9 (4), pp. 47–58, 2005.

[47] T. J. Weyers, *Energy Security of the Baltic States.* Bachelor Thesis, 2013. [Online]. Available: https://repositori.upf.edu/handle/10230/21000. [Accessed: January 7, 2017].

[48] A. Mae, "Estonian Energy Strategy and its implications to the Regional Cooperation," In: A.Spruds and T.Rostoks, eds. 2009. *Energy: Pulling the Baltic Sea Region Together or Apart?* Riga: Latvian Institute of International Affairs, pp.250-282, 2009.

[49] Eurostat, *Gross inland energy consumption by fuel type*, 2014. [Online]. Available: http://ec.europa.eu/eurostat/tgm/refreshTableAction.do?tab=table&plugin=1&pcode=tsdcc320&language=en. [Accessed: January 7, 2017].

[50] European Commission, *Energy Markets in the European Union in 2011*. Luxembourg: Publications Office of the European Union, 2012. [Online]. Available: http://bookshop.europa.eu/en/energy-markets-in-the-european-union-in-2011-pbMJAE12001/. [Accessed: January 7, 2017].

[51] M. Maigre, *Energy Security Concerns of the Baltic States*. International Centre for Defence Studies, 2010. [Online]. Available: https://www.icds.ee/fileadmin/media/icds.ee/failid/Merle_Maigre-Energy_Security_Concers_of_the_Baltic_States.pdf. [Accessed: January 7, 2017].

[52] M. Saul, K. Antso, *Estonian environmental indicators – development and outcomes*. Estonian Environment Agency, 2014. [Online]. Available: http://www.keskkonnainfo.ee/failid/indikaatorid_ENG_web.pdf. [Accessed: January 7, 2017].

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Odour Study with Qualitative and Quantitative Research Methods in Various Districts of Riga

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Abstract. Different emission sources of odours become increasingly important environmental problem which may have a negative impact on human health and quality of life. Human odour perception may be subjective, however on odour perception threshold is considered to be the odorant concentration where at least half of odour assessor's group members confirm the existence of odour, and then it is 1 OU_E /m^3. Nowadays more and more advanced technologies are used to measure odour concentration. Olfactometer Scentroid SM100 allows users to accurately quantify ambient odour concentration in field. Also this equipment allows to collect source samples and analyze odour in a laboratory. Odour study in 2016 and 2017 with field olfactometer Scentroid SM100 and gas analyzer Gasmet DX-4030 in districts of Riga indicates that the highest concentrations of odour are in Bolderaja, Sarkandaugava, Kundzinsala, Mangalsala, Milgravis and Vecmilgravis. Study indicates that the highest odour concentrations, especially among producing companies can reach up to 6-7 odour units (OU_E/m^3), however gas analyzer Gasmet DX-4030 indicates oil products or carbon dioxide.

Keywords: gas analysis, odour, various districts of Riga.

I. INTRODUCTION

Different emission sources of odours become increasingly important environmental problem which may have a negative impact on human health and quality of life. Human odour perception may be subjective, however the odour perception threshold is considered to be the odorant concentration where at least half of odour assessor's group members confirm the existence of odour, and then it is 1 ou_E/m^3 [1]. Odour nuisance is such odour which causes negative effect on human well-being, and its threshold exceeds the odour perception threshold. The cause of the odour, its frequency, intensity, duration, hedonic tone (unpleasantness) and the nature of the location are of essential significance.

Nowadays, increasing attention is being paid to the odour emission studies both in the world [2; 3; 4; 5; 6] and Latvia [7]. Awareness-raising of these issues makes it easier identify the odour emission source, perform more effective control and eliminate faster nuisances caused by odours. Odour emission sources can be both diffuse sources and the point source. Odour emission sources may be pollution caused by the operation of companies such as oil product terminals, chemical plants, waste storage and composting sites, the operation of wastewater treatment plants, etc., however, odours can be caused also by physical persons which do not perform economic activities, for example, by discharging poorly treated or even untreated domestic wastewaters in the environment, during the heating season there is a smell of smoke in the air coming from the private houses, especially when coal is used as fuel.

Nowadays more and more advanced technologies such as electrochemical, metal oxides, photo ionization detectors or "electronic noses" are used to measure the odour concentration by help of which it is possible to make indicative odour concentration measurements on an ongoing basis, however, installations are stationary, they are set for recording a specific parameter (chemical substance). So far still the best odour indicator is a human nose, enabling to identify odour also according to the qualitative method principles.

II. MATERIALS AND METHODS

During the research, the odour concentration and the presence of airborne pollutants were determined by using the quantitative research method, i.e., a method for measuring the odour and pollutant concentration. During the research, the qualitative research method was also used; it is a method which indicates the presence of a substance and which helped identify which pollutants at the relevant time were in the air.

The odour concentration was determined by the Scentroid SM100 field olfactometer, and the presence and concentration of the pollutants in the air were determined by the gas analyzer Gasmet DX-4030.

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Scentroid SM100 field olfactometer

The Scentroid SM100 field olfactometer is designed both to measure the odour concentration from the emission sources and to collect the source samples in order to analyze them further in the laboratory [8]. The equipped field olfactometer uses high pressure odourless gas from a high pressure carbon fibre tank. The sample is drawn by help of vacuum generated by the diluted compressed air flow. The dilution ratio of fresh to ambient air is controlled through the patented Scentroid flow regulator valve (Fig. 1). The panel list offers 15 discreet dilution levels, the minimum dilution is 2 odour units, and the maximum – 30000 [9].

The studies carried out so far [10] indicate that the results obtained by the Scentroid SM100 field olfactometer in the field and stationary laboratory match satisfactory both for the point sources and diffuse sources.

Fig. 1. Field measurements by the *Scentroid SM100 field olfactometer*.

Gasmet DX-4030 gas analyzer

Gasmet DX-4030 is a portable gas analyzer that can simultaneously identify 23 inorganic and organic gases such as carbon monoxide, carbon dioxide, methane, benzene, acids, aldehydes and other volatile vapours [11].

The Gasmet DX-4030 gas analyzer is controlled using Calcmet-Lite software which runs on the Windows Mobile platform [11]. The Gasmet DX-4030 gas analyzer connects to Calcmet-Lite software by help of Bluetooth. The DX4030 analyser module houses a Fourier Transform Infrared (FTIR) spectrometer, Rhodium-Gold coated sample cell and signal processing electronics. The sample preparation is not needed, because sample gas is extracted into the sample cell via a probe with a built-in particle filter [11].

One can freely move using the Gasmet DX-4030 gas analyzer for making the measurements at different locations (Fig. 2).

Fig. 2. Field measurements using the Gasmet DX-4030 gas analyzer.

The real time measurement results are displayed in Calcmet-Lite software, afterwards they are stored and transformed on the computer.

III. RESULTS AND DISCUSSION

The State Environmental Service performs the odour emission control in Latvia in accordance with the 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” of 25.11.2014. Likewise, the State Fire and Rescue Service receives calls from the inhabitants on odour nuisance in case of accidents or if there is suspicion of chemical leakage. Thus, to identify the areas where inhabitants feel odour nuisance, complaints received by the above institutions were summarized.

According to the information provided by the State Fire and Rescue Service, in 2012, 94 calls regarding odour nuisance were received in Riga of which the largest part, respectively, 79 % or 74 calls were from Riga Northern suburban district. In 2013, there were 73 calls received in Riga of which 35 were from the Northern suburban district. In 2014 and 2015, the number of calls regarding odour nuisance was similar – 35 and 34, of which, respectively, 23 and 14 were received from those living in the Northern suburban district.

In 2015, the State Environmental Service received in total in the whole Latvia 962 complaints of which 403 were from the administrative territory of Riga. In 2016, the number of complaints received in Latvia was higher than that of the previous year, respectively, 1087, however, the number of complaints within the territory of Riga has decreased in comparison to the previous year, respectively 384 complaints regarding odour nuisance. It has to be pointed out that the information provided by each person is recorded even if several complaints regarding one emission source are received per day or hour.

In order to select the most suitable locations and time for measuring, the location and time of the respective event specified in the complaints were analysed.

Analysing the complaints regarding odour nuisance within the interval of 24 hours (Fig. 3), it can be concluded that the highest number of complaints in percentage was received during the period of time from 16:00 to 24:00, it means that people feel odour nuisance mostly directly at their homes.

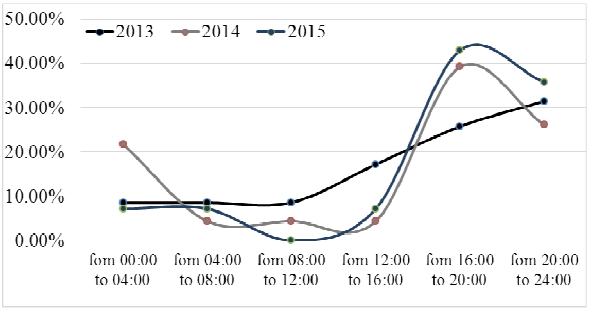

Fig. 3. Complaints within the interval of 24 hours in 2013, 2014 and 2015 (data source: the State Fire and Rescue Service).

Analysing complaints on odour nuisance within the monthly interval, Fig. 4, it can be seen that in 2012 the highest number of complaints were received exactly during the summer months. In 2013, 2014 and 2015 there were no significant differences observed within the interval of months, thus, it can be concluded that the number of the odour nuisance cases are equal in all seasons.

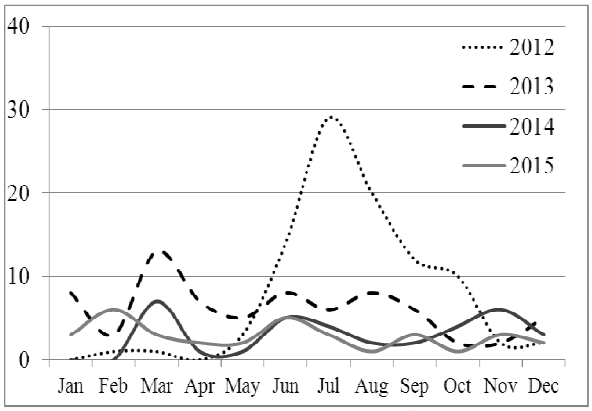

Fig. 4. Complaints at the monthly interval from 2012 to 2015 (data source: the State Fire and Rescue Service).

Analysing the data submitted by the inhabitants of Riga to the State Environmental Service in 2016, it was found that out of 384 complaints received within the administrative territory of Riga 272 complaints were from the inhabitants of seven micro districts, respectively, Bolderaja, Sarkandaugava, Kundzinsala, Mangalsala, Milgravis, Vecmilgravis and Petersala-Andrejsala (Fig. 5). The highest number of complaints was received from the inhabitants of Sarkandaugava, i.e., 74 complaints or 19 % of all complaints received in Riga. 57 complaints or 15 % of the number of complaints recorded within the administrative territory of Riga on odour nuisance were received from those living in Bolderaja. Similarly, there were also 53 complaints (which amounts to 14 % of the total number of the complaints received on unpleasant odours) recorded in Milgravis. The number of complaints in the other districts of Riga does not exceed 10 % of the total number of complaints received.

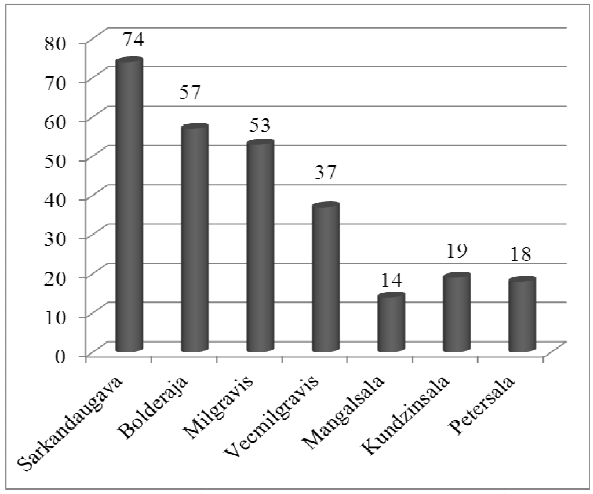

Fig. 5. Breakdown of complaints by micro districts of Riga in 2016.

1 to 5 complaints on unpleasant odours in 2016 were recorded in several micro districts of Riga such as Daugavgriva, Zolitude, Pleskodale, Tornkalns, Ciekurkalns, Darzini, Rumbula, etc. There are no complaints on odour nuisance recorded in several micro districts such as Skanste, Grizinkalns, Maskava suburb, Bukulti, Trisciems, Jaunciems, Katlakalns, Agenskalns, etc.

During the research, the data provided by the inhabitants on the odour quality were also analysed, i.e., which odours people can smell. The highest number of complaints was received on oil product odours, i.e., 147 complaints (Table 1) or 38 % of the total number of complaints were received in 2016 (Fig. 6). A relatively large proportion of the complaints is about smoke odours, respectively, 26 % (Fig. 6), it means that the State Environmental Service was notified 98 times on unpleasant odours and nuisance smoke odours during a year. The State Environmental Service, upon carrying out inspections regarding smoke odours, relatively seldom found violations of the environmental protection laws and regulations, i.e., burning of different waste at the properties owned by the companies or physical persons. Inspecting the territories of the companies and more often private house districts, it was, mainly, found that wet wood or coal is used as fuel causing unpleasant odours, however, the above fuels are allowed.

Table 1.
Breakdown of the number of complaints by the type of odour nuisance in 2016.

Type of odour	number of complaints
oil products	147
smoke	98
sewerage	39
chemicals	36
paint / lacquer	11
Metalworking	7
plastic	9
other	37
Total	**384**

A relatively large number of complaints is received on sewerage odour nuisance, respectively, 39 complaints (Table 1) or 10 % of the total number of complaints (Fig. 6). Despite the fact that the centralized sewerage network is provided for 95-97 % of the administrative territory of Riga, still a part of inhabitants of the private house areas, as well as the companies have their own biological treatment plants, or wastewater is collected in a decentralized manner. The reason for unpleasant sewerage odours is inadequately maintained treatment plants or overflowing exhaustible wells – it is failed to monitor the filling level of exhaustible wells.

In 2016, there were 36 complaints or 10 % (Table 1) on chemical odours (Fig. 6) and 11 complaints or 9 % on paint and lacquer odours. The emission sources of chemical substances and lacquers (often also adhesives) are the operation of such companies as various production facilities, service stations, wood impregnation companies, etc. Inhabitants often mention chemical odour although, in fact, the oil product odour is felt in the air.

Inhabitants have complained on the plastic odour 9 times and on the metal processing companies – 7 times (Table 1).

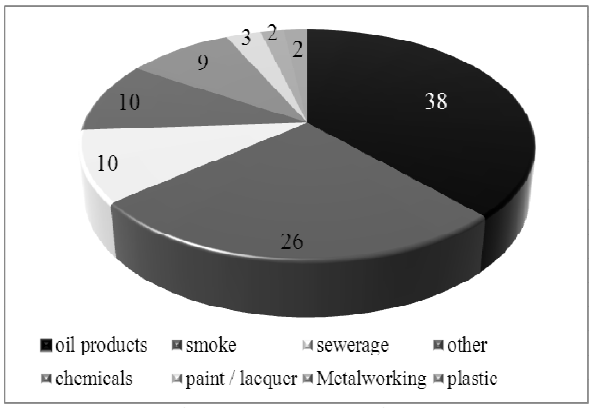

Fig. 6. Breakdown of complaints by types of odours in 2016.

Inhabitants relatively often – 37 times or 10 % – provided information on other odours (Fig. 6) such as odours of various foods from restaurants, cafes and fast food establishments, odour nuisance from the waste management sites, garbage containers at the residential houses if not removed on time, rubber odours from the vehicle racing tracks, odours from street repairs, as well as other types of odours.

During the research, the odour concentration study was carried out using the Scentroid SM100 field olfactometer in the micro districts of Riga where the highest number of complaints on the odour nuisance was reported. During the research from October 2016 to January 2017 almost all streets of Bolderaja, Daugavgriva, Voleri, Petersala-Andrejsala, Kundzinsala, Sarkandaugava, Milgravis, Vecmilgravis, Mangalsala, Vecdaugava and Vecaki were surveyed. During the survey, smoke, wood and oil product odours were found in Bolderaja, Vecmīlgrāvis and Sarkandaugava. Measuring odours, the odour concentration mainly was below 2 odour units. There were 3 units of odour found in the neighbourhoods of Ezera Street (Sarkandaugava) and Tvaika Street (Sarkandaugava). It has to be noted that while the measurements were made no complaints were received. The State Environmental Service, performing the inspection of the territory immediately after receiving the complaints on odour nuisance, found 6 – 7 odour units (ou_E/m^3) in Bolderaja and Milgravis, such level of odour causes adverse impact on human wellbeing.

Table 2.
Substance concentration (ppm) in Sarkandaugava

No	Address	Ezera 20	Ezera 1	Tvaika 68
1	Carbon dioxide CO2	690	483	462
2	Carbon monoxide CO	0	0	0
3	Nitrous oxide N2O	0.25	0.19	0.2
4	Methane CH4	2.04	1.72	1.79
5	Propane C3H8	0.12	0.34	0
6	Butane C4H10	0	0.18	0.05
7	Acetylene C2H2	0.06	0	0.09
8	Benzene C6H6	0.23	0.03	0.07
9	Toluene C7H8	0.33	0.23	0.18
10	Acetic acid C2H4O2	0.7	0	0
11	Formaldehyde CHOH	0	0	0
12	Acetone C3H6O	0	0	0
13	Methanol CH4O	0	0.18	0
14	Ethanol C2H6O	0	0	0
15	tert-Butyl methyl ether C5H12O	0	0	0
16	Acetonitrile C2H3N	0	0	0
17	Nitromethane CH3NO2	0.93	0.43	0.56
18	Chloroform CHCl3	1.71	1.07	1.2
19	Chloroethene C2H3Cl	0	0	0
20	Freon 134A C2H2F4	0	0	0
21	Ammonia NH3	0	0	0
22	Hydrogen chloride HCl	0	0	0
23	Hydrogen cyanide HCN	1.73	1.64	1.7

On 29.01.2017, while measuring airborne substances with the Gasmet DX-4030 gas analyzer in Sarkandaugava, a high concentration of carbon dioxide was recorded, respectively, from 462 to 690 ppm (Table 2). It is interesting that previous measurements made on 17.12.2016 at those locations did not show such a high carbon dioxide concentration, respectively, from 0 to 15 ppm. Carbon dioxide and nitric oxide indicate the presence of smoke, respectively these substances are released in the air as a result of fuel combustion.

Benzene, toluol, acetylene indicate the presence of oil products, and it is only natural as the measurements were made relatively close to the oil product handling terminals.

While analysing gasses, the presence of other substances such as acetic acid, methanol, nitromethan, chloroform and hydrocyan was found.

IV. CONCLUSION

Analysing the information provided by the inhabitants on odour nuisance, it can be concluded that the highest number of unpleasant odours are caused by the oil product handling terminals, therefore the highest number of complaints were received from Bolderaja, Sarkandaugava, Kundzinsala, Mangalsala, Milgravis, Vecmilgravis and Petersala-Andrejsala, where the unpleasant odours caused due to port operations spread to the neighbouring areas depending on the wind direction and speed.

The research results show that smoke, wood and oil product odours found in Bolderaja, Vecmilgavis un Sarkandaugava do not exceed 3 odour units (ou_E/m^3).

The analysis of gas confirms the nose-felt odours, respectively, smoke and oil product odours, however, other pollutants are also identified in such a concentration which can not be felt by a human nose.

Of course, mostly, odour emission sources are pollutants which are discharged into the air due to economic activities of the companies, however, physical persons due to their intentional actions or inactions also cause odour nuisance which can be eliminated by choosing more environmentally friendly fuel, cleaning the chimney and maintaining treatment plants on a regular basis, as well as by not tolerating waste accumulated.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] 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", 2014. Latvijas Vēstnesis, No. 250 (5310), 16.12.2014., Adopted 25.11.2014.

[2] Bokowa Anna H., 2010. Review of Odour Legislation, Chemical Engineering Transactions, Vol. 23. pp. 31 -36.

[3] Brattoli M., De Gennaro G., De Pinto V., Demarinis Loiotile A., Lovascio S., Penza M., 2011. Odour Detection Methods: Olfactometry and Chemical Sensors. Sensors. Vol. 11, pp. 5290-5322.

[4] Dravnieks A., Masurat T., Richard A. Lamm, 2012. Hedonics of Odors and Odor Descriptors, Journal of the Air Pollution Control Association pp. 752-755.

[5] Sironia S., Eusebioa L., Capellia L., Remondinib M., Del Rossoa R. 2014. Use of an Electronic Nose for Indoor Air Quality Monitoring, Chemical engieneering transactions, Vol. 40, pp. 73 – 78.

[6] Zarra T., Reiser M., Naddeo V., Belgirno V., Kranert M., 2012. A comparative and Critical Evaluation of Sampling Marerials in the Measurement of Odour Concentratin by Dynamic Olfactometry, Chemical engieneering transactions, Vol. 30 (12), pp. 307-312.

[7] Kāla A., Beikulis O., Rubins J. 2015. Practical application of commercial ALPHA M.O.S. E-NOSE for air quality control in Riga. European Network on New Sensing Technologies for Air Pollution Control and Environmental Sustainability - EuNetAir COST Action TD1105.

[8] Scentroid Model 110C. Operating and maintenance manual. 2012. IDES Canada Inc. Version 1.4.

[9] Scentroid Model 110. Operating and maintenance manual. 2013. IDES Canada Inc. Version 2.0.

[10] Bokowa Anna H., 2012. Ambient Odour Assessment Similarities and Differences, Chemical Engineering Transactions, Vol. 30.

[11] DX-4030 FTIR Gas Analyser Instruction and Operating Manual, 2009. URL: http://pembrokeinstruments.com/_download_pdf_897/_Pembroke-PDF-Downloads/Gasmet-DX4030-Manual-Pembroke.pdf, Viewed: 22.10.2016.

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Characterization of Antioxidant Activity and Total Phenolic Compound Content of Birch Outer Bark Extracts Using Micro Plate Assay

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Abstract. In modern plants, 2.7 to 2.8 m³ of solid volume veneer blocks are consumed to produce 1 m³ of plywood. After the hydrothermal treatment and debarking of blocks, waste bark is obtained, which makes up 12.5% of the wood mass, while 16-20% of bark is composed of birch outer bark (BOB). Recalculating, BOB makes up 2.0-3.4% of the veneer log mass. Bark is currently burned in boiler houses that is not rational. BOB contains large amount of valuable extractives (up to 34% from o.d. BOB) consisting of various secondary metabolites such as terpenes, flavonoids, hydrocarbons, polyphenols, tannins etc. BOB extractives exhibit antioxidant properties as well as wound-healing and anti-inflammatory activity. The objective of this paper was to compare amount of total phenolic content (TPC) and antiradical activity (ARA) in ethanol extracts from silver birch (Betula pendula Roth.) outer bark using micro plate assay. Among 11 fractions, fraction of average BOB had the highest DPPH free radical scavenging activity with IC50 of 39.28 µg/mL and the highest TPC 7.42 ± 0.52 g GAE/100 g of dry extract.

Keywords: birch outer bark extract, phenolics, antioxidant activity.

I. INTRODUCTION

Betula pendula Roth, the European white birch or Silver birch, is one of the most common deciduous tree species on the Eurasian continent with a wide natural distribution, ranging from the Atlantic to eastern Siberia. [1]. The continuous industrial exploitation of birch wood produces a lot of bark waste [2]. These barks have a chemical richness which could be a potent bioactive material for further use and production of upgraded products, e.g., in the field of functional foods, dietary supplements or cosmetics [1,2].

Birch outer bark has been used for ages as a traditional material and as a provider of medicinal products.

There are therefore many original and review articles that describe research on phytochemicals (e.g., triterpenoids, diarylheptanoids, phenylbutanoids, lignans, phenolics, and flavonoids) in Betula species. Birch outer bark is well-known as the main source of betulin. Its content varies between 10 and 35 % of the total dry weight of the outer bark extract whereas betulinic acid occurs in traces [3]. These phytochemicals have been shown to have antimicrobial, antiviral, antioxidant, immunomodulatory, anti-inflammatory, anti-diabetic, gastroprotective, hepatoprotective, skin protective and wound healing effects [1,4].

The present study was aimed at the characterization of the antioxidant activity and total phenolic compound content of different silver birch (*Betula pendula* Roth.) outer bark extracts. Feedstock for extraction was collected at A/S Latvijas finieris after soaking and debarking operations. While extraction process was carried out in Latvian State Institute of Wood Chemistry, but antioxidative properties were determined in the University of Latvia in the scope of a joint project.

II. MATERIALS AND METHODS

A. Feedstock

Three birch outer bark samples collected at a plywood factory in Latvia, were selected as a representative industrial waste and prepared for the extraction process:

1) birch outer bark from the birch veneer log – BOBL;
2) birch outer bark obtained by floating – BOBF;
3) mechanically separated birch outer bark – BOBM.

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BOBL was collected from the birch log before the soaking and peeling process operation in a plywood factory. For further operations isolated birch outer bark with a moisture content of 35-40 % (determined according to standard EN-14774-3 [5]) was dried at room temperature to a moisture content of 4-7 % and milled in a cutting mill SM 100 (Retsch GmbH & Co) to pass the sieve with holes of diameter 2.00 mm.

BOBF sample was obtained from birch bark after industrial birch veneer log peeling process with the relative moisture content 35-40 %. The collected feedstock was dried at room temperature to a moisture content of 4-7 % and milled in a cutting mill SM 100 (Retsch GmbH & Co) to pass the sieve with holes of diameter 2.00 mm. Milled dry birch bark samples were soaked in deionized water for 24 h by occasional mixing. Birch outer bark, floated on the top of the water surface, was collected and used as a reference raw material for the BOBF sample. After flotation, BOBF was dried and to a moisture content of 2-4 wt% for further operations.

BOBM sample was obtained after industrial birch veneer peeling process by mechanical separation at the plywood factory, where the fraction with the pure birch outer bark was collected after the sieving of birch bark through the fractionation system MUOTOTERA OY classifier using five screens according to SCAN-CM40:01 [6] to decrease the inner bark and woody particles content. For further operations the 10 - 45 mm fraction with a moisture content of 18-20 % (determined according to standard EN-14774-3 [5]) was dried at room temperature to a moisture content of 4-7 % and milled in a cutting mill SM 100 (Retsch GmbH & Co) to pass the sieve with holes of diameter 2.00 mm.

B. Birch outer bark extract

Birch outer bark extract was prepared from Latvian silver birch (*Betula pendula* Roth.) bark collected at the plywood factory as described before. 3 ± 0.15 kg of separated birch outer bark was extracted with 18 ± 0.5 L ethanol or 2-propanol in the 30 L externally heated extraction reactor equipped with a barbotation mixer. After the boiling temperature was reached (82 °C for 2-propanol and 78.1 °C) the first extract 13.5 ± 0.5 L was poured off and collected for further operations. In the reactor was poured in the same amount of clean solvent what was poured off as an extract. The same was repeated also for the third extraction time. Obtained ethanol extract was evaporated using Heidolph Hei-VAP Industrial B Large-Scale equipment and dried in a drying chamber at the 50 °C. For each extraction time (1E, 2E and 3E) extracts were evaporated separately and the yield was calculated, except the average BOBM sample, which was collected from all extraction procedures, mixed together, evaporated and dried. As a result, dry birch outer bark extract was obtained and yields can be seen in Table I. For further analysis dry birch outer bark extract was crushed in a ball mill and fractionated up to 125 µm.

C. Total phenolic content

Total phenolic content (TPC) were determined using Folin-Ciocalteu assay using high-throughput 96-well plate method as described by Herald et al. [7] with slight modifications.

All chemicals used for assays were of analytical grade. The measurement was conducted by mixing working Folin-Ciocalteu solution (1:1 with water), sodium bicarbonate and ethanolic extract or standard solutions. The absorbance was measured after 90 minutes of incubation at 765 nm, along with the blank. TPC was expressed as gallic acid equivalents (g GAE mg/100 g BOB extract), based on gallic acid (GA) calibration curve (range 0.025 – 0.200 mg ml^{-1}, $R^2 = 0.997$).

Analysis were performed on Infinite M200 PRO (Tecan Group Ltd., Männedorf, Switzerland) instrument. Bandwidth 9 mm, temperature 29 °C.

D. Antioxidant activity

The DPPH method is based on the ability to stable free radical 2,2-diphenyl-picrylhydrasyl (DPPH) to react with hydrogen donors. Antiradical activity (ARA) were determined using DPPH assay using high-throughput 96-well plate method as described by Herald et al. [7] with slight modifications.

All chemicals used for assays were of analytical grade The measurements of BOB extracts were done by mixing of 100 µM DPPH solution in ethanol with extract or standard samples. The absorbance was measured at 520 nm, along with the blank. ARA was expressed as ascorbic acid equivalents (AAE mg/ 100 g sample), based on calibration curve (0.03 – 0.09 mg ml^{-1}, $R^2 = 0.998$).

Analysis were performed on Infinite M200 PRO (Tecan Group Ltd., Männedorf, Switzerland) instrument. Bandwidth 9 mm, temperature 28.2 °C. The percentage of radical scavenging activity or BOB average extract was calculated from the following formula (1):

$$\%_{scavenging}\ [DPPH] = [(A_0 - A_1/A_0)] \times 100 \qquad (1),$$

where A_0 was the absorbance of the blank and A_1 was the absorbance in the presence of the average BOB extract.

IC_{50} value of BOBM average extract was determined from the graph obtained using standard ascorbic acid by using the "y =ax + b" formula from the slope of the graph as the amount of ethanolic BOBM extract necessary to decrease the initial DPPH· concentration by 50%.

III. RESULTS AND DISCUSSION

A. Birch outer bark extract

Separated birch outer bark samples was extracted with ethanol and propanol, obtained extracts were evaporated and dried as described in the previous section. As a result, birch outer bark extract was

obtained in the yields, which can be seen in Table I.

Table I
The yield of extracts depending on the solvent and feedstock

Solvent	Feedstock	Abbreviation	Yield (%) o.d.m.
2-propanol	BOBL	Prop-BOBL-1E	13.3 ± 0.2
		Prop-BOBL-2E	9.3 ± 0.1
		Total	22.6 ±0.3
Ethanol		Et-BOBL-1E	19.9 ± 0.2
		Et-BOBL-2E	9.4 ± 0.2
		Et-BOBL-3E	3.5 ± 0.1
		Total	32.8 ± 0.4
	BOBM	Et-BOBM-1E	19.6 ± 0.2
		Et-BOBM-2E	8.5 ± 0.1
		Et-BOBM-3E	3.3 ± 0.1
		Total	31.4 ± 0.3
		Average	30.9 ± 0.3
	BOBF	Et-BOBF-1E	22.1 ± 0.1
		Et-BOBF-2E	6.6 ± 0.1
		Total	28.7 ± 0.2

The total yield of the 2-propanol extract (22.6 %) is lower than that obtained using ethanol as a solvent (28.7-32.8 %). While the highest yield was obtained from the BOBL, which can be explained that the pure birch outer bark without inner bark and woody particle admixture was taken for the extraction process. It was already concluded in the previous study that the extracts yield from the industrial waste is lower due to the elution of monosaccharides and phenolic substances during the soaking of veneer logs. [8]. Thus, the outer birch bark obtained from a plywood factory seems to be a better raw material for the production of triterpenes than that obtained from a freshly cut birch trunk. Despite the fact that the yield of extractives is lower.

At the first extraction time more than 60 % of extractives was obtained from the totally obtained yield, while that for the second extraction time was in the range of 23-28 %. For two samples (BOBL and BOBM) the third extraction time was additionally carried out, which showed that there are small extractive yields (10.7 and 8.4 % from the total yield, respectively) left in the feedstock after two extraction times with ethanol.

B. Total phenolic content

Phenolic compounds, after betulin and betulinic acid, are the next most abundant structures in *Betula pendula* Roth. plants. The phenolic acids and flavonoids present in the plant extracts are natural antioxidants. They have anti-mutagenic and anti-cancerogenic properties, cardioprotective, anti-inflammatory and antimicrobial activity. The corresponding TPC and ARA for different birch outer bark samples are shown in Figures 1; 2 and 3 depending on the used solvents, used feedstock and number of extraction, respectively. The TPC, determined by the Folin-Ciocalteu method are in range of 2.56-7.42 g of gallic acid equivalents per 100 g of birch outer bark extract.

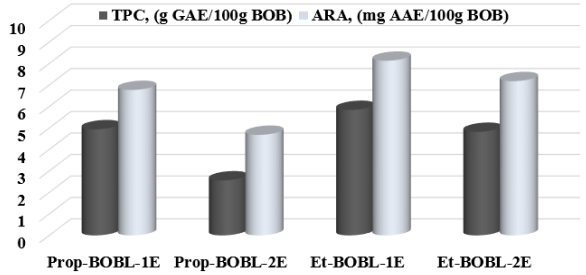

Fig. 1. Dependence of the TPC and ARA of BOBL extracts on the used solvent. TPC expressed as g GAE/100 g extract (λ = 765 nm; b = 0,6 cm). ARA expressed as mg of AAE/100 g extract (λ = 520 nm; b = 0,6 cm). BOBL- Birch outer bark from log.

Fig. 1 shows that there is difference between the BOBL extractives obtained using propanol and ethanol as a solvent. The TPC and ARA are even higher for ethanol extracts, which are more perspective for production of water based cosmetics or dietary supplement, because ethanol is one of the green solvents, which is allowed for obtaining of raw materials for mentioned products [9]. Therefore, for further experiments ethanol was used as a solvent to investigate antioxidant properties of the obtained extracts.

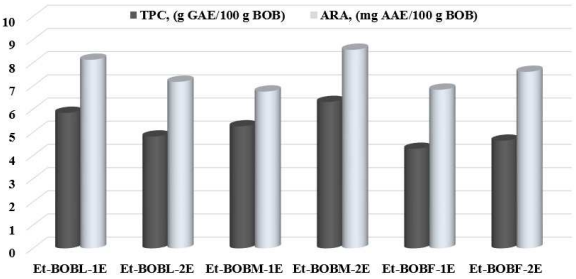

Fig. 2. Dependence of the TPC and ARA of BOB ethanol extract on the used feedstock. TPC expressed as g GAE /100 g extract (λ = 765 nm; b = 0.6 cm). ARA expressed as mg of AAE/100 g extract (λ = 520 nm; b = 0.6 cm). BOBL- Birch outer bark from log; BOBM -birch outer bark mechanically separated; BOBF - birch outer bark obtained by floating.

Fig. 2 shows the differences in TPC and ARA values depending on the feedstock. It is very interesting that for BOBM and BOBF the determined values for second extraction time is higher than that for the first extraction time. While for BOBL it is opposite tendency, which was obtained also using 2-propanol as a solvent (Fig. 1). To check this tendency, BOBM and BOBL two times extracted feedstock was additionally extracted for the third time and compared in the Fig. 3. It is obvious that there is the same tendency, that TPC and ARA values for BOBL

decreases by the number of extraction, while that for BOBM increases.

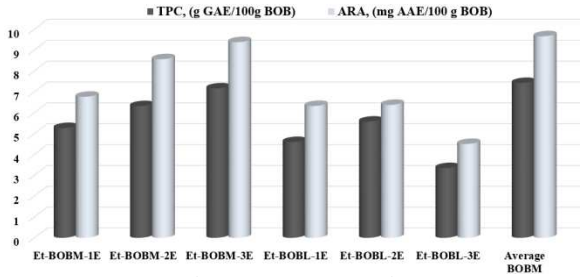

Fig. 3. Dependence of the TPC and ARA of BOB ethanol extract on the extraction time. TPC expressed as g GAE /100 g extract (λ = 765 nm; b = 0.6 cm). ARA expressed as mg of AAE/100 g extract (λ = 520 nm; b = 0.6 cm). BOBL- Birch outer bark from log; BOBM -birch outer bark mechanically separated.

Average sample from BOBM extractions was analysed as well. Surprisingly, the highest quantities between all samples of total TPC and ARA in average extract (7.42 ± 0.52 g GAE/100 g of dry extract and 9.66_± 0.13 mg AAE/100 g BOB, respectively) were found. This means that there is a future in ethanol extracts based on the antioxidant properties, which is a valuable characteristic for cosmetic and dietary supplement.

C. Dilution of ethanol extracts with water

While average dry BOBM extract showed the highest TPC content, it was decided to make measurements of dependence of TPC on sample dilution (Figure 4).

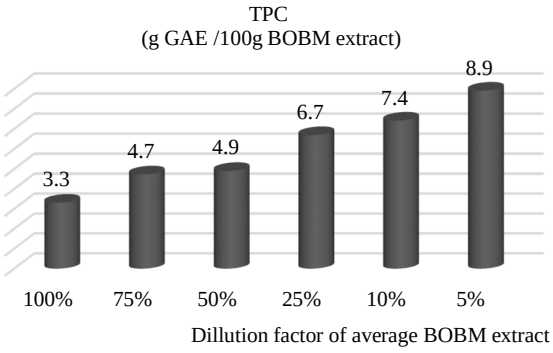

Fig. 4. Total phenolic content dependence on sample dilution of average BOBM extract.

BOB extracts overall don't have very good solubility in alcohol-water media, but it very promising that TPC increases by the increase of dilution percent. These observations of average BOBM extract in ethanol-water solutions can be with high potential for the production of cosmetic preparations and dietary supplement where in most of cases water medium is necessary.

D. Antiradical activity

A number of methods are used to determine the radical scavenging effects of antioxidants. The DPPH method is a preferred method because it is fast, easy and reliable and does not require a special reaction and device.

DPPH radical is a stable organic free radical with an absorption band at 520 nm. It loses this absorption when accepting an electron or a free radical species, which results in discoloration from purple to yellow. Total ARA can be affected by the type and the amount of antioxidants present in BOB extracts [10].

Antioxidant compounds are usually in the phenolic form. The antioxidant properties of phenolic compounds originate from their properties of proton loss, chelate formation, and dismutation of radicals [11]. The free radical scavenging activities of extracts depend on the ability of antioxidant compounds to lose hydrogen and the structural conformation of these components [12].

ARA for different BOB samples are shown in Figures 1; 2 and 3 depending on the used solvents, used feedstock and extraction time respectively. ARA in analysed samples ranged from 4.50-9.66 expressed as AAE in mg/100 g BOB extract. The highest ARA was observed for average BOBM extract (9.66 mg AAE/100 g of dry extract).

ARA depending on the dilution percent of analysed extracts were detected as well. Figure 6 shows dependence of ARA content on dilution expressed as AAE mg/100 g average BOBM extract.

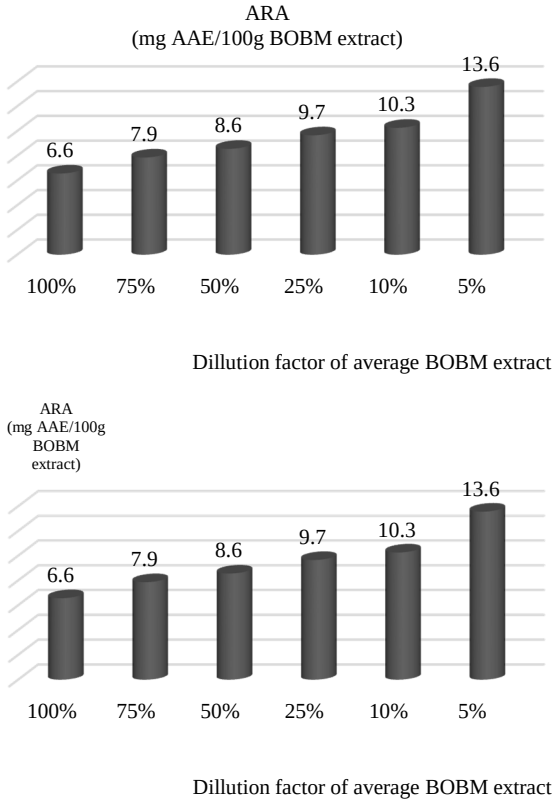

Fig. 5. Antiradical activity dependence on sample dilution of average BOBM extract.

Date from Figure 5 clearly demonstrate that average BOBM extract will not lose its antioxidant

properties by dilution even if will be used in more aquatic solution media.

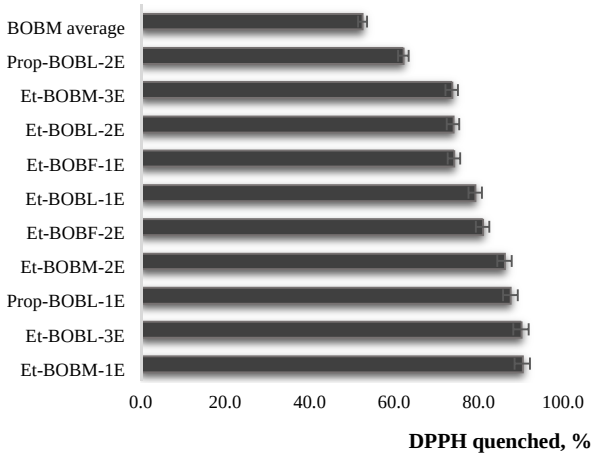

Fig. 6. DPPH radical scavenging activity (%) of birch outer bark extracts from Betula pendula (λ = 520 nm; b = 0.6 cm).

Data from figure 6 shows ability of BOB extracts to quench DPPH· radicals. Lower percentage shows higher ability to quench and reverse. This ability was ranging from 52.5-90.3%. The highest ability to quench free DPPH· radicals (52.5%) was observed for average BOBM extract. It was observed that the radical scavenging effect of the extracts quite positively correlated with their total amount of phenolic compounds (r = 0.628).

Based of obtained data IC_{50} for BOBM average extract and ascorbic acid was determined from the graph by using the "$y = ax + b$" equation from the slope of the graph. IC_{50} shows the inhibitory concentration, defined as the concentration of extract required to scavenge 50% of DPPH· radicals. Since the IC_{50} value of ascorbic acid, which is known to be a potent antioxidant was 6.23 μg/ml, which is significantly low, implies that a very less amount of this antioxidant would give a remarkably high effect in fighting oxidative damage. The average BOBM extract IC_{50} value was 39.28 μg/ml. These values show that average BOBM extract has 6.3 times lower antioxidant activity than ascorbic acid.

IV. CONCLUSION

In this study, total phenolic content, antiradical activity, free radical scavenging activity and total antioxidant level of different silver birch (*Betula pendula* Roth.) outer bark extracts were determined. The high-throughput 96-well plate method proved to be a robust and reproducible method for determining total phenolic content and antiradical activity in BOB extracts. This study demonstrates that all analysed birch outer bark extracts are phenolic-rich materials and very potent sources for natural antioxidants.

As a result, birch bark extracts can be used as well as in pharmaceutical products and cosmetics as a source of natural antioxidants.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] J.P.A. Ferreira, T. Quilhó and H. Pereira, "Characterization of Betula pendula outer bark regarding cork and phloem components at chemical and structural levels in view of biorefinery integration," Journal of Wood Chemistry and Technology, pp. 1–16, 2016.

[2] J.Liimatainen, M. Karonen, J. Sinkkonen, M. Helander and J.-P. Salminen, "Characterization of phenolic compounds from inner bark of Betula pendula," Holzforschung, vol. 66, pp.171-181, 2012.

[3] A. Felföldi-Gáva, B. Simándi, Sz. Pländer, Sz.Sszarka, É. Szőke and Á. Kéry, "Betulaceae and Platanaceae Plants as Alternative Sources of Selected Lupane-Type Triterpenes. Their Composition Profile and Betulin Content," Acta Chromatographica, vol. 21, pp. 671–681, 2009.

[4] R. Muceniece, J. Namniece, I. Nakurte, K. Jekabsons, U. Riekstina and B. Jansone, "Pharmacological research on natural substances in Latvia: Focus on lunasin, betulin, polyprenol and phlorizin," Pharmacological Research, vol.113, pp. 760-770, 2016.

[5] CSN standard EN 14774-3:2009, Solid Biofuels - Determination of Moisture Content - Oven Dry Method - Part 3: Moisture in General Analysis Sample, 2009.

[6] Scandinavian pulp paper and board testing committee standard SCAN-CM 40: 01, Wood chips for Pulp Production - Size Distribution.

[7] T.J. Herald, P. Gadgil and M. Tilley, "High-throughput micro plate assays for screening flavonoid content and DPPH-scavenging activity in sorghum bran and flour," Science of Food and Agriculture, vol. 92, pp. 2326-2331, 2012.

[8] J. Rizhikovs, J. Zandersons, G. Dobele and A. Paze, "Isolation of triterpene-rich extracts from outer birch bark by hot water and alkaline pre-treatment or the appropriate choice of solvents," Ind. Crops Prod., vol. 76, pp. 209-214, 2015

[9] Emergency and Continuous Exposure Limits for Selected Airborne Contaminants: Volume 2. National Research Council (US) Committee on Toxicology. Washington (DC): National Academies Press (US); 1984.

[10] A. Wulf, S. Anttonen, R.Pellinen, E.-M. Savonen, M.-L. Sutinen, W. Heller, H.Sandermann Jr. and J Kangasjärvi, "Birch (Betula pendula Roth) responses to high UV-B radiation," Boreal. Environ. Res. Vol. 4, 1999, pp. 77–88.

[11] L.Aksoy, E. Kolay, Y. Ağılönü, Z. Aslan and M. Kargıoğlu, "Free radical scavenging activity, total phenolic content, total antioxidant status, and total oxidant status of endemic *Thermopsis turcica,*" Saudi Journal of Biological Sciences, vol. 20, pp. 235–239, 2013.

[12] L.R. Fukumoto and G. Mazza, "Assessing antioxidant and prooxidant activities of phenolic compounds," J. Agric. Food Chem., vol. 48, pp. 3597–3604, 2000.

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System Analysis of Region Environmental Dimension

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Abstract. Areas of social systems - regions and their development is the key for national development, main vector of prosperity growth. There can be no prosperity without a strong and developed the country's regions.0

The article dealt with regionics- science that subject of studies are relatively small regions at NUTS-3 level with its historically established determinate territory, the cultural and ethnic identity, their development problems in the environmental dimension aspect. There is analyzed one of the most identical Latvian region - Latgale.

Keywords: Regional studies, tangible and intangible resources, ecosystem services, Latgale region.

I. INTRODUCTION

Starting from the eighties of the 20th century industrialization, technical and scientific progress, the extension of international economic and market links, international cooperation, flow of information, knowledge, technology and innovation as well as movement of products, services and population and the interaction between the countries has led to a sharp increase in the processes of globalisation. But globalization trends are not clearly positive.

Mike Collins [1] analysing this process, lists 16 positive and 13 negative factors, which influence the people and national economic and social situation in relation to the consequences of globalisation. But there are additional negative moments associated with human historical existence territory identity, which greatly affects people's mental state and thus the performance incentives.

However, it can be argued that globalization is a total human development vector and, therefore, this process is inevitable. But at the same time actually exist and always will exist territorial social systems - regions as global complex system building block.

Generalized region can be defined as the territory in which a set of specific characteristics is different from other areas, and which has the unity, the interconnection and interaction between inner elements and commonality, which is objective and logical result of the territorial development.

So, the region is a territorial system. The region has all the characteristics of complex systems, including space and time dimensions [2] structural elements and their mutual links, diversity, stability, resistance and self-learning, proper hierarchy [3].

The boundaries of the region are determined by the adopted parameters and criterions.

The homogeneity of the region is determined on the basis of the indicators that describe the nature of this area.

In the first stage of regional studies dominated economic organization and productive forces deployment aspects of territories. One of the first researchers in the science of regions can be considered German economist Johann Heinrich von Thünen, who in 1826 published his economic object placement concentric rings theory. Continuing this work the German scientist Carl Wilhelm Friedrich Launhardt in 1882.g. developed theory of industrial location and weight triangle method, which was based on transport costs (theory of the trace). Alfred Weber in 1929 formulated a least cost theory of industrial location, which is based on the total production and transportation costs minimization principle in the factory territorial deployment point selection.

Locating method continues to develop in the modern economic geography and regional economy. For example, this theory used in European Union's economic situation analysis [4].

German geographer W.Christaller in 1933 g. developed the central place theory - the geographical theory about optimal number of people in the urban environment, size, shape and mutual placement of the towns. German economist August Losch in 1939 developed the spatial concept of the economy, which is based on maximizing consumer prosperous space, but income is kept at an optimal level – with no aim to maximize.

At the same time developed other direction of regional studies, which was mainly based on the physical geographic characteristics of territory (geographer W.L.G.Joerg, geologist and geographer N.M.Fenneman, sociologist T.J.Woofter). P.V. de la Blach (1910) in his works described the social,

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political, geological, transport and historical aspects of regions as united complex.

American economist Walter Isard in the 50-ies of the 20th century brought together regional economic, geographical, ecological planning aspects as a whole thus creating a modern regional science methodology.

Regional science - interdisciplinary science that object of studies is a region - united by a whole complex of natural and human communities typical indicators spatially and historically determined territory.

Continuous economic development, despite its dynamism and expansion of global economic transformation, did not reduce the gap between individual regions characteristics.

Diversity of sub-national formations -regions is not only leveled - even sometimes it is intensified and deepened due to the fact that industrialization and its expression is highly dependent on the regional cultural and social diversity of structures (Trompenaars' and Hampden-Turner's cultural factors) [5].

Regions remains as the base unit of the world's territorial economic mosaic. M.Porter [6] found that the economic development level analysis should be changed from now existing dominant national to regional, due to the indisputable economic average development in the country overall non-compliance with the development of certain regions.

Exactly the regions are most closely related to ecology, environmental factors and resources of territory.

It is necessary to analyze the national development results, prospects and planning programs taking into account as a criterion not only all the national gross domestic product (GDP), but also the regional Gross Domestic Product (GDPR). This approach is currently used in the EU to analyze the relevant territory for the development of statistical data. According to the Council Regulation Nr.1059 / 2003, the EU has established territorial units in a hierarchical three-level classification for unified European statistical purposes (Nomenclature of Territorial Units for Statistics-NUTS) [7].

Regional science according to relatively small territories-at NUTS-3 level or less, identified as historically developed ethnic, cultural unit we advice to name as regionics.

Research areas of regionics are the regions' natural, tangible and intangible resources, ecological, historical, demographic, ethnic, religious peculiarities in their total interaction, their relationships qualitative and quantitative evaluation, the development process analysis and forecast.

Latgale region in Latvia correctly fit to this definition.

II. MATERIALS AND METHODS

Our research object - region, its nature and its development determinants in the context of the environmental dimension focusing attention on tangible and intangible natural resources.

The region as a complex system includes the structural elements of the following:

1. Environmental dimension functional blocks - subsystems: ecology, natural resources, recreational resources
2. Socio-economic dimension functional blocks: population, economics, production and social infrastructure, market infrastructure.
3. Humanitarian dimension functional blocks: ethnic, national criteria of national identity, cultural and spiritual, religious characteristics, historical factors.
4. Administrative and political dimension functional blocks: an institutional infrastructure, administrative factors, the political structure.

One of the main factors, which determine development of the region is natural resources. Environment and natural resources from time immemorial have been the main drivers of regional development, and now they are playing one of the main roles, less as it was in previous times in region's economy (thanks to a wide inter-regional and international co-operation), but very high in human living structural and substantive unique characteristics.

Until the end of the 20th century regional economic development study models the environment - ecological component did not take into account.

Millennium Ecosystem Assessment (MA) expanded concept of ecosystem services.

Ecosystem services plays serious, and in some sectors determinant (eg., tourism, agriculture, forestry, etc.) role of regional socio-economic development.

The paper describes the types of regions according to their influencing factors, analysis ecosystem services and natural resources, and their role of regional development on the case of Latvian region Latgale.

III. RESULTS AND DISCUSSION

The analysis shows that all regions can be divided into two groups according to their genesis: the regions, which are based on natural, independent of human criteria and parameters (natural-physical-geographic) and regions which developed by human activity – direct or indirect, targeted or unorganized.

The first group of regions are related to the natural processes in the environment, they are primary, that territory as the objective reality of the existence of determining factors.

The second group of regions has two types – ethnic- cultural regions developed historically during long period of time gradually (endogenous) and administrative, political (exogenous), created by the people, adopted the different levels of national or international laws, treaties, pacts and other legal instruments (table 1).

Accordingly, these regions influencing factors - time, space, climatic and other role in regional development dynamic are very different.

Table 1
Regions characterized according to those influencing factors

Dimension	Environment	Ethnic	Legal
Regions	Physical and geological, geographical, nature	Cultural-ethnic, historical	Administrative and political
Space factor	Deterministic diffusion boundaries through natural processes	Fugitive boundaries as a result of historical people's migration	Strictly determinate limits laid down in the decision of people
Time factor	Stable according to geological time scale	Stable according to long-standing historical time scale	Unstable, changing in a relatively short time scale
Other influencing factors	Geological and global climatic processes	Human populations migration and accommodation processes	Political, administrative, authoritarian decisions

Natural regions are the most conservative, unchangeable, long-term, stable at least for many human generations - for the most part, many hundreds and thousands of years - the geological time scale intervals.

Historical endogenous regions are much more susceptible to changes in time - humanity's historical timeline intervals.

Administrative - political exogenous regions are most prone to perturbations during - human generation timeline. They are strongly influenced by various human activities factors - political, economic, administrative, including subjective, ambitious, violent, and so on.

At the same time, since these regions and their boundaries are legally defined and human activities are adequately regulated and regulated exactly within this range, they become determinants of life progress and development processes in these areas.

Also the boundaries of the political administrative regions are strictly determined.

Less accurate with quite a wide range of interactions (mixed) zone are historical (ethnic) regions.

Physical and geological natural regions can be sharply separated from each other by natural boundaries, but can also be a transient phase in each other - diffuse area.

Since all of these regional boundaries do not match (fig.1), but the most powerful effects on human and social activities gives the administrative regions and national boundaries, forms disagreements, conflict situations in humanitarian, socio-political, economic sphere, non-compliance in production and consumption of the resources, non-optimized production and operating conditions, unfavorable socio-economic environment, stress, tension between population groups.

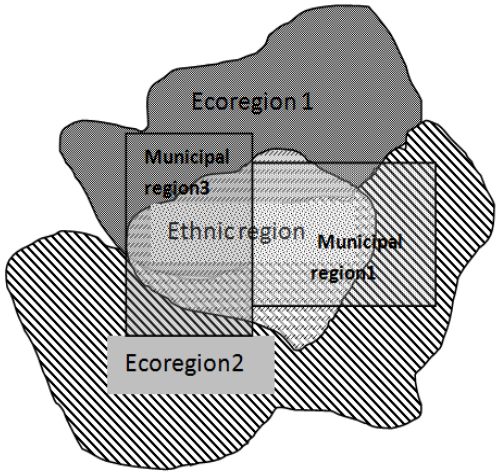

Fig.1. Inadequacy of the bounderies of different regions.

So, there is a discrepancy between social and geo-spatial region components mainly that each of them is developing at its own different laws and times.

Social components are developing and changing fast, geologically geographical - slow or for long time does not change at all and the in the most cases a man do not have any influence on these changes limited with modern scientific and technological development level.

Optimum conditions, which can develop in the region, are the ones where the administrative borders of the region coincides with the cultural-historical and physical-geographic.

This disagreement stimulated natural regions (bioregions) concept formation, which offers establish administrative regions borders based on ecological criteria and environmental conditions of territory. On that basis have been set up virtual countries directly in the boundaries of bioregion, such as Cascadia bioregion (includes two countries - US and Canadian sites) [9], bioregion Ozark plateau (within the US, but includes a territory of different states [10].

At the moment, as it was already mentioned, is becoming a popular concept of ecosystem services [11].

Under this concept understands all the benefits that a person can get directly from ecosystems relatively with no effort on his part - the product developed as a result of natural ecosystems existence.

European Environment Agency developed a common international classification of ecosystem services (CICE) [12] where services of nature are grouped into three sections:

- provisioning (nutrients, materials and energy, which ecosystems offers for human directly).
- regulation and maintenance (ecosystem functions which provide other ecosystem services).
- cultural (intangible benefits which can offer the ecosystems - physico and intellectual, mental and symbolic interactions with biota, ecosystems).

Ecosystem service concept focuses on goods which are produced by ecosystem, and thy are primarily related to the ecosystem biota.

However, they are only at the lowest level. In principle, any benefit obtained from the nature is not toll-free. Its withdrawal requires functioning of the human hand (even picking mushrooms). In addition, the quality of the benefit may be much higher if one carries additional forces for the collection and further processing.

Ecosystem service terminal value EV depends on the primary value of service E_0, as well as of service transformation coefficient of the k_{tr}, (which is usually more than one, but sometimes can also be negative) and benefit demand index α, which characterizes the human desire to get this service.

$$EV = (E_0 * k_{tr})^{\alpha} \quad (1)$$

Ecosystem services need to be seen as the resource potential of the respective region, as well as the possible consequences of its use intensity (present or designed) - the ecosystem's ability to maintain their service functions further.

Index of load on the ecosystem L is calculated by formula

$$L = C\delta / t\beta g\gamma, \quad (2)$$

where C- environmental carrying capacity,

ρ- environmental resistance to external effects parameter,

t- time of impact on the ecosystem

g- impact intensity,

β, γ-coefficients (β = 2-2.5, γ = 2.5-4).

Optimally this parameter L must be more than 1. In principle, all ecosystem's biotic and abiotic components can be used in human well-being.

So, the ecosystem service concept is actually just the common concept of "natural resources" conditionally separated part. Therefore, in our view, more appropriate is to operate with the concept of natural resources and to analyze their possibilities to use them, their prospects, accessibility and value.

Resources can be defined as any kind of tangible and intangible values and the sources from which one can obtain the relevant benefits according to the diverse human claims.

Type of the resource depends on the target to achieve which it can be used.

Is the goal - according to this are searched resources, which are necessary to achieve that objective. The objectives are manifold, in addition they changes and broaden in time, their nature is changing.

Human existence as an individual objective is different from the social group, community, national or global human development goals. These differences also change with time – in certain periods can be reduced, in other to grow and can sometimes move to the confrontation stage. Accordingly the range of resources changes, as well as attitudes towards them, their value, demand and availability. With equipment and technology development, human interest and demand changes and some types of resources loses its meaning, others become decisive.

So - the resource is variable during the time and dynamic concept.

Analyzing the resources of the region's environmental dimension point of view it is necessary to classify them differently.

At first, the resources can be primary and underlying or derived - developed after the transformation - a new type of secondary sources, of which it is possible to create the next generation of resources.

Second - different types of resources are not isolated from each other - they are linked to each other - they are a single complex system with interaction of elements and emergency processes between them.

Primary resources are natural resources which in turn can be divided by secondary criteria as biotic and abiotic, renewable and non-renewable, widely available and localized, used and potential. The listed resources provide human material welfare.

However, people's spiritual, aesthetic, psychological, internal comfort, curiosity desires provision are not directly related to the material values of resources. The ability of natural objects to meet people's spiritual requirements are intangible natural resources.

Their profit for man is derived by emotional, spiritual path based on a specific vision and environmental assessment of a given cultural symbolic experience within. [13,14,15]. Analyzing the resources from this point of view it can be concluded that:

1. Any natural object may become as a resource in the certain circumstances.

2. Also, any waste formed by human activity, is actually a secondary technogenic resource.
3. All resources are virtually multipurpose.
4. For all resources, in addition to use of the material have to a greater or lesser extent intangible function- ability to directly interact through the sense organs of the human body and consciousness and thus influence the spiritual life and change the state of health.

So for analysis of regional environmental dimension we offer classification of natural resources, which includes 4 main groups of resources (table 2) - substance resources: biotic and abiotic; resources of physical fields; complex agro-physical resources.

Each of these resources can be characterized by their role, which it executes or potentially is able to meet human residency of providing material, energy or non-material needs and desires.

Table 2
Classification of natural resources by the types and components (components: M-material, E-energy, N-intangible)

Nature resources	Groups	Components			Available	Prospective	Renewable.
		M	E	N			
Biotic	Flora	*	*	*	*		*
	Fauna	*		*	*		*
Abiotic	Minerals	*	*		*		
	Water	*	*	*	*		*
	Atmosphere		*	*	*		*
Physical fields	Gravitation			*		*	*
	Magnetic			*		*	*
	Radiation			*		*	*
	Seismic			*		*	*
	Geothermal		*		*		*
	Electro magnetic		*	*	*		*
	Cosmic rays			*		*	*
Agro-physical, climatic, physio-geographic	Soil			*	*		*
	Climatic complex			*	*		*
	Relief, topographic			*	*		
	Water-earth rate			*	*		
	Protected natural areas			*	*		

Physical fields and their complexes (agro-physical, climatic geographical) form natural conditions of a given region. They also have an intangible resource - it is human existence environment from which he obtains daily life energy and the ability to live, to act. In contrast to the classic definition of resources this resource functions can be not only beneficial, but also the evil. It should be understood only that the concept of "evil" is just as subjective as "good". In nature there is no such category. Therefore, assessing the ecosystem or environmental services it is need to adopt a point of reference notional zero line, which is understood as a person's standard of living and welfare conditions. All factors which lowers these conditions can be expressed by a number with negative sign - and vice versa. Environmental conditions often can affect a person's life negatively - that is, they become negative natural resources. Their role in research on resources and their impact on regional development is analyzed quite rare. First, there are climatic factors, secondly, geophysical fields and cosmic radiation. Undoubtedly, any physical phenomena and physical fields influence on people can be the negative or positive, depending on the field intensity, changes in space and time and other parameters

Also the ecosystems not gives only a positive results on human existence. For example, about 90% of NO_2, 23-30% of CH_4 emissions in the atmosphere, 25% of infectious diseases are linked to ecosystems. It means, that there are strong necessity for study the effects of field interacts with the human conditions of existence and elimination the negative consequences or modification them for benefits.

Let us analyze the most identically pronounced Latvian region Latgale. Latgale is a cultural and ethnic region in the Latvian eastern part. Evaluating the Latgale region it can be determined that the region is different from the other Latvian regions not only in it's own ethnic identity, but also from the point of view of the environmental dimension. Our research showed that there is a difference in the region's geological structure, geophysical field intensity, in the tangible and intangible resources.

Latgale region cultural and historical boundaries do not coincide with the set up NUTS-3 level Latgale planning region [fig.2] according to the European Council Regulation Nr.1059 / 2003, but it is pretty close. Therefore, the planning region statistical data is conditionally applicable for analyse this historical region.

Latgale Planning Region covers an area of 14550 km^2- 22.5% of Latvia territory(fig1), while the number of inhabitants per 2016 year was 286,238, what means 14.4% of the Latvian population.

Fig. 2. Latgale planning region

The level of ecosystem service to this moment has not been evaluated in Latgale region as well as in the Latvia due to lack of more or less accurate statistical data. In Latvia there are only some local researches in this field [16] based on the experts' assessment methodology. But available data about Latgale generally show that the ecosystem services offered there are large and varied, but the scope of the use is incomplete. It is one of the factors which resulted in the Latgale region seriously lagging behind in their economic development from other Latvian regions.

According to the developed resource classification were assessed Latgale region's resources, including ecosystem services utilization rate for this moment.

The following table (table 3) shows the main types of Latgale region resources as the percentage of the optimal distribution of its components (the upper number) and its current utilization rate (lower number).

Table 3
Latgale region's resources , ecosystem services and the level of potential use

Component / Resource	Material		Energy		Intangible	
	%	character	%	character	%	character
Forest	40/50	Wood as a material, hunted animals, berries, mushrooms, pharmaceutical plants	40/30	Wood as fuel	20/10	Rehabilitation, recreation, tourism
Surface water	20/10	Fish, aquatic plants, water for household	10/10	Hydropower plants	70/30	Rehabilitation, recreation, tourism
Minerals	90/30	All Minerals	8/4	Peat	2/0,5	Sapropel, therapeutic sludge
Geophysical and cosmic fields	0		5/2	Solar, wind, geothermal energy	95/0	Vitagenic and pathogenic effects on the body
Agro-physical and climatic	0		0		100/60	Agriculture, livestock farming, recreation, tourism
Protected natural areas	0				100/40	Cultural development, environmental education, intellectual interaction, science, holistic approach

Latgale forests occupy 39% of Latgale territory - and this is 78% of the average Latvian forest cover percentage. Latgale wood stocks representing 17% of total Latvian. Forest supply services is higher than the optimal due to too intensive deforestration for obtaining wood. However, incomplete are used forest other resources -intangible as well as tangible.

After the site area, which occupies a surface water, Latgale almost twice the average Latvian indicators, but their use efficient is quite low, with the exception of small hydro power plants. This position has exhausted its potential and further expansion of hydroelectric power threaten ecosystems existence.

In the field of mineral resources Latgale can be valued quite low compared to the total Latvian scene (fig.3) except clay resources. But all those also at this level is not currently being fully exploited.

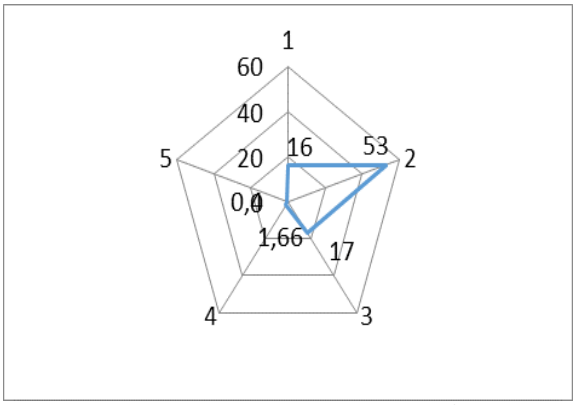

Fig.3 Latgale mineral and timber resources (% of total Latvian resources) 1-dolomite, clay-2, 3-wood, sand-gravel 4-, 5-sapropel.

Exploiting of geophysical fields in Latgale currently is associated in a small quantity with wind and solar energy, but this energy potential is low also.

Geophysical and cosmic fields significance in the region is mainly related to their observance in region territory economic planning.

In Latgale exists gravitational field anomalies, which have a positive impact on human health. The optimum gravity field anomaly range is between 20 to 45 mGal (fig 4a).

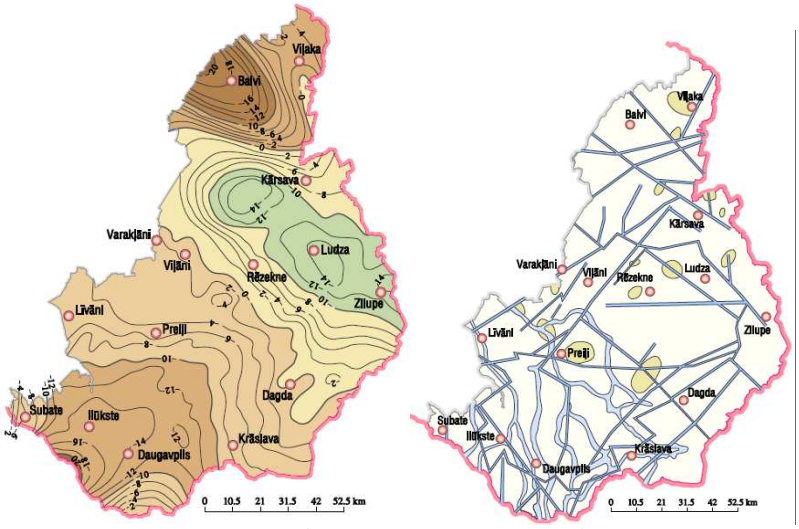

Fig.4 Latgale gravitational field anomalies (a) and tectonic fracture zones (b)

Latgale average magnetic field anomaly is + 44nT.That fits in the interval optimal for human health in the range of -300 to + 300nT and is much lower than the average Latvian magnetic field anomaly (+ 261nT).

But in Latgale there are also geopathogenic areas where geophysical field becomes unfavorable to human life.

As Latgale rocks' crystalline basement is closer to the Earth's surface and has quite large quantity of fractures (see fig .4 b), there are areas with elevated radon release from the ground. Depending on the created by radon radiation level along with other fields can be given the positive - vitagenic, as well as negative - pathogenic effects on human. All of these factors is no met in territorial planning at Latgale and in Latvia currently.

Agrophysical and climatic fields in Latgale region is also different from other regions. Precipitation is lower than other regions -550-650 mm per year, temperature fluctuation range is wider, more continental climate, sum of active temperatures (ATS) is higher (1900 to 2100) as well as greater hydrothermic coefficient (1.8 to 1.9). (fig.5).

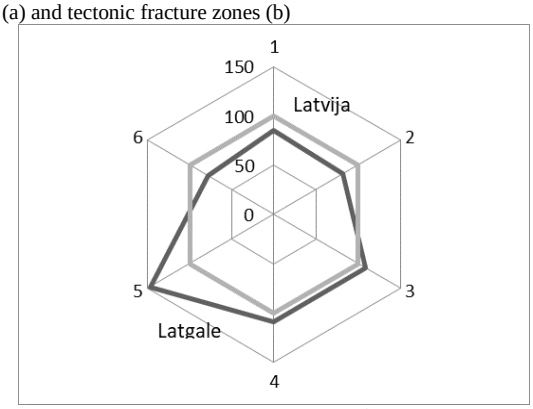

Fig.5.Latgales agro-climatic resources (% of the average in Latvia) 1-precipitation, 2-mean temperature 3- sum of active temperatures, 4-hydrothermic coefficient 5- agricultural land (% ratio), 6-woodland (% ratio).

Land used for agriculture is 44%from total territory of region which is more than the average over Latvia

Given the fact that the composition of soil in Latgale differs little from that in other regions can be assumed that in Latgale are high potential for agricultural development.

But the actual figures show that after production region seriously lags behind other regions level (fig.6).

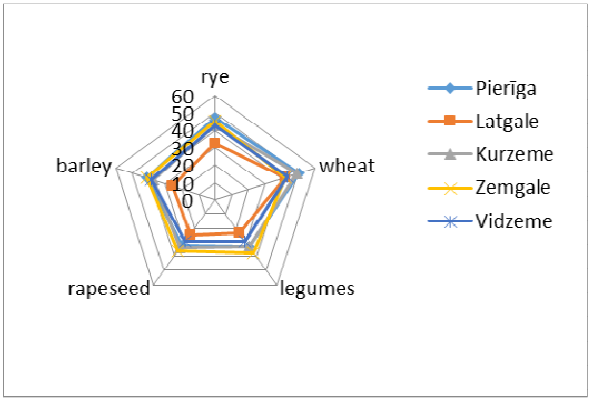

Fig.6. Cereal harvest in Latvian regions 2015

Average cereal harvest in the 2015 in Latgale did not exceed 37 t / ha, while in Zemgale it exceeded 50 t/ha, Kurzeme and Pieriga - 45t / ha. A similar situation is with other indicators.

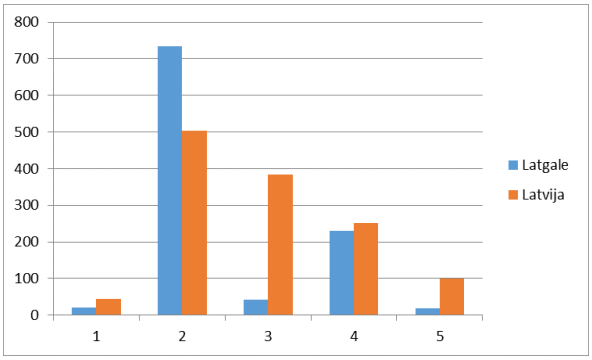

Fig.7. Produced Latvian agricultural production average per capita and Latgale in year 2016. 1-meat, kg ;2-milk, kg ;3-eggs, units; 4-potatoes, kg; 5 -vegetables, kg.

The same also applies to the livestock industry. After the number of domestic animals, as well as by the produced quantity Latgale lags behind all other regions in some positions very seriously. For example, Latgale produced a meat almost 6 times less than the Pieriga region and 4 times less than Zemgale region.

In the year 2015 in Latgale was higher than in other regions the number of cows, but also there is less productivity-each cow in Latgale gave only 5 tons of milk per year - about 1- 1.7 tons less than in other regions.

Protected natural areas in Latgale despite their great potential is currently not used for human goodwill to meet the needs according to their capabilities.

IV. CONCLUSIONS

1. The region is dynamic and balanced with the environment complex system-unified on the natural and human communities typical indicators spatially and historically determined territory.
2. According to the genesis of regions they may be natural physical-geographical; ethnic and cultural historical; administrative political.
3. Regional science - interdisciplinary science the object of study of which is the region - its natural, tangible and intangible resources, historical, demographic, ethnic, religious peculiarities of their total interaction, analysis and forecast its development processes.
4. One of the main factors which determinate development of the region are resources, any kind of tangible and intangible values and the sources from which may be obtained the corresponding benefits to the human variety of claims.
5. A resource is a variable in the time, a dynamic concept.
6. Resource exploitation also include ecosystem services.
7. Exactly the rational use of ecosystem services along with the material, energetic and intangible resources of the region are able to activate the regional economic development and human living standards growth.
8. Latvian region of Latgale has a high natural resources and ecosystem services potential, but it is not rationally used.
9. One reason for this situation is a contradiction between the social and geo-spatial region components of existence.

REFERENCES

[1] Mike Collins, The Pros And Cons Of Globalization, Saving American Manufacturing http://www.manufacturing.net/article/2010/06/pros-and-cons-globalization.

[2] R.P.Mishra, Regional planning: Concepts, Techniquers, Policies and Case Studies, Concept Publishing Co, 1992.

[3] Darwent Whittlesey, Major Agricultural Regions of the Earth, Annals of the Association of American Geographers, Feb. 2009.

[4] Peter Holland. Location Theory and the European Union, October 23, 2016 http://www.landisfree.co.uk/sa51-location-theory-and-the-european-union-by-peter-holland/

[5] Smith, Peter B., Shaun Dugan, and Fons Trompenaars. "National culture and the values of organizational employees a dimensional analysis across 43 nations." Journal of cross-cultural psychology 27.2 (1996): 231-264.

[6] Michael E. Porter. "The Five Competitive Forces that Shape Strategy", Harvard Business Review, January 2008, p.86-104.

[7] COMMISSION REGULATION (EU) No 868/2014 of 8 August 2014 amending the annexes to Regulation (EC) No 1059/2003 of the European Parliament and of the Council on the establishment of a common classification of territorial units for statistics (NUTS).

[8] Millennium Ecosystem Assessment 2005 report Ecosystems and human well-being: synthesis. Washington, DC: Island Press. (UNEP 2005).

[9] Crane, David, Paul Fraser, and James D. Phillips. "Western Regionalism: Views on Cascadia." *Canada-United States Law Journal*, 2004, Vol. 30, p321-347, 22p

[10] Abell, R.,Olson, D.,Dinerstein, E.,Hurley, P. T.,Diggs, J. T.,Eichbaum, W.,Walters, S.,Wettengel, W.,Allnutt, T.,Loucks, C. J.;Hedao, P. "Freshwater ecoregions of North America" Washington, D.C.: Island Press,2000.

[11] Guo, Z.W., X.M. Xio and D.M. Li. 2000. An assessment of ecosystem services: water flow regulation and hydroelectric power production. Ecological Applications 10: 925-936.

[12] Common International Classification of Ecosystem Services (CICES): Consultation on Version 4, August-December 2012.

[13] 13.Cf. Cosgrove, D.E. Social Formation and Symbolic Landscape, London,1984.
[14] Schama, S.Landscape and memory. New York, Backhaus1995.
[15] Michal Semian & Pavel Chromý .Regional identity as a driver or a barrier in the process of regional development: A comparison of selected European experience Published online: 25 Sep 2014 Pages 263-270
[16] L. Brūniņa E.Konstantinova A. Peršēvica. Necessity of Mapping and Assessment of Ecosystems and their Services in Planning and Decision Making Process. LIFE "Ecosystem Services" (LIFE13 ENV/LV/000839) project.

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Choice the Filter for Tar Removal from Syngas

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Abstract. One of devices for removing char from syngas is a cloth-based filter. Char is mainly carbon black which is a good adsorbent and can be used for removing tar from syngas. When the latter passes through the filter, the char accumulates in it and adsorbs tar. In order to study effectiveness of this way of removing tar, samples of syngas for further analysis were taken twice, before and after the filter with char. A solid-phase adsorption (SPA) method for determining concentration of tar compounds has been chosen. The research showed that the filter for removing char from syngas proved quite cheap and effective in removing tar from syngas. Concentration of the total tar in the samples taken after the filter for removing char from syngas decreased by nearly 90% comparing to the total tar concentration in the samples taken before it. A solid-phase adsorption system consisting of amino-phase sorbent and activated coconut charcoal is a very convenient and effective device for sampling tar in syngas. If its concentration in syngas is high, light tar compounds are adsorbed on both sorbents. With a low concentration of tar in syngas, all compounds might be adsorbed only on the first sorbent.

Keywords: adsorbent, analysis, char, syngas, tar removal.

I. INTRODUCTION

Biomass fuels as a carbon neutral renewable energy source can be used for the production of electricity and heat. Gasification of biomass produces lower levels of sulfur, nitrogen compounds and reduced carbon emissions, than those in coal gasification [1], which is particularly important today.

The planned 20 percent of the EU's power are to be obtained by 2020 from renewable sources such as biomass alongside with wind, solar or geothermal sources. Although it is true that clean energy technologies cost more than fossil fuels, the European Union says a low-carbon economy will create millions of new jobs, which is particularly important at the time of crisis right now (Green jobs vs unemployment, Euronews 16/06/2009 08:27 CET). So the use of biomass is not a question of purely academic importance.

Biomass gasification results in the production of a syngas that can be used as a fuel gas to power combustion engines, turbines, and fuel cells to produce electric power. The gas composition resulting from biomass gasification depends on conditions of gasification.

Gasification process generates solid char and tars whose quantities depend on the gasifier type and operating conditions. Tars are condensable in the gasifier, in downstream processing steps, or in conversion devices [2]. The amount of tars in the gas stream can be as high as several hundred g m-3 depending on the type and operating conditions of the gasifier [3]. The unwanted tar may deposit on the walls of piping and in other process units downstream of the gasifier. Tar in the gas stream hinders the removal of particulates in the gas stream, utilization of the syngas, and affects steam reforming of the syngas into hydrogen [4]. This leads to blocking and fouling of downstream processes resulting in a low cold gas efficiency of the system and low heating value of the final fuel gas produced [5].

Char removal from syngas is usually considered as a very important process where the cost of the removal device should not be high. One of such devices is a cloth-based filter which adsorbs char when syngas passes through it. The filter pores get blocked with time, and it becomes less effective. That is why regular shaking out helps remove char from the filter during gasification.

By virtue of its nature, char is mainly carbon black which, due to its large surface, is a good adsorbent. That is why the filter with char adsorbed on it can be used for removing tar from syngas. When syngas passes through the filter, the char accumulated in it can adsorb tar. In order to study effectiveness of this way of removing tar, samples of syngas for further analysis were taken twice, before and after the filter with char. Sampling was performed in different conditions of biomass gasification, i.e. the temperature of the process varied as well as the biomass – air ratio. To analyze the adsorbed tar, the char shaken out of the filter was also examined. The aim of the present research is to examine the effectiveness of removing tar from syngas with the

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help of the filter filled with char resulting from biomass gasification.

In the present work, solid-phase adsorption (SPA) method for determining concentration of tar compounds has been chosen. The SPA method was developed by The Royal Institute of Technology in Sweden [6] to measure tar compounds ranging from benzene to coronene. Traditional methods [7] are based on cold solvent-trapping (CST). They proved very impractical for light compounds and require lengthy sampling times (15–60 minutes per sample). By contrast, the SPA method is easy to handle, and one sample is typically taken in only 1 minute. According to this method, tars are sampled by collection on a column with a small amount of amino-phase sorbent. For each sample, 100 mL of gas is taken from a sampling line with the help of a syringe or a pump. The sampling line is kept at 250–300°C to minimize tar condensation. The aromatic fraction is extracted using dichloromethane, and the solution is then analyzed by a gas chromatograph (GC-MS). With a high concentration of volatile organic compounds in biomass tar, not all of them will be collected on an amino-phase sorbent. Trying to solve this problem, it was decided to install a second column with another adsorbent designed for collecting volatile organic compounds, following the column with the amino-phase adsorbent.

In the previous papers [8–11], an improved system for sampling tar, namely, equipped with one more adsorbent cartridge loaded with another sorbent, was suggested and described. The best results were obtained while using activated coconut charcoal as the second sorbent. So, a modified sampling device consisting of 500 mg of amino-phase sorbent and 100 mg of activated coconut charcoal was chosen as optimal for sampling tar and volatile organic compounds it comprises in synthesis gas produced in biomass gasification.

II. MATERIALS AND METHODS

A. Gasifier

For research in a real-life context, the Circulating Fluidised Bed (CFB) gasifier situated in eastern Latvia (Rēzekne region) was chosen. Peat extracted several kilometres from the gasifier was employed as biomass. The main characteristics of the gasifier are as follows: heat output is ~600 kWth, reaction temperature reaches ~800–1050°C, the mass of dry peat is ~250 kg hour^{-1}, and the mass of air ~120 kg hour^{-1}. The peat biomass has the following fuel characteristics calculated as for dry basis: gross calorific value is 20.00 MJ kg^{-1}, moisture 13.0%, C 53.23%, H 7.63%, N 0.86%, S 0.10%, O 38.18% (by difference). The product gas comprises H_2 (13.43%), N_2 (50.52%), O_2 (0.38%), CO (12.72%), CH_4 (2.41%), CO_2 (16.91%). The temperature of syngas in the point of sampling before the filter is about 250°C, after the filter about 150°C. For analysis, 100 mL syngas at the flow-rate 100 mL min^{-1} were sampled and 100 mg of the shaken-out char from the filter were sampled.

B. Tar sampling device

A tar sampling device consisting of two consecutively joined columns with adsorbents was made particularly for the present research (Fig. 1).

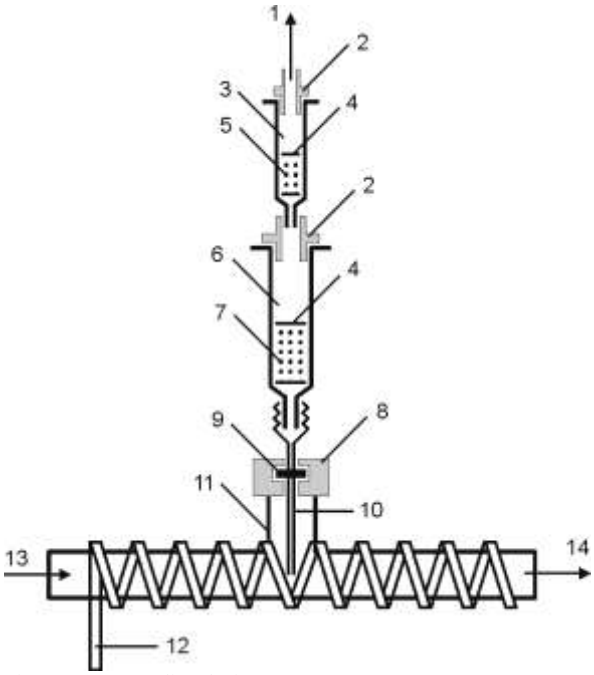

Fig. 1. A tar sampling device.
1 - connection to a pump, 2 - adapter (polypropylene), 3 - sorbent column (polypropylene, 1 mL), 4 - fritted disc (polyethylene), 5 - activated coconut charcoal, 6 - sorbent column (polypropylene, 4 mL), 7 - amino-phase sorbent, 8 - septum nut (polyethylene), 9 - rubber/silicone septum, 10 - hypodermic needle (stainless steel), 11 - glass "Tee" tube, 12 - heating tape, 13 - product gas inlet, 14 - connection to electric pump.

The first column was a 4 mL solid-phase extraction adsorbent cartridge with 500 mg of loosely packed aminopropyl-bonded silica adsorbent (the surface area was about 400–600 m^2 g^{-1}, the particle size was 50 μm, the average pore size was 60 Å, from Alltech). The second column was a 1 mL SPE adsorbent cartridge (Alltech) with 100 mg of activated coconut charcoal (the surface area was 1070 m^2 g^{-1}, the particle size was 20/40 mesh, 420–840 μm, from SUPELCO) packed loosely.

Using an insulated heating tape to minimize tar condensation, the "Tee" tube was heated to 250°C. The product gas was drawn through the heated tube with the help of an air sampling pump (SKC). A required volume (depending on tar concentration) of product gas at ~atmospheric pressure was sampled with a mass flow rate regulator and a specific gas vane-type pump at the constant flow rate of 100 mL min^{-1}. The product gas with tar was drawn into the first adsorbent cartridge with the amino-phase adsorbent. The core amount of the compounds such as indene, naphthalene, acenaphthylene,

acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, and pyrene was adsorbed in the first adsorbent cartridge, while volatile organic compounds, mainly benzene and toluene, were drawn with syngas into the second adsorbent cartridge loaded with activated coconut charcoal. After sampling, the inlet and outlet sides of the cartridges were sealed with plastic stoppers.

C. Sample preparation

There are two procedures, one for the amino-phase sorbent by column extraction with dichloromethane/acetonitrile and the second for the activated charcoal sorbent by solvent extraction. The following applies to the first column. The inlet of the adsorbent cartridge was connected to a reservoir (an empty adsorbent column). The cartridge was positioned vertically in a stand exactly above a vial (1.8 mL) placed on a laboratory jack. The internal standards dissolved in dichloromethane were added to the reservoir. The fraction containing aromatic compounds was eluted with 3×600 µL of dichloromethane. The fraction containing phenolic compounds was eluted with 3×600 µL of dichloromethane/acetonitrile (1:1 v/v). Dichloromethane or dichloromethane/acetonitrile was drawn through the amino-phase adsorbent by means of a 100 mL syringe. The sorbent from the second column was placed in separate vials, 1.8 mL each; 1.0 mL of carbon disulfide was added to each vial, and crimp caps were immediately attached to each vial. The vials were allowed to stand for at least 30 min with occasional agitation.

The char shaken out from the filter was analyzed similarly to activated coconut charcoal: 100 mg char was placed in separate vials, 1.8 mL each; 1.0 mL of carbon disulfide was added to each vial, and crimp caps were immediately attached to each vial. The vials were allowed to stand for at least 30 min with occasional agitation.

D. Analysis

A Shimadzu GCMS-QP2010 system (Shimadzu Corporation, KYOTO, Japan) was used for the analysis. The gas chromatograph was equipped with an electronically controlled split/splitless injection port. GC was carried out on a 5% diphenyl-/95% dimethylpolysiloxane fused-silica capillary column (Rtx-5SIL-MS, 30 m×0.32 mm, 0.25 µm film thickness; Restek). Helium (99.999%) was used as the carrier gas, at a constant flow of 1.6 mL min-1. The injection (injection volume of 1 µL) was performed at 250°C in the split mode, split ratio 1:10. The oven temperature program was as follows: the temperature was held at 30°C for 5 min, then 30–180°C at the rate of 10°C min^{-1}, 180–300°C at the rate of 15°C min^{-1}, and finally held at 300°C for 5 min. The mass spectrometer was operated in the electron ionization mode (ionisation energy of 70 eV). The source and transfer line temperatures were 200 and 310°C respectively. Detection was carried out in the scan mode: m/z 35–300.

E. Calibration and quantification

Calibration method with internal standards was used for analysis. For mixing standard solutions, standard compounds most common in biomass gasification tar were used: benzene, toluene, xylenes, phenol, indane, indene, cresols, naphthalene, acenaphthylene, acenaphthene, fluorene, phenanthrene, anthracene, fluoranthene, pyrene, chrysene, and benzo(a)pyrene. Deuterated compounds benzene-d_6, phenol-d_6 and naphthalene-d_8 were used as internal standards. Calibration curves were performed with five points, each of them realised in triplicate. The criteria for the linear regression (R^2) were a minimum of 0.995 according to [7]. Five calibration mixtures were made using pure standards of the compounds to be quantified and a known amount of internal standards added to each calibration mixture and to the studied samples. All areas were measured and referenced to the area of the internal standards. To determine concentrations of the tar compounds that were not among the quantified ones, the response factor of the quantified compound with the retention times closest to the unquantified compound was used. The total tar concentration (mg m^{-3}) was calculated as a sum of concentrations of all identified and quantified compounds.

III. RESULTS AND DISCUSSION

A. Sampling in different conditions of biomass gasification

The present research studied dependence of the concentration of the total tar and its individual components in syngas on the temperature of the reactor. Sampling was performed before the charred filter. While changing the biomass – air ratio, varying temperature of the reactor was obtained. Sampling was performed 30 min after the change of parameters and the following change of temperature, i.e. the time necessary for stabilization of all parameters including the syngas composition. The reactor temperature was gradually increased from 800°C to 1050°C with the interval of 50°C. Moreover, the temperature of syngas in the point of sampling was practically unchanged, about 250°C, which is connected with the fact that syngas was going through heat exchangers. 100 mL syngas was drawn through sorbents at the flow-rate 100 mL min^{-1}.

Tables I and II contain concentration of the total tar and some of its components in the syngas in different conditions of gasification. Compounds whose concentration is not less than 1 per cent of the total tar amount were selected for comparison.

In course of experiment, concentration of the total tar in syngas varied with the change of gasification conditions which were registered as the change of reactor temperature.

Table I
Concentration of the total tar and some compounds in syngas (mg m-3) at the gasification temperature 800–900°C. Average values and standard deviations are given for three replicate runs

Compound	Reaction temperature		
	800°C	850°C	900°C
Total tar	370.3±15.3	369.2±12.7	382.9±17.2
Benzene	283.7±10.1	279.8±14.6	289.1±16.3
Toluene	21.93±1.22	21.81±1.47	22.93±0.97
Naphthalene	30.41±2.03	30.19±1.29	31.01±2.11
Acenaphthylene	5.28±0.47	5.42±0.38	5.25±0.29
Acenaphthene	3.84±0.19	4.02±0.33	4.29±0.41
Phenanthrene	3.71±0.30	3.95±0.35	4.33±0.29
Pyrene	4.21±0.22	4.48±0.40	4.99±0.21

Table II
Concentration of the total tar and some compounds in syngas (mg m-3) at the gasification temperature 950–1050°C. Average values and standard deviations are given for three replicate runs

Compound	Reaction temperature		
	950°C	1000°C	1050°C
Total tar	388.3±17.9	352.6±11.6	338.7±10.9
Benzene	291.6±19.1	262.2±15.0	252.2±12.3
Toluene	22.81±1.61	20.19±1.08	19.66±0.79
Naphthalene	31.59±1.87	29.03±1.62	27.66±1.90
Acenaphthylene	5.73±0.50	5.33±0.44	5.05±0.28
Acenaphthene	4.69±0.38	4.48±0.35	4.13±0.26
Phenanthrene	4.63±0.31	4.39±0.51	4.01±0.29
Pyrene	5.01±0.45	4.80±0.26	4.51±0.41

With an increase of temperature from 800°C to 950°C, the total tar amount slowly goes up whereas with a further temperature increase it goes down. Similarly, the temperature increase changes the ratio of volatile and heavy tar components, namely the part of volatile components decreases and that of heavy components grows. For example, the proportion of benzene slowly changes from 76% to 74% with temperature increase, the proportion of naphthalene, about 8.2%, has practically not changed whereas the proportion of pyrene increased from 1.14% to 1.33%. This proves that amount and composition of tar depends not only on the biomass composition but also on the conditions of its gasification.

B. A study of filter effectiveness

Given the results obtained from the study of the dependence of tar concentration on the reactor temperature, the following gasification parameters were selected for the investigation of filter effectiveness: reaction temperature reaches ~900°C, the mass of dry peat is ~250 kg hour^{-1}, the mass of air ~120 kg hour^{-1}. Sampling was performed simultaneously before the filter with the temperature of syngas 250°C, and after the filter, with the temperature of syngas 150°C. Only those compounds that were discovered in syngas after it passed the filter were selected for further comparison; besides, concentration of the total tar in syngas before and after the filter was analysed.

Table III shows concentrations of the total tar and selected compounds before the syngas passed through the filter, and amount of each compound in the total tar in per cent.

Table III
Concentration of total tar and some compounds in syngas before filter. Average values and standard deviations are given for three replicate runs

Compound	Concentration before filter	
	mg m^{-3}	%
Total tar	395.3±14.5	100.0
Benzene	298.5±12.3	75.5
Toluene	24.33±0.88	6.2
Indene	2.12±0.25	0.5
Naphthalene	32.46±2.45	8.2
Acenaphthylene	5.82±0.42	1.5
Acenaphthene	4.71±0.36	1.2
Fluorene	1.87±0.21	0.5
Phenanthrene	4.93±0.33	1.2
Anthracene	2.75±0.19	0.7
Fluoranthene	1.35±0.17	0.3
Pyrene	4.75±0.41	1.2

Table IV shows concentrations of the total tar and selected compounds after the syngas passed through the filter, and removal effectiveness in percent for each compound. Before the filter, 25 compounds were identified, with benzene and toluene discovered on both amino-phase sorbent and on coconut charcoal whereas all other compounds were found only on the amino-phase sorbent. In the syngas sampled after the filter, only 11 compounds were found, all of them on the amino-phase sorbent. This can be accounted for by a relatively low syngas temperature (150°C) and small concentration of tar in it.

Table IV
Concentration of total tar and some compounds in syngas after filter and effectiveness of removing these compounds from syngas with the help of a filter. Average values and standard deviations are given for three replicate runs

Compound	Concentration after filter		Adsorption efficiency
	mg m^{-3}	%	%
Total tar	41.29±3.20	100.0	89.6
Benzene	13.88±1.62	33.6	95.4
Toluene	22.39±1.93	54.2	8.0
Indene	0.23±0.03	0.6	89.2
Naphthalene	2.52±0.29	6.1	92.2
Acenaphthylene	0.57±0.06	1.4	90.2
Acenaphthene	0.53±0.04	1.3	88.7
Fluorene	0.14±0.02	0.3	92.5
Phenanthrene	0.39±0.05	0.9	92.1
Anthracene	0.24±0.02	0.6	91.3
Fluoranthene	0.11±0.02	0.3	91.9
Pyrene	0.29±0.04	0.7	93.9

Effectiveness of tar removal from syngas with the help of the filter for adsorbing char was within 90%. Effectiveness of adsorbing individual compounds on char is likewise, with no dependency of adsorption on how volatile a compound is. Effectiveness of benzene adsorption appears slightly higher, 95%, while adsorption effectiveness of toluene was abnormally low, only 8%.

Table V contains the mass in μg of the total tar and compounds under study per 100 mg of char shaken out from the filter after the syngas passed through it. It was found that the char adsorbed 36 compounds, i.e. more than the sorbents while

sampling syngas. This can be explained by the fact that while passing through the filter, syngas is in contact with it for a longer period of time than it is with the sorbents during sampling. That is why it appears possible to discover on char those compounds whose concentration in syngas is very low.

Table V
Amount of total tar and some compounds per 100 mg of char shaken out from the filter. Average values and standard deviations are given for three replicate runs

Compound	Per 100 mg char	
	µg	%
Total tar	1416±117	100.0
Benzene	1264±106	89.3
Toluene	6.14±0.47	0.4
Indene	4.64±0.39	0.3
Naphthalene	62.83±3.20	4.4
Acenaphthylene	8.03±0.58	0.6
Acenaphthene	6.83±0.37	0.5
Fluorene	3.51±0.27	0.2
Phenanthrene	6.44±0.39	0.5
Anthracene	5.86±0.41	0.4
Fluoranthene	4.42±0.40	0.3
Pyrene	7.28±0.42	0.5

Table V also contains percentage of each studied compound in tar. As was expected, the amount of toluene in the total tar discovered on char is very small. It explains why concentration of toluene in syngas sampled before and after the filter is practically the same. Inability of the filter to adsorb toluene is not a big disadvantage as toluene has practically no influence on the tar dewpoint. A higher proportion of benzene in the total tar adsorbed on char in comparison to its proportion in the syngas tar had also been expected because effectiveness of removing benzene from syngas with the help of char is the highest among other compounds.

IV. CONCLUSION

The research showed that the filter for removing char from syngas proved quite cheap and effective in removing tar from syngas. Concentration of the total tar in the samples taken after the filter for removing char from syngas decreased by nearly 90% comparing to the total tar concentration in the samples taken before it. While 25 compounds were identified in the syngas sampled before the filter, only 11 compounds were identified after the filter. Toluene radically differs from other tar compounds in the ability to be adsorbed by char. Up to 95% of toluene passes through the char without being adsorbed; hence the concentration of toluene in the syngas samples taken before and after the filter is practically the same. The fact that the char does not adsorb toluene is not a disadvantage since toluene is not a problematic compound in the real biomass gasification gas. Its combustion is clean and results in no clogging, so a complete removal of toluene is not required.

An improved solid-phase adsorption system consisting of amino-phase sorbent and activated coconut charcoal is a very convenient and effective device for sampling tar in syngas. If its concentration in syngas is high, light tar compounds such as benzene, toluene, and xylenes are adsorbed on both sorbents, the other ones only on the first sorbent. With a low concentration of tar in syngas, all compounds might be adsorbed only on the first sorbent.

REFERENCES

[1] S.T. Chaudhari, A.K. Dalai, N.N. Bakhshi, *Energy Fuels*. 2003, 17, p. 1062.
[2] T.A. Milne, R.J. Evans, Biomass Gasifier "Tars": Their Nature, Formation, and Conversion, National Renewable Energy Laboratory, 1998, NREL/TP-570-25357.
[3] D. Stevens, Hot Gas Conditioning: Recent Progress with Larger Scale Biomass Gasification Systems, National Renewable Energy Laboratory, 2001, NREL/SR-510-29952.
[4] P. McKendry, *Bioresource Technology*. 2002, 83, p. 55.
[5] Y. Cao, Y. Wang, J. T. Riley, W.-P. Pan, *Fuel Processing Technology*. 2006, 87, p. 343.
[6] C. Brage, Q. Yu, G. Chen, K. Sjöström, *Fuel*. 1997, 76(2), p. 137.
[7] CEN/TS 15439:2006. Biomass gasification - Tar and particles in product gases - Sampling and analysis. European Committee for Standardization, Brussels, 2006.
[8] S. Osipovs, *Anal. Bioanal. Chem*. 2008, 391, 4, pp. 1409-1417.
[9] S. Osipovs, A. Vīksna, *Latvian Journal of Chemistry*. 2008, 2, pp. 147-156.
[10] S. Osipovs, Proceedings of the 16th European Biomass Conference & Exhibition, 2008, p. 776.
[11] S. Osipovs, *Intern. J. Environ. Anal. Chem*. 2009, 89, 8-12, pp. 871-880.

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Problems of Legal and Evaluation of the Objects of Subsoil Usage

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Abstract. Evaluation of the objects in the mineral resources sector depend on type of the legislative framework for the different stages of exploration process.

The article covers to problems of legal and evaluation to objects of subsoil usage according to different stages of geological exploration in International Financial Reporting Standard 6 «Exploration for and Evaluation of Mineral Resources», Russian Financial Standard 24/2011 « Cost accounting of the mineral resources deployment», US GAAP and other normative documents.

The results present the possibility of capitalizing mineral reserves as assets in mining oil and gas companies.

Keywords: subsoil usage, reserves, evaluation, international standards, russian financial standard.

I. INTRODUCTION

System of subsoil usage plays a fundamental role in the economy of countries, as it covers economic relations in its primary sector.

Capitalization of assets related to the exploration and evaluation of mineral resources is one of the most important factors of sustainable development in mining oil and gas companies.

To build properly a conceptual framework that is consistent with the of professional practice of assets concepts, to justify the possibility of presenting the financial statements information on changes in the cost of exploration and evaluation of mineral resources assets is a hot topic for modern economic science in the extractive industries.

Nowadays as part of the resumed scientific discussion on methods of capitalization of mineral prospects the presence of a large number of undeveloped problems of the theory and methodology of mineral prospects evaluation is indicated[1,2,3].

Thus the cost of the most significant asset of mining, oil and gas companies - mineral reserves - is not reflected in their financial statements that distorts the capitalization of assets and as a result the company's investment attractiveness .

II. MATERIALS AND METHODS

The concept of "natural resources", and similar terms are used to it in various aspects of the current legislation.

Evaluation to objects of natural resources usage is largely determined by the characteristics of the legal framework for the conduct of work at various stages of exploration, evaluation and mining operations of minerals.

Oil and gas companies (OGC) of US often acquire the rights for the exploration and extraction of minerals, concluding leasing agreements for mineral raw materials, and the surface of the earth. Leasing contract provides that the lessee (OGC) uses property, has the right to derive a profit, extracting minerals, and ownership right remains with the lessor (usually the state). Since the assets are transferred with the right of ownership to the company, the risks associated with the ownership of the property are also transferred [4].

The concept of "subsoil" is covered in the RF Law "About subsoil" (hereinafter - the Law on Subsoil). In accordance with this law, it follows that "the subsoil are a part of the Earth's crust below the soil, and in his absence - below the earth's surface and the bottom of ponds and streams, stretching to depths that are available for exploration and development." [5]

In accordance with the Law of Subsoil subsoil resources in the borders of the Russian Federation, including the subsurface and minerals contained in subsoil resources, energetic and other resources are state property (Article 1.2). [5]

In the Russian Federation only alienation and change the right to use subsoil resources from one person to another is allowed. Provision of subsoil resources in a use is made by special government permission in the form of a license.

Mined from the subsoil minerals and other resources under the terms of the license may be in the federal state ownership, ownership of constituent entities of the Russian Federation, municipal, private and other forms of property.

In other words, in Russia mining companies are not always able to control the receipt of income from the use of the property (subsoil). Based on the written

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above, we can conclude that according to the legislation of Russia mining companies don`t have the right of ownership for the reserves, but only the right to exercise a particular activity. Thus, the problem of reserves reflection in the financial statements does not only affect directly the scope of financial accounting, but also a number of legal aspects, indicating that it has comprehensive nature.

III. RESULTS AND DISCUSSION

In his work, C. Wright and R. Gallun pointed out that the true cost of the oil and gas company - the cost belong to it reserves that can fairly be attributed to each mining enterprises. [6].

In developing Western methodology for evaluation of natural resources-mineral reserves treated as assets, which it is necessary to take into account when determining the market value of specific fields and the determination of the national wealth in the composition of natural capital. Because of the difficulty of direct correlation of assets in the form of building machines and equipment assets in the form of the mineral reserves this term has not yet been reflected in the international accounting standards on accounting and evaluation. However, this approach to mineral resources developed in the scientific literature.

The concept of "reserves" is disclosed in the Subsoil Law. [5] In accordance with this law that the "mineral reserves - is the amount of mineral in the subsoil of a current or perspective conditions, supported by the results of geological work."

As it historically formed, the biggest companies leading their business in oil industry were based on two basic standings groups.

The first one, representing the most comprehensive instruction, is Generally Accepted Accounting Principles (US GAAP), developed by the American Council accounting to the financial standards of accounting and supplemented by the №1 (SEC)[4].

Until recently, the accounting standards for investors in Russia have been US GAAP, as they regulated the accounting of real situations in oil industry in detail.

However, due to the new federal law «About the Consolidation of Financial Accounting» №208-FL by 27.07.2010, the organizations whose securities were admitted to organized trading by including in the quotation list, had to prepare consolidated financial statement in accordance with IFRS. As a result, many oil companies were forced to refuse US GAAP. Table 1 provides information about the investor accounting standards used by the leading Russian oil companies.

Table 1
The use of foreign accounting standards of the Russian oil and gas companies

Companies	Accounting standards
Gas companies	
JSC «Gasprom»	IAS (since 1996)
JSC «NovaTAC»	IAS (since 2005)
Oil companies	
JSC «Lookoil»	GAAP US (since 1998)
JSC «TNK-BP Holding»	GAAP US (until 2011), IAS (since 2012)
JSC «Surgut neftegas»	GAAP US (1999-2001)
JSC «Gaspromneft»	GAAP US (until 2011), IAS (since 2012)
JSC «Tatneft»	GAAP US (since 1996)
JSC «Rosneft»	GAAP US (until 2011), IAS (since 2012)
JSC «NGK Slavneft»	GAAP US (until 2011), IAS (since 2012)

Source: official financial statements of companies

Oil and gas industry is a specific one as special financial accounting regulations were established directly for it:

- SFAS 19 «Financial Accounting and Reporting by Oil and Gas Producing Companies»,
- SFAS 25 «Suspension of Certain Accounting Requirements for Oil and Gas Producing Companies – an amendment of SFAS 19»,
- SFAS 69 «Disclosures about Oil and Gas»,
- SFAS 143 «Accounting for Asset Retirement Obligations»,
- SFAS 144 «Accounting for the Impairment or Disposal of Long-Live Assets».

Statements S-X Rule 4-10, SEC.

These statements allow conveying the oil and gas industry accounting statement specifics:

a) There are particular types of assets which have their own features of genesis, amortization and depreciation.
b) An oilfield classification of expenses is used in this industry.
c) Two accounting methods of capital-productive investments are allowed.
d) Additional information about oil and gas extraction activity is covered in the accounting, including non-financial information of proved reserves.

In accounting practice existing in USA there are two possible approaches used to count the costs: the method of successfully completed surveys and method of full costs. The principle difference

between the methods lies in the allocation of costs that did not lead directly to growth stocks. These costs occur as a rule, during the period of «exploration and evaluation». In accordance with the method of full costs such costs are capitalized, and in accordance with the method of successfully completed surveys these costs refer to the current costs of this period. It is important to point out that the costs incurred before obtaining the case rights and license according to the method of full costs are capitalized, but according to the successfully completed exploration method proposes similar expenses incurred at the time of their occurrence. The biggest Russian oil companies use this method of successfully completed surveys.

US GAAP involve the requirements of the content of the additional oil and gas activity information which is included in annual company statements. Companies are obliged to submit the following information:

I. Capitalized costs in the sphere of oil and gas extraction.
II. Costs for the acquisition of the reserves their exploration and development
III. Results of oil and gas extraction.
IV. Information of the value of reserves/
V. Standardized evaluation of discounted net cash flows.
VI. Fundamental reasons for alterations in the standardized evaluation of discounted net cash flows.

The date on the reserves are the most significant section for external users – investors and creditors. It is they that determine company`s attractiveness, its market prospects, and, eventually, the market price[9].

The second standards are the International Financial Reporting Standards of Accounting (IFRS) 6 «Exploration and Evaluation of Mineral Recourses» [7] and developed on their bases the Russian standard (PBU 24/2011) «Accounting for the Development of National Recourses"[8].

If we talk about the stages of exploration work, the only formation if a cost of search operations after obtaining the license, exploration and evaluation of mineral resources is reflected in legislation. These standards do not apply to cost that arose before the exploration phase, that is, until of acquisition licenses for exploration activities, and the cost incurred after the determination of the technical capabilities and commercial viability of mining operations of minerals. They apply only to the mineral assets that occurred during exploration, as well as during evaluation of mineral reserves. It was as a result of evaluation of mineral reserves. It was as a result of evaluation of mineral deposits forms information about the quantity and quality resources in the subsoil.

Never the less, there are a number objective reasons according to which the reflection of the reserves the financial statement may lead to certain problems [4].

Firstly, currently, there is no methodology to determine the procedure for calculating the cost of mineral reserves.

Secondly, prices for these mineral reserves fluctuant and that can cause frequent revaluation of the reserves put on the balance sheet.

This situation may cause additional problems, first of all, for the financial services.

Besides there problems, which any company of this industrial activity cab face there are a number of moments worsening the situation for Russian companies particularly[10].

Based on the fact that the subsoil can only be in the state ownership. Consider how to handle the objects of subsoil usage in budget accounting.[11]

The chart of accounts provides for budget accounting balance account "non-financial assets", which includes the expense 010301000 "non-plagued assets - real estate enterprises". [11] This account is used to account for assets used in the activity of the institution, not the product of production, ownership of which must be set and legislated.

Based on the chart of budget accounting shows that to the non-produced concern assets include, in particular, subsoil. Thus, in this case the objects of accounting are not subsoil as such curves, but their useful content.

These objects are reflected in account 010312000 "Subsoil assets - non-movable assets of participants." Instructions of paragraph 36 that on this account included proved reserves of mineral resources (oil, natural gas, coal, ore reserves and non-metallic resources located underground or on the surface, including the seabed);

Thus, in the financial statement the proved reserves of mineral resources can be used in the long-turned assets.

In this context, the substantial classification systems operating in Russian Federation, USA, Great Britain and in the World oil and gas industry have been considered.

Based on the classification of the UNO of the fuel and mineral reserves and resources 2009, at three-dimensional classification of mineral resources was developed (mineral reserves), it is based on three criteria: availability of development (D1, D2); geological knowledge (F, B, C1, C2); economic expediency (R1, R2, R3). This classification allows to identify previously chosen and proved subsoil reserves as the reserves from which the economic profit is expected.

The issue of including in financial accounting the proved subsoil reserves it being considered, in this case while reflecting them as the objects of financial accounting, it is necessary to reflect them in the

balance assets of an organization in the section called «Non-current Assets».

Therefore, the assets of the balance-sheet can be presented in a following way:

	Indicator's name
	ASSETS **I Non current assets**
1	Intangible assets
2	Proved reserves of mineral resources
3	Tangible assets
4	Long-term financial investments
5	Deferred tax assets
6	Other non current assets
Total for I	
	II Current assets
Total for II	
BALANCE	

IV. CONCLUSION

Mineral resources data are the most important section for external users - investors and creditors. They determine the attractiveness of the company, its market prospects and, ultimately, its market value.

Despite the global and widespread process of convergence and harmonization of standards, specific oil industry is still focused on the detailed, prescribing every step of the US GAAP standards. Russia, followed by the European Community, obliged large companies, whose shares are quoted on the stock exchange, to prepare its financial statements in accordance with IFRS.

US GAAP standards are closer to understanding the need to consider mineral reserves in the financial statements because they contain requirements for the content of additional information on oil and gas exploration activities, among them mineral reserves, which are included in the annual reports of the company.

Given the above, it should be noted that the need of legislative resolve all inconsistencies in legal and financial reporting of mining industries, so that the evaluation of their market value to account as the asset value of the reserves of mineral resources as proved subsoil reserves in the section called «Non-current Assets».

REFERENCES

[1] Ришар Ж. Бухгалтерский учет: теория и практика. М.: Финансы и статистика, 2000.-160 с.

[2] Маковей С.Л. Применение иностранных стандартов отчетности для отражения деятельности по добыче нефти и газа российскими нефтяными компаниями/ «Аудит и финансовый анализ», 2007, №4.

[3] Чая В.Т. Особенности учета в нефтегазовых компаниях / «Аудит и финансовый анализ», 2010, №1.

[4] Учет расходов на освоение природных ресурсов в соответствии с требованиями US GAAP и IAS:сайт аудиторско-консультационной группы «Развитие бизнес-систем»[Электронный ресурс].2012.URL: http://www.rbsys.ru/print.php?page=80&option=public (дата обращения:31.03.2016).

[5] Закон РФ «О недрах» Пост. Правительства РФ № 2395-1 от 21.02.1992 (с изменениями и дополнениями)..

[6] Райт Ш, Галлан Р. Финансовый и бухгалтерский учет в международ-ных нефтегазовых компаниях. М.: Олимп Бизнес, 2007.

[7] МСФО // М., Бухгалтерский учет, 2012.

[8] Положение по бухгалтерскому учету «Учет затрат на освоение при-родных ресурсов» (ПБУ 24/2011). Приказ МФ РФ № 125н от 06.10.2011.

[9] Тарабаринова Т. А. Оценка и учет объектов недропользования. Записки Горного института*. – 2013. – том 205. – С. 263–265.

[10] Пашкевич Н.В., Тарабаринова Т.А Учет и оценка объектов недропользования Научно-практический и теоретический журнал «Инновационное развитие экономики» №3 (15), Йошкар-Ола, 2013 ISSN 2223-7984 с 85-88.

[11] План счетов бухгалтерского учета бюджетного учреждения. Приказ МФ РФ № 174н от 16.12.2010.

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Refining Vent Emissions from Fine Droplet Aerosols

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Abstract. Vent emissions from industrial enterprises cause air pollution to a great extent. These emissions contain solid or liquid particles. it is necessary to install cleaning units for those particles. Existing methods of cleaning as applied to fine droplet aerosols have a number of limitations, especially within liquid disperse phase. This is why it is relevant to design highly-efficient cleaning units for vent emissions refining from droplet aerosols of sub-micron sizes. The research reveals the most important parameters for designing highly-efficient cleaning units for vent emissions refining from droplet aerosols. The authors designed a pilot plant and performed a series of experiments to define the optimal geometrical characteristics and modes of operation for cleaning units. These theoretical and experimental studies mase it possible to design three types of cleaning units with precipitating elements in the form of pipes and slotted channels with L/D = 250 dimensions.

Keywords: purification devices, ventilation emissions, high-dispersity aerosols.

I. INTRODUCTION

In modern times in industrialized countries the industrial production performance should include environmental protection through technical and organizational complex of measures that directly or indirectly targeted at stopping or reduction of air pollution. The ventilation emissions of factories containing solid or liquid suspended particles or aerosols contribute significantly to air pollution and to purify the air from these emissions it is necessary to provide the installation of purification devices being a part of the ventilation system [1].

Taking into account the fact that for the modern industry, on the one hand, the increase in the use of high dispersion ability materials is typical and on the other hand, increasing adoption of technology in industrial process that involves submicron particles emissions and finally the requirements for cleanness of working places are constantly growing [2]. The creation and development of air purification devices from high-dispersity aerosol particles with the size less than 1 mkm, that are the most dangerous for human health, plays an important role.

Small size and the mass of such particles exclude or significantly limit the use of traditional purification methods. The analysis of existing methods and purification devices has shown that they have a number of significant disadvantages that limit their use as high-dispersity aerosol purifiers, especially with the availability of liquid dispersed phase [3].

As can be seen from the above, it is really important to design high efficiency ventilation emissions purification devices from submicrometer dropping aerosols with low air drag, user – friendly and assisting the return of caught raw materials back in the production.

II. THEORETICAL BACKGROUNDS OF THE CREATION OF AIR PURIFICATION DEVICES

The design basis for purification devices is the movement peculiarities of turbulent stream in the thin pipes and parallel-plate ducts. The analysis of literature sources revealed that aerosol particles settling in the pipes and parallel-plate ducts are determined by turbulent diffusion effect and turbulent migration of particles [3] - [5]. The settling unit made in the form of a pipe or parallel-plate duct is the main element of the device.

Purification efficiency η of the device with the settling unit made in the form of a pipe or parallel-plate duct can be observed as dependence of:

$$\eta = 1 - \frac{C_x}{C_n} = 1 - e^{-\frac{LVt}{Du_m}}. \quad (1)$$

where: Cx is the final particle concentration as they leave the settling unit, g/m3, Cn – is the initial concentration of particles on entering the pipe (channel), g/m3, Vt is the particle settling velocity, m/s, L is the settling unit length, m, D - pipe diameter (De – equivalent channel diameter), m, mean flow velocity um, m/s.

As it is known, the main characteristic affecting efficiency of air purification from the fine particles is the particles settling velocity on the walls of parallel-plate ducts or small-diameter pipes [3] - [6].

It is possible to define the particles settling velocity (solid or liquid) V_t (m/s) by the semirational

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characteristic curves or experimentally. In the general case, settling velocity relation appears as follows:

$$V_t = f(Re_D, \lambda, \rho_p, d_p, \mu) \quad (2)$$

where: Re_D - Reynolds number; λ - friction resistance coefficient; ρ_p, - particles density, g/m^3, d_p - particle size, m; μ – absolute viscosity coefficient of dispersion medium, Pa•s.

From the dependance (2) it is seen that the turbulent velocity value of particle settling V_t vary with physical characteristics of airborne particles and fluid dynamics parameter of dispersion medium.

Thus, it is possible to apply results of the unit experiment with some aerosol to calculate the V_t value of another aerosol with the same physical characteristics and in the same dispersion medium.

Analysis of (1) and (2) formulas allowed to conclude, that aerosol particle settling in pipes and parallel-plate ducts is influenced by the settling unit dimensions and motion mode of turbulent aerosol flow.

Running efficiency of the air purification device, besides air purification rate, is characterized by the device aerodynamic drag, Δp, Pa, when specifying which the following dependence is used:

$$\Delta p = (\lambda \frac{L}{D} + \xi) \frac{\rho}{2} u_m^2 \quad (3)$$

where L – is the settling unit length, m, D – pipe diameter (in the case of channel D_e - is the equivalent diameter), m, u_m - average aerosol speed, m/s, ρ - dispersive medium density, kg/m^3, λ - friction resistance coefficient; ξ - restriction losses.

A number of experiments were carried out to determine constructively technical engineering factors of the devices for high-dispersity dropping aerosol separation in pipes and parallel-plate ducts providing high efficiency purification.

III. EXPEREMENTS

Pilot unit scheme is shown on Fig. 1. For the experiments dioctyl phthalate aerosol was used, its particle distribution function is changed according to normal law and the size of 99% particles is less than 1 mcm [2], [7]. Dioctyl phthalate aerosol was formed from fluidizing agent vapour, produced by controlled heating, which was mixed with air in the upper part of the cabinet unit. The concentration of high-dispersity dioctyl phthalate aerosol was supported at the level of 100-200 mg/m^3. Pipes and slick bores D=8÷25 mm, «were blown» in the form of bank consists of 8-10 pipes assembled in a package.

All experiments were conducted for a range of 2300<Re_D<34000, in which all investigational settling elements refer to hydraulically smooth pipes.

A great number of experiments was devoted to finding optimal value of particle precipitation efficiency based on the relation of pipe length or channel L to their equivalent diameter D.

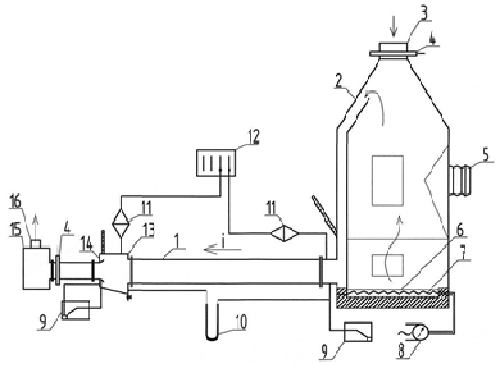

Fig. 1. Pilot unit: 1- settling element; 2- airing cupboard; 3- pipe union under ASO – 3 measurement; 4 - chimney valve flow control regulator with screw; 5 – pressurized hung sleeve; 6 – atmometer; 7 - heater; 8 - current controller; 9 – mictomanometer; 10 - U-type magnahelic gauge; 11 – allonge; 12 – portable rotary device; 13 – storage of equal static pressure; 14 – collector; 15 – blower unit; 16 –air extraction pipe to the atmosphere.

In our experiment several kinds of pipes of different diameter, length and materials were investigated. Research results on efficiency determination of dioctyl phthalate aerosol particles settling in pipes at various L/D dependence are shown in figure 2.

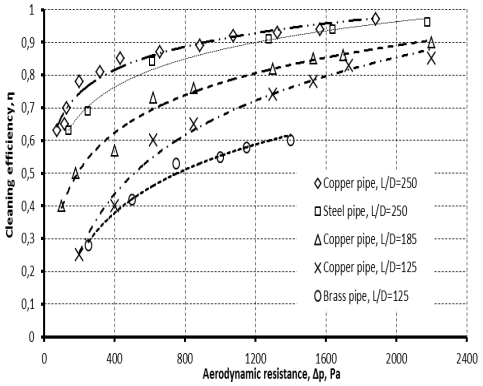

Fig. 2. The dependence of perufication level on aerodynamic drag for different

Separation efficiency η is shown in a from of full aerodynamic drag – dependence, Δp, which is the main characteristic in economic efficiency estimating (from the energetic point of view) when selecting separation method in one case or another. As can be seen in the figure, all experimental data are well approximated by logarithmic relationships.

It was founded that [8] the best separation effect is achieved by L/D = 250 proportion. By $L/D \leq 250$ proportion, the separation effect is significantly reduced due to aerosol particles stay time in them is less than in longer pipes. Thus, further experiments were carried out for settling elements with L/D = 250 geometrics. Special attention was paid to the aerosol particle settling in the channel with dimensions of

0,5×4,0 cm, because these data were accepted as a basis for the designing of the industrial-grade device.

Figure 3 shows summarizing results of the experiments on settling efficiency determination of dioctyl phthalate aerosol particles in pipes and channels with L/D = 250 proportion. It is noted that when settling element geometrics satisfy L/D = 250 proportion, the shape of settling element and material from which it is made has no effect on purification efficiency.

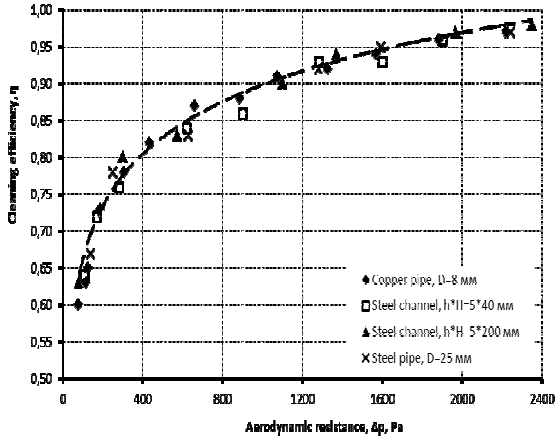

Fig. 3. The depandance of purification level on aerodynamic drag when L/D=250.

IV. RESULTS AND DISCUSSION

In order to evaluate device purification efficiency with the settling element and L/D=250 geometrics over a range of Reynolds numbers from 2300 to 3400 ($2300 \le Re_D \le 34000$) the dependence $\eta = f(\Delta p)$ is given:

$$\eta = 0,107 \times \ln(\Delta p) + 0,153 . \quad (4)$$

The dependence $\eta = f(\Delta p)$ can be transformed into $\eta = f(u_m)$.

$$\eta = 0,189 \times \ln(u_m) + 0,412 \quad (5)$$

Experimental data has a good repeatability with proposed dependences, which is characterized by determination coefficient R^2=0,9835 and 0,9815 respectively. As can be seen from Figure 3, when aerodynamic resistance value Δp varies from [1200 Pa; 1600 Pa] and appropriate speed u_m varies from [14m/s; 17m/s], the expected separation efficiency varies from [92%; 95%].

Obviously, when designing purification device it is necessary to follow this prerequisites and to use this characteristics as reference. In case of special need (high toxic level or importance of recovered products) it is possible to achieve higher value of purification efficiency by increasing the aerosol flow rate. However, it is necessary to weigh practicability η increasing taking into consideration growth of energy losses.

It is known that for the high-performance aerosol particles settling, the gas flow should be evolved turbulent, i.e. the Reynolds number in pipes is $Re_D \ge 4000$ and in flat channels it is $Re_{De} \ge 2000$. Consequently, using the flat channels, it is possible to reduce the length of settling element and overall size of purification device.

Also an important factor impacting aerosol separation efficiency is channel curves, which are estimated by ratio of the curvature radius R_b to equivalent diameter D_e. A number of aerosol settling in curve channels experiments (D_e = 8 mm) were carried out to reduce the working length L of the prototype device. The experiments showed that when $R_b > 8D_e$ the influence of curves on the interlayer formation is insignificant and when straight and curve channels having the same length, particle settling efficiency η is almost the same. However, the picture is changed as the R_b/D_e is reduced. Comparison of two equal channels with channels initial length ($L_1=L_2$, $D_{e1} = D_{e2}$), one of them is having curves at $R_b/D_e \le 1,5$, showed, that with the same pressure losses Δp, channel with curves has a high degree of particle settling. For example, when R_b/D_e= 0,75 purification efficiency coefficient is $\eta >$ 0,99, while in the straight channel in pari causa η value does not exceed 0,95.

As a result of the made experiments, a number of devices for air purification from high-dispersity dropped aerosol have been designed. In all constructed devices the length ratio of the settling elements (of thick pipe or parallel-plate duct) to their diameter is L/D_e=250. In Fig. 4 the configuration of aerosol tilted-plate separator is shown [9].

Vertically positioned thin metal plates arranged in plane-parallel package with rimose splits h= 4 mm between the plates are used as the settling elements. h size is adopted on the basis of turbulence scale, where submicrometer dimension particles are captured most effectively.

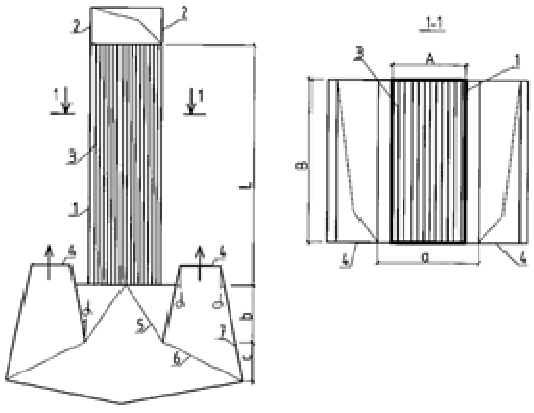

Fig. 4. Aerosol tilted-plate separator.

Working principle of aerosol tilted-plate separator is as follows. Purified gas enters separator-housing 1, through equal distribution air flue 2, travels into parallel-plate ducts between the settling plates 3. On

the plate walls there is coagulant which flows down through the drop coagulant net 5 into the hopper 7, and purified gas through the net 6 and stabilizing converging pipes 4 is removed from the separator.

V. CONCLUSION

Thus, the performed experiments allowed determining the he most significant geometric characteristics of air purification devices from dropping aerosols, identifying specific analytic dependences and defining devices optimal operation.

The results of theoretical and experimental research allowed to develop three types of air purification devices with adhesional-settling elements in the form of thick pipes or parallel-plate ducts with the dimensions L/D=250, ensuring the most optimal working mode when trapping high-dispersity dropping aerosol [9] -[11].

REFERENCES

[1] I.A. Hurin, N.P. Tyurin, Ochistka pechnyh gazov pri plavke alyuminievogo loma [Furnace gases purification during aluminium scrap melting process]. Regionalnaya arhitektura i stroitelstvo [Regional architecture and construction], 2, 2011, pp.149-154.

[2] V. Uajt, Tekhnologiya chistyh pomeshchenij [Cleanroom technology: design, test and exploitation basis]. Moskva, 2002.

[3] E.V. Sugak, N.A. Vojnov, N.A. Nikolaev, Ochistka gazovyh vybrosov v apparatah s intensivnymi gidrodinamicheskimi rezhimami [Gas emissions purification in the devices with intense hydrodynamic regimes], Kazan, 2009.

[4] L.I. Zajchik, V.M. Alipchenkov, Statisticheskie modeli dvizheniya chastits v turbulentnoj zhidkosti [The statistical model of particle motion in a turbulent fluid]. Moskva, 2007.

[5] D. Eskin, J. Ratulowski, K. Akbarzadeh Modeling of particle deposition in a vertical turbulent pipe flow at a reduced probability of particle sticking to the wall. Chemical Engineering Science, V.66, I.20, 2011, pp.4561-4572.

[6] S.M. Puring, D.N. Vatuzov, Eksperimentalnye issledovaniya po opredeleniyu konstruktivnyh osobennostej apparatov po ochistke vozduha ot submikronnyh chastits [Experimental studies into determing the design features of devices for cleaning air from sub-micron particles]. Nauchnoe obozrenie, 4, 2014, pp. 90-93.

[7] P.I. Basmanov, V.N. Kirichenko, Yu.N. Filatov, Yu.L. Yurov, Vysokoeffektivnaya ochistka gazov ot aerozolej filtrami Petryanova [High-performance gas purification from aerosol by Petryanov Filters]. Moskva, 2002.

[8] S.M. Puring, D.N. Vatuzov, N.P. Tyurin. Parameter choice optimization of ventilating air cleaning equipment while designing and constructing industrial buildings. Procedia Engineering, V.153, 2016, pp. 563-568.

[9] Patent RF 2246340. Plastinchatyj separator aerozolya [Patent of the Russian Federation 2246340 entitled tiled-plate aerosol separator]. Byul.№5, 2005.

[10] Patent RF 2259861. Separator tumanov s izognutymi plastinchatymi osaditelnymi elementami [Patient of the Russian Federation 2259861 entitled the mist separator with curved plate sttling elements], Byul.№25, 2005.

[11] Patent RF 2327508. Koaksialnyj separator kapelnogo aerozoly [Patent of the Russian Federation 2327508 entitled dropping aerosolcoaxial separator]. Byul.№ 18, 2008.

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Impact of Blue Growth on Baltic Sea Region Ports

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Abstract. There is little attention in the Baltics dedicated to the research of ports as economic subjects and their impact on environment. It is vital to strengthen the links between the ports and the Blue Growth while raising awareness of the Blue Growth and making it a cross-cutting issue of the sea-oriented priority areas by creating a special mechanism to support Blue Growth which so far has had insignificant links to port operations. The aim of the article is to analyze the trends and summarize the measures already taken for promotion and integration of the Blue Growth in the Baltic Sea region, and to develop guidelines for ports based on the general and the Baltic Sea Blue Growth strategy, to draw conclusions and to submit proposals for improvement and increase of the Blue Growth. Latvia needs to develop an action plan in order, without unnecessary errors, to quickly implement sustainable port infrastructure and reduce pollution of the sea. The task is to identify the best practices for usage of marine/coastal resources for economic development, and for identification and testing of new smart specialization measures.

Keywords: blue economy, ports environmental impact, marine ecology.

I. INTRODUCTION

The Baltic Sea is endangered and actions that are being taken to regenerate the environment of the Baltic Sea are not sufficient to improve the situation. At this moment, the economic resources of the Baltic Sea are not being used sustainably and the Baltic Sea region risks losing hundreds of thousands of potential work places and future profit that can be measured in billions, if thought-out and focused measures will not be taken to protect and sustain the sea's ecosystem, as well as to use the sea's resources sustainably.

The **aim** of article is to analyse the trends and summarise the measures already taken in the Blue growth and integration of the Baltic Sea region, and develop guidelines for ports based on the general and the Baltic Sea Blue Growth strategy, to draw conclusions and to submit its proposals to improve the Blue growth and increase.

The tasks that are established to reach the aim: based on the available specialised literary sources to analyse the overall concept of Blue Growth as well as the concept of the Baltic Sea region [4], by summarising and analysing the taken measures and implemented projects in the Baltic Sea region in the context of Blue Growth to disclose contributing and delaying factors for successful Blue Growth integration and to develop guidelines for realisation of Blue Growth tendencies and adaptation possibilities in ports of the Baltic Sea region.

II. MATERIALS AND METHODS

In the last years, terms like "Blue Economy" and "Blue Growth" are widely used, but there is no consensus as to what it means - some understand it as management without impoverishing the economic goods provided by the sea ecosystems in long term, others consider "Blue Economy" as any economic activities in industries connected with sea[2].

Blue Growth is a long-term strategy to strengthen sustainable growth in maritime affairs industry and in marine industry economy in general. It acknowledges that seas and oceans stimulate Europe's national economy, and they are inherent to a big innovative and growth potential. Integrated maritime affairs policy helps to reach the goals of smart, sustainable and inclusive growth strategy of "Europe 2020"[3].

Blue Growth strategy consists of three parts:

1. Specific policies of integrated maritime affairs - actions that include knowledge about sea, to improve access to information about sea, planning of maritime space to ensure effective and sustainable sea management and integrated sea supervision so that authorities would have more specific information about the processes at sea.
2. Sea-basin strategies - which is recognised as the most suitable body of actions to advance sustainable growth and which considers the local climatic, oceanographic, economic, social and cultural factors in different sea-basins.

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3. Specific actions approach - which includes: aquaculture (fisheries website), coastal tourism, sea biotechnology, ocean energy and extraction of natural resources at sea[3].

These above mentioned strategic points are worked into a special programme of advancing Blue Growth of the Baltic Sea region. Namely – the Baltic Sea, even though it is the youngest sea in the world, now it faces serious environmental problems (eutrophication, overfishing, pollution etc.) which, by collaboration between all the Baltic Sea region countries and following the proposed strategic aims, are slowly being solved.

III. RESULTS AND DISCUSSION

At this moment, the biggest challenge for the Baltic Sea region countries is creating a determined and ambitious strategy and policy of Blue Economy at the level of government, society and individuals.

The task of the Baltic Sea's Blue Economy is to help returning sea's health, by not exceeding the capacity of sea as an ecosystem, by quickening the transition to cleaner technologies and sustainable energy and by creating an environmentally friendlier flow of materials (by optimising usage and circulation of reusable materials). Also, the Blue Economy strategy must create new work places and economic opportunities, but, in the planning and implementation process, representatives of government, business and different science branches must be involved, as well as inhabitants of the region's countries, so that the common aims could be reached easier and faster.

The principles of sustainable Blue Economy must give clear indications on smarter managing. At the beginning a vision of sustainable Blue Economy must be created, as soon as the vision becomes clear, precise aims and points of conduct must be set by taking specific measures in different sectors of economy in all involved stages. Realistic Integrated Maritime Policies, adequate economic and legislative allowances, as well as provided support for the flow of finances and investments in public and private sectors, and successfully realised, ecosystem based spatial planning of sea are the main tools that will help to approach the set goals.

Blue Economy can only be sustainable when sustainable economy is also being successfully realised on land, ergo economy that renews, protects and sustains diverse and stable ecosystems, as well as an economy that is created based on clean technology, renewable energy and optimised flows of materials.

Because of the population growth, global competition for resources, food, water, threats to marine safety, climate change, sea pollution and technical possibilities, weight is increasingly being put on marine resources and the ability of seas to further provide goods on which functioning of society is depending on is decreasing. The existing international regulation of ocean management is not sufficiently effective to solve these joint problems and it fails to ensure sustainable management of oceans and their resources.

Since EU is and will be even more dependent on seas and oceans, for the last 10 years it has tried to strengthen inner processes of ocean management and purposefully collaborated by creating a better multilateral regulation worldwide. EU accomplishments till now:

- comprehensive access is established to all marine and maritime affairs questions, namely, integrated EU maritime affairs policy;
- strict environment regulations are introduced, which will achieve sustainable usage of sea resources and which are mandatory to all EU members involved in the field of maritime affairs, wherever they are engaged in;
- EU level strategy is developed on how to promote sustainable and inclusive growth of marine industries, it is integrated in EU outward dimension, for example, concerning natural resources, energetics, trade, development and safety;
- regional strategies are established to solve joint problems and possibilities, by closely collaborating with countries outside EU and non-governmental members;
- marine research has been reserved around 350 million euros a year for establishing mechanisms to improve collaboration and information exchange and to publish marine data;
- EU has joined international and intersectional forums to look after with joint forces that seas and oceans all over the world are safe, clean and productive.

The data of countries does not provide all necessary information about the sea, because it is a global system, where changing winds, seasonal currents reign and migrating species can be encountered, that is why it is very important to conduct analysis on Europe level.

EU decides authority in such industries as fisheries, environment, transport, research, business and industry, which allows to attach EU funding and to adopt legal acts that are necessary for extending the knowledge basis till year 2020.

In 2011 Commission adopted Communication about growth of maritime industries [1], which shows that European seacoasts, seas and oceans can be a significant source in the field of new work places and growth [2], and that in its turn can help to realise "Europe 2020" strategy and to improve the way we use the planet's resources. Communication pays special attention to specific new industries.

To develop the potential of marine industries in Europe, Commission has researched how with EU

level measures such problems characteristic to economy of marine industries can be solved [6]:

- imperfections in knowledge and data about the condition of oceans, sea-bed resources, marine organisms and risk habitats and ecosystems;
- heterogenous research efforts in the field of marine scientific and technological research, which delays acquisition of intersectional knowledge and slows down advancement in key sectors of technology and innovative business sectors;
- lack of such scientists, engineers and qualified employees who can use new technologies in the sea environment.

According to the programme "Horizon 2020", research will be aimed at how new technologies marine resources can be used productively and create sustainable growth and employment, at the same time ensuring that these resources can also be used by the next generations.

Growth in economy of marine industries will need corresponding innovations which can help to develop economy of marine industries, which not only promotes EU growth and creation of work places, but also maintains the public sector's support for commercial use of marine resources and at the same time ensures protection of marine environment to create understanding about seas and modern technologies with the intention to develop their economic potential in a sustainable way.

To achieve that a series of actions must be taken:

1. To create a sustainable process which ensures that marine data is easily accessible, compatible and without usage restrictions;
2. To create a digital multi-resolution map of the entire seabed for all Europe waters;
3. To create information platform about marine research in the whole programme;
4. To create a business and science forum of Maritime affairs economy;
5. To promote creation of union of skills connected with marine industries.

Maritime spatial planning

The activity of industries' interests is always growing: shipping and marine transport, marine energy plants, port development, fishery and aquaculture, and environment protection.

It is very likely that climate change, especially the rising of sea level, acidification and rise of water temperature and more frequent extreme weather conditions will create changes of economic activity in marine territories and changes in marine ecosystems. Maritime spatial planning can be a significant tool for lessening the impact of these changes, by promoting effective usage of marine territories and renewable energy and profitable adaption to the impact of climate change in marine territories and coastal waters [10].

The Baltic Sea region has all the necessary elements to move towards sustainable and innovative maritime economy and, in comparison with other EU regions, it has a lower level of unemployment, accelerated growth and a lower public debt in proportion to GDP, as is stated by European Commission in the 2014 Working Document about the growth programme for the Baltic Sea region [4].

Thus, to promote advancement for Blue Growth strategy, a work plan is developed specifically for the Baltic Sea region, which has taken into account all the specific characteristics of the region, following which four elements are stressed:

1) Consequent approach to innovations, collaboration and increased sustainability

Such activities as coastal tourism, aquaculture and fisheries depend on healthy environment and good condition of water. As it has been clarified within this work, the Baltic Sea is facing rather big problems (eutrophication, overfishing etc.), which - if not solved - maybe not in short-term, but in long-term will leave a negative impact on everything - people, economy, environment and the activities mentioned above. That is why the development of Blue biotechnologies and aquaculture is necessary, as well as a stronger link between research and economic market.

2) Raising of skills and qualifications, cluster development

To achieve the potential of Blue Growth and overall economic growth skilful and qualified people are necessary, especially in industries connected to research and innovation. Also, competent and young people are necessary in sectors with potential for growth, for example, sea transport and coastal tourism, where one of the recognised problems is insufficiency of corresponding knowledge and skills, as well as the ageing of work force. Founding of clusters is also important, so that the region's countries have a chance to create in between themselves a link between science and research.

3) Development based on what is achieved until now

A basis for Blue Growth must be provided with support and promoting activities: planning, supervision and monitoring, because they are the basis of well-functioning coastal and water ecosystem, the collaboration between public and private sectors. As the Blue Growth studies estimate, in the Baltic Sea region this growth will mainly be promoted by the private sectors, which is followed by connected data and analysis to support the infrastructure projects and to avoid uncertainty in planning and investments [6].

4) Access to funding in maritime industries

The access to funding can be seen as the main obstacle or hindrance for development of maritime economy in the Baltic Sea region and elsewhere. Suggested European Structural and Investment Funds

are developed for the 2014 - 2020 financing period, adjusting to the sea basin/Macro regional strategy and Blue Growth.

Main threats to development of Blue Growth in the Baltic Sea:

1) In the Baltic Sea region, Blue Growth does not work because of the heavy load on environment both from dry land and the human activities at sea. The biggest problems in the Baltic Sea have occurred as a result of people's thoughtless usage of marine resources: eutrophication, pollution and unsustainable fishing industry - of course, there are many others, but these are the three main ones.

2) Thus, for example, fish resources are only almost 30-40% of the historical minimum, not to mention the fact that in separate regions the usage of caught fish in food is questionable [8], as well as the tourism clients that are being lost as a result of eutrophication and pollution. Usage of fossil fuel - mainly in economic activities on land, which further global warming, which in its turn because of rising average annual temperature furthers eutrophication, and eutrophication leaves a negative impact on biological diversity. In conclusion, the negative impact at sea must be mentioned, which results from construction, excavation etc., as well as the entry of invasive species in the Baltic Sea from ship's ballast waters and the threats that fish hatcheries create by spreading illnesses and genetic materials between wild fish.

3) In the Baltic Sea region, both Blue Growth and economy on land is based on linear flow of materials and non-renewable energy. As a result of these linear, sometimes even toxic, flows of materials and usage of non-renewable energy, the Baltic Sea region is not only subjected to the problems mentioned above - eutrophication, pollution and insufficient fish stocks, but also the long-term productivity of these activities is being threatened from the perspective of lack of natural resources. Linear usage of materials means using the material once and leaving remainders - if there are some - as waste. Scientists foresee that if soon in the Baltic region circular for all sorts of raw materials - ergo recycling possibilities - will not be considered, then such natural nutrient as phosphorus could disappear during a period of two or three generations [9]. Concerning non-renewable energy, the Baltic Sea region is under a big economic risk by using fossil fuel as the main source of energy, not to mention the consequences this all leaves on productivity of ecosystem as the result of climate change.

4) Development of Blue Growth risks putting nature of the Baltic region under pressure even more, as well as heightening competition for who will have more marine space. Blue Growth has been fixed definite economic numbers, for example, creation of working places and promoting of tourism, and in the Baltic region these numbers are growing, but sadly very often not in a way which ensures sustainability and that is exactly why nature of the Baltic Sea region is put under an even bigger pressure.

Until now researchers were more worried about pollution created by airplanes, cars and railways, but comparatively less attention has been paid to emission sources at sea. It must be considered that air pollution at sea can travel great distances, thus it influences not only the marine environment, but also land. The main innovation in marine industry is collaboration and partnership. Member states of the Baltic Sea region are already gaining from the smart specialisation platform specially created by European Commission, which is created to promote better experience exchange, provide consultations for policy creators and to help them concentrate their resources on those spheres, where they have relative advantages, but still the biggest work in this industry should be done by scientists. Serious work must be put into reducing pollution and eutrophication in the whole Baltic Sea region, as well as reducing air pollution created by ships in the whole Baltic Sea region, as well as in ports and harbour towns, which is demanded by Annex IV of MARPOL [7] convention which came into effect on January 1, 2015. To be able to lessen content of sulphur emission in ship fuel and make the Baltic Sea an example of clean seafaring, it is important to avert the main seafaring problems. We lack not only environment-friendly infrastructure, but also research that could help finding solutions on how to improve the sea's condition [5]. EU White Paper anticipates to take polluting fuels out of circulation and replace them with more environment-friendly types of fuel. That is why there is importance in collaboration between different institutions and involving funding from other programmes, where the main aim is to conduct research on what is necessary for improvement of port infrastructure to decrease eutrophication and emissions from ships.

Cargo flow in ports is increasing, number of passengers is also growing, but many actions still are more based on the concept "more, faster and more effective", where the influence on environment is left in the background, that is why during the last years the concept of "green thinking" is becoming more popular also when analysing sea transport e.g. possibilities for ports to support environmental protection and sustainability. What tendencies decide, whether a port is "Blue thinking" is not publicly and legitimately determined, but ports are an important element of Blue Growth. The way how ports can ensure a bigger value is with the help of effective elements of logistics. The aim of a modern port is to avert delays, shorten the processing time and to increase efficiency. But it must be admitted that the activities of ports influence the surrounding environment and a way to lessen this negative

influence, is to connect the ship with coastal electricity, obtaining Blue Growth from a Green Port.

IV. CONCLUSIONS

Blue Growth is not only limited to maritime industry, it is an attempt to unite environment protection with economy and, following that, it can be called a style of management and life or philosophy, where the main key words are integration, wisdom (intelligence) and sustainability, which will help solving problems of poverty, welfare and good environment. Blue Growth is a new economic concept and the Baltic Sea region is still in the process of adaptation, because the programme or plan specifically for Blue Growth Integration in the Baltic Sea region (A Sustainable Blue Growth Agenda for the Baltic Sea Region) was only developed in 2014. Specifically, ports as a sector do not have developed guidelines for integrating Blue Growth and thus they have a chance for interpretation. But it must be admitted that there can be seen Blue Growth tendencies in ports, although they could as well be connected to concepts of Green and Circular economy, which more or less are supported by and included in Blue Growth. Ports and conductors of business in ports have a possibility to subordinate tendencies announced by Blue Growth, create projects and attach investments form EU funds. To solve the questions of sustainability and integration, as well as to promote innovations in technologies connected to seafaring and connection with Horizon 2020, member states of European Union could create a united universal general plan for the Baltics, as well as ports specifically, where there would be clearly established, measurable and internationally consequent aims and tasks, also in the process of integration they must be mutually coordinated to avoid conflicts about some negative consequences created by actions or inactivity of one sector. Also, very important is control of these tasks and aims, evaluation of progress and transparency, so that information would be available to all, which could be provided by European Commission. Ports and business sectors need to found new maritime clusters, because that is a chance to increase the business efficiency of the involved companies by collaboration between industry's companies, educational institutions and research institutions, also EU (Regional Development Fund) gladly provides financial support for that.

REFERENCES

[1] Blue Economy Challenge invites new solutions for our oceans, World Wildlife Fund, Available from Internet: http://www.worldwildlife.org/stories/blue-economy-challenge-invites-new-solutions-for-our-oceans

[2] Blue growth, European Commission, Available from Internet: http://ec.europa.eu/maritimeaffairs/policy/blue_growth_en

[3] Europe 2020, European Commission, Available from Internet: http://ec.europa.eu/europe2020/index_en.htm

[4] European Union Strategy for the Baltic Sea Region, European Commission, Available from Internet: http://ec.europa.eu/transparency/regdoc/rep/10102/2015/EN/10102-2015-177-EN-F1-1.PDF

[5] Gunter A. P.,The Blue Economy: 10 Years, 100 Innovations, 100 Million Jobs, 2010, pp. 45-49.

[6] Innovation in the Blue Economy: realising the potential of our seas and oceans for jobs and growth, European Commission, Available from Internet: http://eur-lex.europa.eu/legal-content/LV/TXT/?qid=1422528426503&uri=CELEX%3A52014DC0254R%2801%29

[7] International Convention for the Prevention of Pollution from Ships (MARPOL), International Maritime Organization, Available from Internet: http://www.imo.org/en/about/conventions/listofconventions/pages/international-convention-for-the-prevention-of-pollution-from-ships-(marpol).aspx

[8] Kathijotes N., Blue Economy - Environmental and Behavioural Aspects Towards Sustainable Coastal Development, Procedia - Social and Behavioral Sciences, Volume 101, 8 November 2013, pp.7-13

[9] Principles for a Sustainable Blue Economy, World Wildlife Fund, Available from Internet: http://d2ouvy59p0dg6k.cloudfront.net/downloads/15_1471_blue_economy_6_pages_final.pdf

[10] Roadmap for Maritime Spatial Planning: Achieving Common Principles in the EU, European Commission, Available from Internet: http://eur-lex.europa.eu/legal-content/LV/TXT/?qid=1396432777228&uri=CELEX:52008DC0791

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Ecological, Economical and Technological Aspects of Development. Decomposition Analysis of Energy Consumption Related to CO_2 Emissions in Ecuador

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Abstract. Decomposition Analysis (DA) is widely applied in understanding changes of economical, technological, environmental, and different indicators as energy consumption, employment and other socio-economic indicators. This work discusses the DA methodology and is applied within Ecuadorian case. We present the used technique, the applied mathematical methodology and the construction of an appropriate identity to measure the change of CO_2 emission in Ecuador during the period of 1980-2025. Change is measured in both macro and disaggregated sectorial level. Specific aspects related to the application of DA to both the historical period (1980-2010) and in medium term prevision (2011-2025) for four proposed macro scenarios are discussed. The findings show that the evolution of the BS scenario, which implies a trend-growth GDP scenario, is almost a flat curve, however the CO_2 emission increases steadily because of the absence of attenuation measurements. A similar behavior, although slightly sloping down, is observed for SC-2 scenario, where a rapid growth of the GDP is assumed without any attenuation action regarding to CO_2 emissions. The other two scenarios, SC-3 and SC-4 show a steady reduction of the Dtot = Dact ratio due to the changes in the sectorial structure and in the energy mix, which allows compensation of rapid GDP growth. This analysis suggests that, with the appropriate changes in the energy mix, the sectorial structure, and the share of renewable energies, Ecuador can move into a more environmentally sustainable state.

Keywords: Decomposition Analysis, Sustainable development, Ecuador.

I. INTRODUCTION

It is well known that humans have dramatically altered the global environment, but there is a limited understanding of the driving forces of these impacts. The absence of a refined set of analysis tools is cited as a fundamental limitation [1]. Analysis methodologies and tools have been developed in the field of analysis of decomposition, including sustainability framework known as the IPAT[1] [2], [3]. The decomposition of changes in an aggregate environmental impact and of its driving forces has become popular to unravel the relationship of society and economy with the environment.

The specific application in energy consumption and CO_2 emissions is the so called Kaya identity [4]. The Kaya identity is a linking expression of factors that determine the level of human impact on environment, in the form of CO_2 emissions. It states that total emission level can be expressed as the product of four inputs: population, GDP per capita, energy use per unit of GDP, carbon emissions per unit of energy consumed. The Kaya identity[2] plays a core role in the development of future emissions scenarios in the IPCC Special Report on Emissions Scenarios [5]. The scenarios set out a range of assumed conditions for future development of each of the four inputs. Population growth projections are available independently from demographic research; GDP per capita trends are available from economic statistics and econometrics; similarly to energy intensity and emission levels. The projected carbon emissions can drive carbon cycle and climate models to predict future CO_2 concentration and climate change.

Some similar conceptual bases can be found in the field of decomposition analysis (DA). In particular, with the advent of the global oil crisis in 1973 and 1974, special attention was given to the use of energy in industry among policymakers because energy in

[1] Human Impact (I) on the environment equals the product of P= Population, A= Affluence, T= Technology. This describes how our growing population, affluence, and technology contribute toward our environmental impact.

[2] Note that, a limitation of this equation is that it does not account for i) the direct release of carbon dioxide by deforestation through burning ii) the loss of the carbon sink due to that deforestation.

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industrial constituted most of the primary energy demand in most countries. Therefore, researchers focused on the mechanisms of change in industrial energy use. This new area of research emerged to quantify the impact of a structural change in industrial production on the total energy demand. These initial studies showed a significant impact of structural changes on the trends of energy demand. The need to identify and quantify its impact became an imperative for policy-making. This line of research was expanded considerably in the methodology and in its application; it is now a widely accepted tool for the formulation of national policies on energy and environment analysis [6]. It is particularly useful to provide the analysis of contributing factors, such as structural changes and changes in energy intensity. Steenhof et al. (2006) [7] manifested that decomposition of a predefined set of factors helps to understand the progression of the driving forces, the consequences of the processes occurring and the political dimensions associated with these processes. The same author also proposed that this would allow a rationalisation for possible progression into the future [7].

The scope of the IDA was expanded beyond the analysis of industrial energy demand, now being used in the analysis, at country level, of fields such as energy or environment[3].

The need for political views[4] of the IDA has mainly focused on historical analysis of the driving forces. While decomposition techniques such as IPAT can be used to predict future changes in the driving forces of a given system [8], DA is on the cusp of a new scenario analysis techniques and forecasting. For defining areas of future research in DA, Ang and Zhang (2000) [9] suggest its use in projecting energy demand and emissions in short and medium term. Sun (2001) [10] used a complete decomposition method to forecast GHG emissions in the EU-15 up to 2010. Sorrell et al. (2009) [11] recommended more research in the use of the decomposition framework for scenario development. Although both, IDA in energy and emissions, as well as scenario analysis in the context of energy emissions are often based on the framework of Kaya, the combination of these approaches has often not applied. In this line some studies have combined these approaches [7], [12]–[14].

This work discusses the DA methodology and is applied within Ecuadorian case. We present the used technique, the applied mathematical methodology and the construction of an appropriate identity to measure the change of CO_2 emission in Ecuador during the period 1980-2025.

II. MATERIALS AND METHODS

A. Logarithmic Mean Divisia Index

As it was already explained, Ang (2004) [6] compared various index decomposition analysis methods and concluded that the multiplicative and additive Logarithmic Mean Divisia Index (LMDI) method is the preferred method due to their its theoretical foundation, adaptability, ease of use and result interpretation, and some other desirable properties in the context of decomposition analysis.

The used approach is a variation of the Kaya identity, where the amount of CO_2 emissions from industry and from other energy uses may be studied quantifying the contributions of five different factors: i) global industrial activity, ii) industry activity mix, iii) sectorial energy intensity, iv) sectorial energy mix and v) CO_2 emission factors. Moreover, we consider different sub-categories concerning the industrial sectors and the fuel type. The CO_2 emissions can be written as,

$$C = \sum_{ij} C_{ij} = \sum_{ij} Q.S_i.EI_i.M_{ij}.U_{ij}\,, \qquad (1)$$

where *C* is the total CO_2 emissions (in a given year); *Cij* is the CO_2 emission arising from fuel type *j* in the productive sector *i*; Q is the total GDP of the country; *Si* (*Qi/Q*) is the share of sector *i* in the total GDP; the energy intensity of sector *i* is given by *EIi* (*Ei/Qi*); the energy matrix is given by *Mij* (*Eij/Ei*) and the CO_2 emission factor by *Uij* (*Cij/Eij*).

Throughout this work, as a convention, we will always refer to the productive sector with the *i* index and to the type of energy source with the *j* index.

This equation is an extension of the Kaya identity because we disaggregate in type of productive sector and kind of fuel used, while in the original formulation only aggregated terms are considered: *C*, *Q*, and *E*.

In this section we will present the methodology that has been applied based on the LMDI approach [15]. This analysis allows us to determine the relative importance of each term conforming the CO_2 emission (see Equation 3). Indeed, it is very enlightening to write down the increase of CO_2 emission relative to the value of a given period, and to decompose it as the sum or product of the terms corresponding to the different driving forces that conform the CO_2 emission. i) In the case of the additive decomposition:

$$\Delta Ctot = C^T - C^0\,, \qquad (2)$$

$$\Delta Ctot = \Delta Cact + \Delta Cstr + \Delta Cint + \Delta Cmix + \Delta Cemf\,, \qquad (3)$$

where *Ctot* is the CO_2 emission (relative to the base year), C^0 and C^T represent the emission in the base and final year respectively, *Cact* is the GDP term,

[3] Energy efficiency measures are required by several international and national policies as the EU directive 2006/32/EC and while these can be executed using tools like DA and LMDI (Logarithmic Mean Divisia Index) techniques [6].

[4] The development of policy, reporting and monitoring of progress depends on the right as the index decomposition analysis analytical tools.

Cstr is the structure term (the share of the different sectors to the GDP), *Cint* the energy intensity term, *Cmix* the energy mixing term, and *Cemf* the emission factor term. Note that because the emission factors, given by the IPCC, do not change over the time, *Cemf* = 0 all the time and therefore it will not be shown in the tables. ii) In the case of the multiplicative decomposition:

$$Dtot = D^T - D^0, \tag{4}$$

$$Dtot = Dact\ X\ Dstr\ X\ Dint\ X\ Dmix\ X\ Demf\ , \tag{5}$$

where *Dtot* is the CO_2 emission (relative to the base year), *Dact* is the GDP term, *Dstr* is the structure term (the share of the different sectors to the GDP), *Dint* the energy intensity term, *Dmix* the energy mixing term, and *Demf* the emission factor term. As said before *Demf = 1* all the time and therefore it will not be shown in the tables.

Applying as indicated before for the case of CO_2 emissions (see Equation 3 and 5) the following formulas are obtained for decomposing changes in each of the terms involved in Equation 1, for both additive and multiplicative forms:

LMDI formula additive decomposition is,

$$\Delta Cact = \sum_{ij} \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \left(\frac{Q^T}{Q^0}\right), \tag{6}$$

$$\Delta Cstr = \sum_{ij} \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \left(\frac{S_i^T}{S_i^0}\right), \tag{7}$$

$$\Delta Cint = \sum_{ij} \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \left(\frac{EI_i^T}{EI_i^0}\right), \tag{8}$$

$$\Delta Cmix = \sum_{ij} \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \left(\frac{M_{ij}^T}{M_{ij}^0}\right), \tag{9}$$

$$\Delta Cemf = \sum_{ij} \frac{c_{ij}^T - c_{ij}^0}{\ln c_{ij}^T - \ln c_{ij}^0} \left(\frac{U_{ij}^T}{U_{ij}^0}\right), \tag{10}$$

LMDI formula multiplicative decomposition is,

$$Dact = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln\left(\frac{Q^T}{Q^0}\right)\right), \tag{11}$$

$$Dstr = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln\left(\frac{S_i^T}{S_i^0}\right)\right), \tag{12}$$

$$Dint = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln\left(\frac{EI_i^T}{EI_i^0}\right)\right), \tag{13}$$

$$Dmix = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln\left(\frac{M_{ij}^T}{M_{ij}^0}\right)\right), \tag{14}$$

$$Demf = \exp\left(\sum_{ij} \frac{(c_{ij}^T - c_{ij}^0)/(\ln c_{ij}^T - \ln c_{ij}^0)}{(C^T - C^0)/(\ln C^T - \ln C^0)} \ln\left(\frac{U_{ij}^T}{U_{ij}^0}\right)\right), \tag{15}$$

B. Proposal of scenarios for Ecuador 2010-2025

Taking into account the general purpose of improve the quality of life of people with the least environmental impact and specific goals on each case, we propose four scenarios concerning the growth of the income, the evolution of the energy matrix and of the productive sectorial structure for the period 2011-2025.

1) Baseline scenario (*BS*): the GDP, the energy matrix and the productive sectorial structure will evolve through the smooth trend of the period 1980-2010 extrapolated to 2011-2025 using the geometric growth rate method.

2) Increasing GDP scenario (*SC-2*): GDP will increase approximately up to be double of reference GDP (2010) by 2025 in order to by 2025 the GDP per capita will reach the international average according to our estimates based on World Bank data) through a process of industrialization and improvement of the productive sectorial structure of the country. To generate this scenario a constant annual growth of GDP formation components of 7% per year between 2011 to 2025 will be assumed and a structural change in the productive sectorial structure will be implemented through a growth of 1% per year in the GDP share in the sectors with more profit in the country's economy (industry sector and trade and public service sector). The rest of the variables will evolve as in the *BS* scenario. This scenario clearly corresponds to a situation where the economy is growing rapidly and no mitigation measurements to reduce the CO_2 emissions are carried out.

3) Increasing GDP and share of renewable energies scenario (*SC-3*): increasing GDP and change in productive sectorial structure as in the *SC-2* scenario is considered, however the share of fossil energy, will be reduced approximately by one point per year, passing from a 88% in 2011 to a 67% in 2025 due to a constant annual growth of share in renewable and alternative energy, so then, the use of renewable energy will be increased up to almost 30% of the total energy consumption. This scenario shows a first measure of environmental responsibility in order to try to reduce dependence of fossil energy.

4) Increasing GDP and share of renewable energies and improvement in energy efficiency scenario (*SC-4*): increasing GDP, change in productive sectorial structure and change in share of fossil energy as in *SC-3* scenario is carried out. Moreover, an improvement in energy efficiency is implemented with a 1% reduction of energy intensity in industry sector, in trade and public services sector and in transportation sector, so then; the energy efficiency will be enlarged by a reduction of the energy intensity and by changes in the productive sectorial structure. This scenario takes a step towards improving the country's environmental responsibility and sustainable development by supporting their energetic saving measures and energy efficiency.

Both *SC-3* and *SC-4* scenarios goals are realistic considering the state of development and evolution of energy technology in various energy projects implemented by the Ecuadorian government, and the trends in the use of renewable energies in the country [16].

III. RESULTS AND DISCUSSION

We will use three periods of 16 years to perform the analysis, two within the set of historical data (1980-1995 and 1995-2010) and the last one corresponding to the forecast period (2010-2025). This analysis will allow us to determine the relative importance of each term related to CO_2 emission. The aggregate CO_2 emissions in kilo tonnes of CO_2 (kt), income in billions of USD (BUSD) and energy consumption in kilotonnes of oil equivalent (ktoe) are shown in Table I.

Table I.
Aggregate data for Ecuador for the period 1980-2025.

Year	CO_2 emissions (kt)	Income (BUSD)	Energy consumption (ktoe)
Data 1980	11,900	45,4	5032
Data 1995	19,600	63,4	7143
Data 2010	28,100	104	11930
BS 2025	55,000	167	20520
SC-2 2025	96,600	271	36040
SC-3 2025	66.,500	244	32430
SC-3 2025	54,700	251	26700

For The findings (see Fig. 1 and Fig. 2) show that in the period 1980-1995 there was an increase in emissions by 35% (see Table III) or equivalently of more than 5400 kt (see Table II).

Table II.
Results of the co_2 emission additive decomposition factors for the period 1980-2025.

Scenario	Δ Ctot	Δ Cact	Δ Csrt	Δ Cint	Δ Cmix
Data 1980-1995	5410	4780	194	196	292
Data 1980-1995	14800	12300	-637	1160	1990
BS 2025	22600	20100	-82	2500	96
SC-2 2025	62100	55600	3020	3300	192
SC-3 2025	32500	39900	2400	2640	-12400
SC-3 2025	23200	37100	2200	-5040	-11100

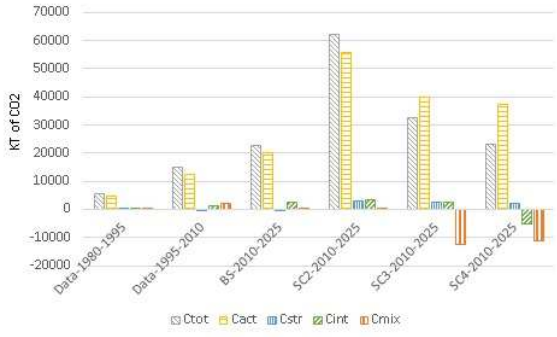

Fig. 1. Bar view of the CO_2 emission additive decomposition factors for the period 1980-2025 in Ecuador.

The LMDI analysis shows that the activity effect led to an increased just 3 percent points (38%), so that, the margin in emission increased. The effect of structural change (*Dstr* = 1:01) in productive sectors and change in energy mix (*Dmix* = 1:02) does not have significant impact over the emission in this period. Actual growth in emissions was lower because of the reduction of the sectorial energy intensity (*Dint* = 0:95), see a pictorial view in Fig. 3. Note that the ratio *Dtot* = *Dact* is almost 1 and is a proxy of that country emissions in this period growth in the same factor that the income (see Fig. 1).

The period 1995-2010 reflected a greater increase in emissions (85%) or equivalently of more than 14800 kt (sees Tables II and III). The LMDI analysis shows that the activity effect led to an increase of 0:80 times (68%), so that, the margin in emissions increase. In addition, changes in energy intensity (*Dint* = 1:04) and in energy mix (*Dint* = 1:09) led to an additional increased in emissions. The impact of structural change (*Dstr* = 0:98) in productive sectors has a reduction effect in emission. Note that the ratio *Dtot* = *Dact* equal to 1:10 is a proxy of the higher economic growth in this period (regarding to the previous one) accelerated the emission growth of the country (see Figures 3).

Table III.
Results of the co_2 emission multiplicative decomposition factors for the period 1980-2025.

Scenario	Dtot	Dact	Dsrt	Dint	Dmix
Data 1980-1995	1.35	1.38	1.01	0.95	1.02
Data 1980-1995	1.85	1.68	0.98	1.04	1.09
BS 2025	1.72	1.61	1.00	1.07	1.00
SC-2 2025	3.03	2.59	1.09	1.07	1.00
SC-3 2025	2.08	2.33	1.09	1.07	0.77
SC-3 2025	1.71	2.41	1.09	0.85	0.77

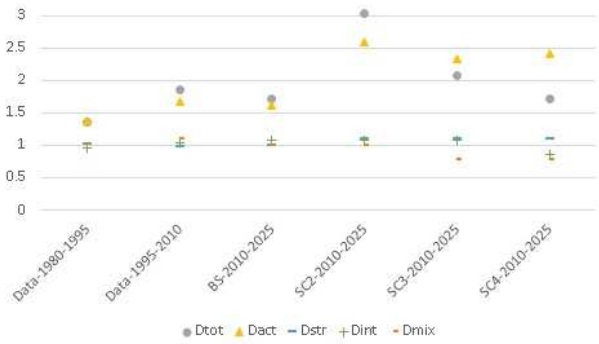

Fig. 2. View of the CO_2 emission multiplicative decomposition factors for the period 1980-2025 in Ecuador.

Regarding to the forecast period, the findings show that in 2025 the CO_2 emissions would increase by 72% or equivalently of more than 22000 kt in the BS scenario. The LMDI analysis shows that the activity effect led to an increase of 0:85 times (61%) that the margin in emissions increases. The effect of structural change (*Dstr* = 1:00) in productive sectors and change in energy mix (*Dmix* = 1:00) does not have impact on the emission in this period. Actual growth in emissions was higher because of the

increase in sectorial energy intensity (Dint = 1:07), as an pictorial view of Fig. 3. Note that the ratio *Dtot* = *Dact* is almost the same as the previous period (1:07) (see Fig. 4) and is a proxy of the growth in emissions depends mainly on the scale term (*Dact*) in *BS* scenario.

The SC-2 scenario presents an amount of emissions in 2025 that is more than 3 times in 2010 (3:03 times) or equivalently of more than 62000 kt. The LMDI analysis shows that the activity effect led to an increase of 0:57 times (2:49 times) so the margin in emissions increased. The effect of energy mix (*Dmix* = 1:00) does not have impact on the emission during this period. As in BS scenario, actual growth in emissions was higher because of the increase in sectorial energy intensity (*Dint* = 1:07) and by the impact of the structural change (*Dstr* = 1:09), as in the pictorial view of Fig. 3. Note that the ratio *Dtot* = *Dact* is 1:17 (higher than *BS* scenario) (see Fig. 4) and is a proxy of the higher economic growth achieved in this scenario is because an increase in the economic scale and in energy intensity, arising from the shift in the composition of industry output towards energy-intensive sectors of the country as has been considered in this scenario.

The *SC-3* scenario presents an amount of emissions in 2025 that is more than 2 times in 2010 (2:08 times) or equivalently of more than 32000 kt. The LMDI analysis shows that the activity effect led to an increase of 1:23 times (*Dtot* = 2:33) so the margin in emissions increased. In addition, impact of structural change (*Dstr* = 1:09) in productive sectors changes and in energy intensity (*Dint* = 1:07) led to an increase in emissions. The impact of energy mix (*Dstr* = 0:77) used in productive sectors has a reduction effect in emissions as it has been considered in this scenario, see a pictorial view in Fig. 3. Note that the ratio *Dtot* = *Dact* is lower than 1 (0:89) (see Fig. 4) and is a proxy for first time in the country (in the analyzed period), the growth of economics is higher than the growth of emissions. The reason is that in addition to the growth in the economic scale, the impact of energy mix change leads to a reduction of this ratio.

Finally, in the *SC-4* scenario the emissions just increase by a factor of 1:71 or equivalently more than 23000 kt. The LMDI analysis shows that the activity effect led to an increase almost 2 times (*Dtot* = 2:33) the margin in emission increased. As in previous scenarios, the impact of structural change (*Dstr* = 1:09) in productive sectors changes led to an increased in emissions. However, actual growth in emissions was lower than in rest of scenarios because the impact of energy mix (*Dstr* = 0:77) and the reduction in sectorial energy intensity (*Dint* = 0:85) has a reduction effect in emission as it has been considered in this scenario, see a pictorial view in Fig. 3. Note that in this scenario the ratio *Dtot* = *Dact* is the lowest (0:71) (see Fig. 4) and as in the *SC-3* scenario, in addition to the growth in the economic scale, the impact energy mix are present and adding the impact of the reduction of energy intensity considered in this scenario is reducing even more this ratio.

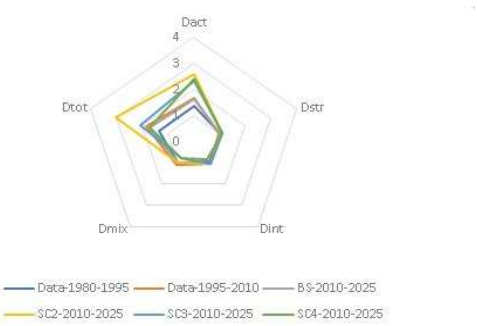

Fig. 3. Pictorial view of the CO_2 emission multiplicative decomposition factors for the period 1980-2025 in Ecuador.

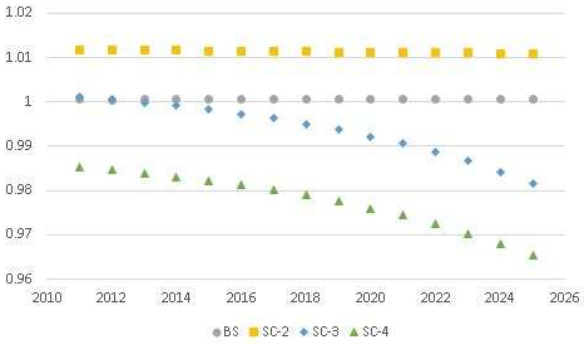

Fig. 4. *Dtot* = *Dact* for the period 2011-2025 in Ecuador.

All the coefficients are summarized in Table II and III and in a pictorial way in Fig. 3. In this figure five axes are depicted corresponding to the five columns appearing in table III. The value of the vertical axis, *Dtot*, corresponds to the product of the five remaining variables, *Dact*, *Dstr*, *Dint*, *Dmix* and *Demf*.

IV. CONCLUSION

This work presents a decomposition analysis of CO_2 related to income growth and energy consumption bases on Logarithmic Mean Divisia Index (LMDI) analysis for Ecuador in the period of 1980-2025. For this purpose three periods have been selected, the first sub-period is 1980-1995 where the LMDI analysis findings concluded that the country emissions in this period almost grow (38%) in the same factor that the income (35%), see Fig. 1. The second sub-period is 1995-2010 and the evidence concluded that a higher economic growth (68%) led to an even greater emissions growth (85%) in the country.

The third sub-period is 2010-2025 and it includes the analysis for the different macro-scenarios that have been proposed. To see more clearly how the income-CO_2 relationship behaves as a function of time, it is very enlightening to depict the ratio *Dtot* =

Dact as a function of the time (see Fig. 4). The first striking thing is the very different behaviour for each scenario. On one hand, it is somehow surprising the almost flat curve corresponding to the *BS* scenario which implies a trend-growth GDP scenario; however the CO_2 emission increases steadily because of the absence of attenuation measurements. A similar behaviour, although slightly sloping down, is observed for *SC-2*, where a rapid growth of the GDP is assumed without any attenuation action regarding CO_2 emission. It is worth noting a certain decrease of the ratio *Dtot* = *Dact* in the final part of the period under this study. The other two scenarios, *SC-3* and *SC-4*, show a steady reduction of the ratio *Dtot* = *Dact* due to the changes in the sectorial structure and in the energy mix, which allows a compensation of rapid GDP growth.

This study combines decomposition analysis with a basic scenario modelling to create a baseline prevision as guidance for possible new policies. This allowed the development of an approach with a set of integrated exploratory scenarios about income growth, energy use and CO_2 emissions for Ecuador in a medium term (2025). The scenarios show plausible more environmental-friendly pathways that the country could take to get closer to a sustainable development.

This preliminary analysis suggests that, with the appropriate changes in the energy mix, the sectorial structure, and the share of renewable energies, Ecuador can move into a more environmentally sustainable state. All these results encourage us to perform a more rigorous analysis and macro-scenarios in regard to income and emission relationship.

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REFERENCES

[1] R. York, E. A. Rosa, and T. Dietz, “STIRPAT, IPAT and ImPACT: analytic tools for unpacking the driving forces of environmental impacts,” Ecological Economics 46(3), 351-365, 2003.

[2] B. Commoner, “A Bulletin Dialogue on The Closing Circle,” Response. Bulletin of the Atomic Scientists 28 (17), 42-56, 1972.

[3] P. R. Ehrlich and J. Holdren, “A Bulletin Dialogue on the Closing Circle: Critique. One-Dimensional Ecology,” Bulletin of the Atomic Scientists 28:16-27, 1972.

[4] Y. Kaya, “Impact of Carbon Dioxide Emission Control on GNP Growth: Interpretation of Proposed Scenarios,” Paper presented to the IPCC Energy and Industry Subgroup, Response Strategies Working Group, Paris, (mimeo), 1990.

[5] IPCC, IPCC Special Reports. Emissions Scenarios. Cambridge University Press, The Edinburgh Building Shaftesbury Road, Cambridge CB22RU England, 2000.

[6] B. Ang, “Decomposition analysis for policymaking in energy: which is the preferred method?” Energy Policy 32, 2004.

[7] P. Steenhof, C. Woudsma, and E. Sparling, Greenhouse gas emissions and the surface transport of freight in Canada. Transportation Research Part D-Transport and Environment 11 (5), 369-376, 2006.

[8] P. Waggoner and J. Ausubel, “A framework for sustainability science: a renovated IPAT identity,” Proceedings of the National Academy of Sciences 99 (12), 7860-7865, 2002.

[9] B. Ang and F. Zhang, “A survey of index decomposition analysis in energy and environmental analysis,” Energy 25, 1149-1176, 2000.

[10] J. Sun, “Energy demand in the fifteen European Union countries by 2010 -A forecasting model based on the decomposition approach,” Energy 26, 549-560, 2001.

[11] S. Sorrell, M. Lehtonen, L. Stapleton, J. Pujol, and T. Champion, “Decomposing road freight energy use in the United Kingdom,” Energy Policy 37 (8), 3115-3129, 2009.

[12] T. Kwon, “A scenario analysis of CO2 emission trends from car travel: Great Britain 20002030,” Transport Policy 12 (2), 175-184, 2005.

[13] P. Steenhof, “Decomposition for emission baseline setting in China’s electricity sector,” Energy Policy 35 (1), 280294, 2007.

[14] P. Agnolucci, G. Ekins, P. abd Iacopini, K. Anderson, A. Bows, S. Mander, and S. Shackley, “Different scenarios for achieving radical reduction in carbon emissions: a decomposition analysis,” Ecological Economics 68, 1652-1666, 2009.

[15] B. Ang, “The LMDI approach to decomposition analysis: a practical guide,” Energy Policy 33 (2005) 867871, 2005.

[16] A. Mosquera-Rodr´iguez, Policies and Strategies for Changing the Energy Matrix in Ecuador. Ministry of Electricity and Renewable Energy, Ecuador, 2008.

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The Dependence of Morphological and Physiological Indicators of the Leaves of Woody Plants on the Degree of Technogenic Pollution

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Abstract. Plants of modern urban ecosystem suffer from negative effects of a series of technogenic pollution which leads to changes in their morphological and physiological state. The reason for this is the penetration of phytotoxicants into plant organs, primarily, into leaves, thus distorting the structural components of cells and their functioning. In various species the degree of this reaction is manifested differently, so this fact must be taken into consideration when creating environmentally effective plantations. For this purpose the integrated study of the impact of pollutants on the morpho-physiological state of deciduous trees was conducted. Some morphological, physiological and biochemical indicators of leaves of Tilia cordata Mill., Populus tremula L., Salix fragilis L., Salix alba L. from different urban areas, characterized by different levels of technogenic pollution, were also studied. It was found out that the increase of technogenic load led to the decrease in the size of leaves, the increase of their necrotization and the total ash content of the tissues of these organs as well as the reduction of the photosynthetic pigments concentration with increase of relative portion of carotenoids which is the most significantly revealed in the leaves of the lime-tree, brittle willow and, to a lesser extent, in the white willow. At the same time the increased relative portion of carotenoids in the photosynthetic organs in case of strong pollution by pollutants indicates an increase of the protective role of the yellow pigment. Besides, the increased ratio of chlorophyll a/b characteristic for the resistant plant species was established in the leaves of these trees, which is a sign of a higher potential photochemical activity of leaves and the rate of photosynthesis.

All the studied morpho-physiological indicators characterize a greater resistance to pollutants of Tilia cordata, Salix fragilis, Salix alba, which can be recommended for the reconstruction of the sanitary and protective plantations of Arzamas. The studied tree species have a great capacity of gettering harmful technogenic substances with a further effective ability to accumulate them in the tissues of the leaves.

Keywords: technogenic pollution, woody plants, size of leaves, degree of necrosis, water content and ash content of leaves, concentration of photosynthetic pigments, species resistance.

I. INTRODUCTION

Modern cities are the source of all kinds of technogenic pollution, which have a negative impact on the morphological and physiological condition of plants of urban ecosystems [3; 12; 15].

Phytotoxicants penetrate into plants and distort structural components of cells and their functioning. Depending on the strength and duration of exposure, the chemical composition of pollutants and the general physiological state of the plant body, the degree of this reaction is manifested in various species in different ways [3]. Woodland in the urban landscape performs a number of important functions – recreational, environmental, aesthetic; it neutralizes harmful harmful gases, accumulating pollutants in the tissues of the leaves [2; 6; 8; 10; 23; 24]. At the same time, changes in morphological and functional processes in the conditions of urban environment have not been properly studied. In this regard, the creation of eco-efficient plants without taking into account ecological and biological characteristics of plants is impossible.

Under the conditions of technogenic pollution indicators of physiological state of woody plants can be: the size of the lamina, the degree of damage and water content, the amount of mineral salts in them, as well as the functioning of the photosynthetic organ, which is very susceptible to external factors [3; 5; 17; 22; 23].

At the same time, in our city the integrated studies of the influence of pollutants on the physiological condition of deciduous trees were carried out for the first time [18; 19; 20]. The purpose of this work is a comparative analysis of several morphological

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exponents such as a leaf size and the degree of necrotic deterioration; physiological and biochemical features: amount of water, ash and photosynthetic pigments, of different tree species growing under different levels of man-made pollution.

II. MATERIALS AND METHODS

The objects of the study were the tillet (*Tília cordáta Mill.*), aspen or *Pópulus trémula L.*, brittle willow (*Sálix fragílis L.*) and white willow or common willow (*Sálix álba L.*) from four habitats in the gray forest soils, which are characterized by different levels of pollution. Arzamas is an industrial city of Nizhny Novgorod region with the developed sectors of mechanical engineering and instrument-making, production of construction materials and others. The least polluted city area – a pedestrian Karl Marx street – was chosen as the zone of control (ZC). The sectors under the research were the territories adjacent to: 1) Arzamas Engineering Works (AEW) (average degree of pollution); 2) Plant for the production of building mixtures “Arzamix"; 3) the old landfill of solid domestic wastes (SDW). The level of pollution in the last two sections was higher compared with the territory of AEW. The content of heavy metals in soil samples of the studied areas was determined by atomic absorption spectroscopy with the help of the technical detector MGA-915 MD.

The research was carried out in August, during two vegetative periods. We selected leaves of the middle size at the annual vegetative growth from the lower third of the crown of trees of the southern exposure. In each sample at least one hundred leaves were analyzed. We determined the size of the leaf area, the degree of necrotization [1], the amount of water by drying to constant weight at 50 – 60 ° C and ash after combustion in a muffle furnace at 600 – 800ºS t [9], the contents of photosynthetic pigments with the help of a spectrophotometer PE 5400VI "Ekohim" [7]. The analyses were performed in 3 of biological and chemical 2 replicates. The results obtained were processed statistically [13], the validity of differences between control and experimental variants was assessed by Student’s-test with the program BioStat 2008 Professional 5.2.5.0 for Windows.

III. RESULTS AND DISCUSSION

The degree of pollution can be indicated by the analysis of soils for the accumulation of heavy metals in the studied areas (Table. 1). It was revealed that most polluted territory was the one adjacent to "Arzamix" because of a high concentration of lead and zinc and SDW for all studied elements.

It was found that the leaf size of all the studied species of woody plants in the polluted areas of the city was less than in the ZC (Fig. 1). Moreover, the rate of the lamina reduction depends both on the place of growth, and the type of the plant. By far the smallest leaf size is characteristic of the more polluted areas - SDW and "Arzamix". The inhibitory effect of toxicants on leaf growth manifests itself in a much lesser extent in the area adjacent to the AEW (Fig. 1). Aspen leaves suffer most severely from pollution.

Table 1
The content of heavy metals in the soils of the studied areas

exponent, mcg/g	Studied area			
	ZC	AEW	Arzamix	SDW
Cu	7,3 ± 0,7	11,5 ± 1,1	9,8 ± 0,9	45,6 ± 2,3
Pb	25,0 ± 1,3	36,8 ± 2,5	48,1 ± 3,2	56,0 ± 4,5
Ni	6,8 ± 0,6	10,9 ± 1,0	7,9 ± 0,4	20,2 ± 2,0
Zn	10,2 ± 0,9	14,5 ± 1,3	22,1 ± 2,8	34,3 ± 2,3

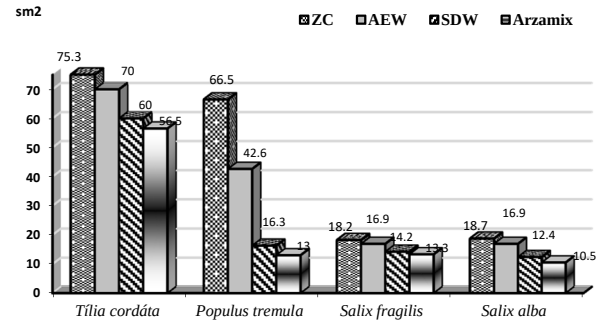

Fig. 1. The leaf size (sm^2) of deciduous trees in Arzamas habitats polluted to a different degree

With increasing degree of pollution of the territory all species of plants have a growing number of leaves damaged by necrosis (Fig. 2).

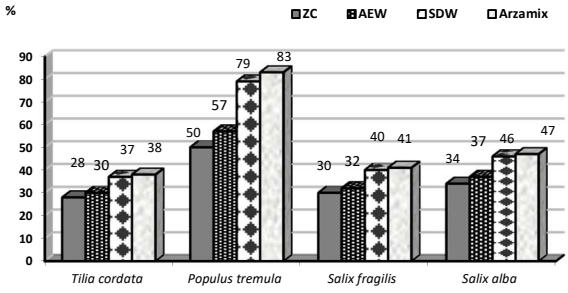

Fig. 2. The proportion of necrotic leaves (% of the sample) of deciduous trees in habitats with different degree of pollution in Arzamas

As is in the case with growth ratio, the study of the degree of necrotization showed that aspen leaves were exposed to the most severe damaging effect of pollutants. These changes can be explained by impaired regulatory mechanisms under the effect of toxicants - inhibition of ATP synthesis and reduction of enzyme activity [3], resulting in the inhibition of growth of cells, tissues and organs [8; 22].

For normal existence the cells and tissues of plants must have a sufficient water content [3]. Lack of water leads to the distortion of a number of physiological processes, and first of all the

photosynthesis, that causes a decrease in the growth of plant organs [5]. It was found that in the polluted areas the quantity of water compared with ZC significantly decreased only in aspen leaves (Fig. 3). Moreover, with the increasing degree of pollution, the figure becomes smaller.

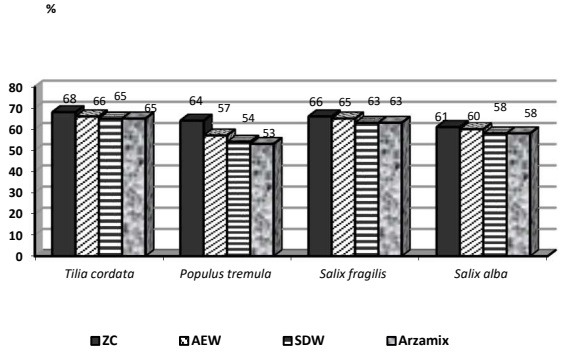

Fig. 3. Water content in the leaves of deciduous trees in the habitats of Arzamas with different degree of pollution

It is known that the amount of water in the cells influences the resistance to adverse environmental factors, and can serve as a criterion for evaluating the resistance of plants [17]. The fickle species increase the of cell membranes in case of environmental pollution, which naturally causes a rapid loss of water by cells [5].

When pollutants are accumulated, leaves stock up mineral elements, which also serves as an indicator of state of the environment. It was revealed that in case of anthropogenic impact the total ash content of the leaves of all the studied species of woody plants, with the exception of aspen leaves in AEW area significantly increased (Fig. 4).

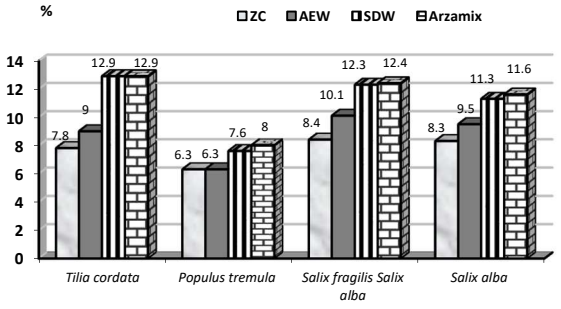

Fig. 4. Ash content in leaves (%) of deciduous trees in habitats with different degree of pollution in Arzamas

Similar results in other kinds of woody plants were noted by a number of authors [11; 14]. Our findings are not associated with a favorable mineral nutrition, and most likely these are the consequences of the accumulation of pollutants by leaves, or metabolic disorders.

Comparison of species by accumulation of pollutants showed that in the situation of pollution of the territory there are several trees whose leaves have greater accumulative capacity (linden and brittle willow), and a slightly lesser – the white willow. At the same time the aspen leaves have the least accumulation of mineral elements in a highly-polluted area. Accumulating activity of different leaves of the studied species of woody plants, apparently, is a consequence of their physiological state.

Moreover, in a much polluted environment a high ability to accumulate contaminants by leaves of linden and brittle willow may be due to the greater resistance of these species thanks to more active absorption of pollutants by these species cells [23]. This, in turn, leads to the removal of the technogentic pollutants from the air.

In addition, another important indicator of the physiological state of woody plants in the urban environment can be photosynthetic system; one of which main components is a pigment system. Photosynthetic activity is an indicator of the general state of the plant body, as a series of man-made gases have an impact on the structural and functional activity of chloroplasts inhibiting the process of photosynthesis [3; 8]. It was found in our experiments that the increase in the degree of an anthropogenic impact on the territory leads to a significant distortion in the pigment complex in the leaves of all the studied species of woody plants. There was a decrease in the content of photosynthetic pigments (chlorophylls and carotenoids) compared to ZC in all the areas of research. Besides, there was no credible decrease in carotenoid content only in the linden leaves in the area adjacent to the plant «Arzamix» (figure 5; 6; 7).

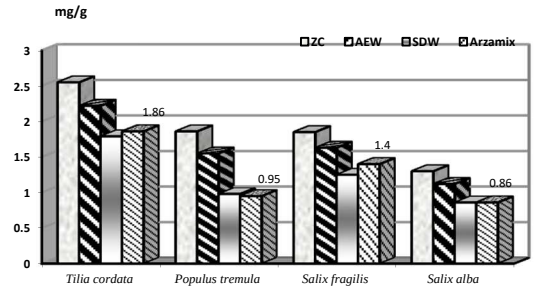

Fig. 5. The content of chlorophyll "a" (mg / g green weight) in the leaves of deciduous trees in habitats with different degree of pollution in Arzamas

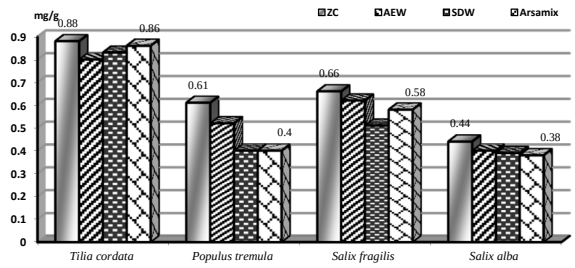

Fig. 6. The content of chlorophyll "b" (mg / g green weight) in the leaves of deciduous trees in habitats with different degree of pollution in Arzamas

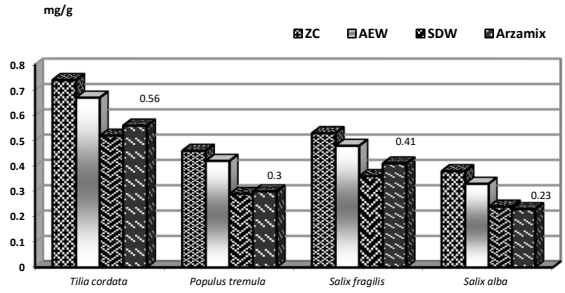

Fig. 7. The content of carotenoids (mg / g green weight) in the leaves of deciduous trees in habitats with different degree of pollution in Arzamas

For example, in the brittle willow leaves in the moderately polluted area adjacent to AEW the concentration of chlorophyll "a", decreased by 12%; while in the more polluted areas around the waste dump SDW and «Arzamix» plant this figure decreased by a greater degree, namely 32% and 24%; concentration of chlorophyll "b" decreased by 9%, 32% and 23%. At the same time, there were no significant changes in the ratio of the above forms of chlorophyll. The only exceptions are aspen leaves, in which the increasing pollution of the territory causes the change in the exponents *a / b* in the direction of increase of the concentration of *chlorophyll b* (Table 2).

Table 2
The ratio of the content of pigments in the leaves of deciduous trees in habitats with different degree of pollution in Arzamas

Species	Habitat			
	ZC	Near the territory of AEW	Near the waste dump SDW	Near the «Arzamix » plant
a/b				
Linden	3,4	3,3	3,4	3,3
Aspen	4,0	3,7	3,4	3,2
Brittle willow	3,5	3,4	3,4	3,4
White Willow	3,4	3,4	3,6	3,6
a + b / carotenoids				
Linden	3,8	3,6	2,8	2,8
Aspen	3,8	3,8	3,2	3,1
Brittle willow	3,6	3,4	2,4	2,3
White Willow	3,8	3,6	2,8	2,8

Such a change may be an adaptation of the most affected by pollution and therefore less resistant to high concentrations of pollutants species of woody plants [14].

Similar results on resistance to pollutants have been identified in other plant species [4; 16]. According to the authors, the increased correlation of *chlorophyll a / b*, which was observed in resistant species and the reduced one in unstable and moderately stable species, characterizes a higher potential of photochemical activity of leaves. At the same time, the increased value of *chlorophyll a / b* may be a sign of the greater potential intensity of photosynthesis, that, along with the studied parameters (leaf size, necrosis, water content and mineral elements), characterizes a higher resistance to industrial pollutants of such species of trees as linden, white willow and brittle willow.

However, in the heavily polluted areas (waste dump SDW and «Arzamix») in the leaves of plants of all the studied species the degree of the decrease of carotenoids, in comparison with chlorophylls, is significantly less. It is particularly noticeable in the leaves of the linden and white willow. So if linden total *chlorophyll (a + b)* in the SDW waste dump areas decreased by 30%, near "Arzamix" – by 27%, the carotenoid concentration in the leaves at the waste dump is reduced by 6%, and in the enterprise zone «Arzamix» it remains on the level of control.

In the white willow *chlorophyll* content decreased by 35% and 37%, and *carotenoids* – only by 11% and 14%. At the same time the aspen has a significantly smaller difference in decrease in the amount of green and yellow photosynthetic pigments. Thus, if the chlorophyll content of the waste dump areas of SDW and "Arzamix" respectively decreased by 45% and 46%, the carotenoids in both cases decreased by 33%.

As a result, all the studied species of plants on the highly polluted sites had an increased ratio of *chlorophyll a + b / carotenoids* (Table 2). This implies that the relative proportion of carotenoids in the photosynthetic organ in the polluted areas substantially increases in comparison to ZC. Most significantly it is evident in the leaves of the brittle willow and, to a lesser extent, linden and white willow. Similar data, indicating the increase in carotenoids due to the increase of environmental pollution, is given on the leaves of other woody species [4; 14]. At the same time, the increased relative proportion of carotenoids in the photosynthetic apparatus in case of a strong pollution is an indication of the enhanced role of the protective yellow pigments. In this regard, it is believed that basing on this indicator, the white willow, linden, and particularly brittle willow in comparison with aspen, can be named as species which are more resistant to man-made pollution.

Also, the obtained data on the decreasing chlorophyll amounts and relative increase in yellow pigments in leaves, in the situation of anthropogenic pollution growth, to some extent correlates with the reduction in their water content. Similar results were obtained by other authors in the studies of various kinds of plants [14; 22].

IV. CONCLUSION

Thus, air pollution in Arzamas, caused by industrial wastes, has a negative impact on the anatomical, morphological, physiological and

biochemical parameters of the leaves of the trees growing in urban areas. All the studied species of plants manifested the decrease in the size of the lamina, water content of cells, concentration of photosynthetic pigments along with the increase in the relative proportion of carotenoids that perform a protective function against pollutants. Besides, there is an increase in such indicators as total ash content of leaf tissue and the number of leaves exposed to necrotization. With the increasing degree of technogenic pollution in urban areas all the studied species of woody plants manifested the results of the negative impact of harmful substances on the morphological and physiological characteristics of leaves.

On the basis of the obtained results, we may use some of the studied species of woody plants in Arzamas for the purpose of reconstruction of sanitary and protective plantations, as they combine a higher gas resistance and leaves with the capacity to absorb pollutants. The most suitable in this respect are the linden, brittle willow, and to a lesser extent the white willow. The leaves of these trees in heavily polluted areas have less, compared with aspen, decrease of morphological and physiological parameters, namely, leaf size, water content of tissues, the concentration of green and yellow pigments, the incidence of necrosis, and high content of ash elements.

REFERENCES

[1] Bioindication of pollution of terrestrial ecosystems / ed. R. Schubert. Moscow, 1988, 350 p.

[2] Bulygin N.E. Dendrology / N.E. Bulygin. – Moscow, Agropromizdat, 1985, 280 p.

[3] Bukharin I.L. Bioecological features of herbaceous and woody plants in urban plantings / I.L. Bukharin, A.A. Dvoeglazova. Izhevsk, Publishing House of Udmurt. University Press, 2010, 184 p.

[4] Bukharin I.L. Analysis of the content of photosynthetic pigments in leaves of woody plants in the urban environment (for example, the city of Naberezhnye Chelny) / I.L. Bukharin, P.A. Kuzmin, I.I. Gibadulin // Bulletin of Udmurt University. 2013, Vol. 1, pp. 20 – 25.

[5] Volzhanina E.M. Estimation of stability of introduced species of pines in terms of water-holding capacity of needles / E.M. Volzhanina // Vestn. Nizhegorod. Univ. – №8, Vol. 2, 2004, pp. 94 – 99.

[6] Vorobeichik E.L. Reaction of forest communities in to technogenic pollution: dose-effect / E.L. Vorobeychik, E.V. Hantemirova // Ecology, 1994, № 3, pp. 31 – 43.

[7] Gavrilenko V.F. Large workshop on plant physiology / V.F. Gavrilenko, M.E. Ladygina, L.M. Handobina. Moscow, Higher School, 1975, 392 p.

[8] Goryshin T.K. Plant photosynthetic apparatus under medium / T.K. Goryshin. Leningrad, Leningrad State University, 1989, 202 p.

[9] Ermakov A.I. Methods of biochemical studies of plant / A.I. Ermakov, V.V. Arasimovich, N.P. Yarash. – Leningrad, Agropromizdat, 1987, 400 p.

[10] Ivanov A.A. Bioindication stress Betula pendula Roth in the conditions of anthropogenic pollution / A.A. Ivanov, V.K. Velikova // Plant Physiology. – 1990. – V. 16. – № 3 – pp. 76 – 82.

[11] Kavelenova L.M. About the specific content of mineral elements in the leaves of woody plants in the urban environment in the conditions of forest-steppe (on the example of Samara) / L.M. Kavelenova, A.G. Zdetovetsky, A.Y. Ognevenko // Chemistry of plant materials, 2001, №3, pp. 85 – 90.

[12] Kulagin A.A. Woody plants and biological preservation of industrial pollutants / A.A. Kulagin, Yu Shagieva. Moscow, Nauka, 2005, 190 p.

[13] Lakin G.F. Biometrics. / G.F. Lakin. Moscow, Higher School, 1990, 352 p.

[14] Maracayev O.A. Technogenic stress and its effects on deciduous woody plants (for example, parks in Yaroslavl) / O.A. Maracayev, N.S. Smirnova, N.V. Zagoskina // Ecology, 2006, №6, pp. 410 – 414.

[15] Neverov O. Environmental Assessment of woody plants and pollution of the industrial city (on an example of Kemerovo): Abstract. Dis. ... Dr. biol. Sciences. M., 2004, 36 p.

[16] Nicholas B. C. Biological Basis of gas resistance of plants / B. C. Nicholas. – Novosibirsk: Nauka, 1979. – 275 p.

[17] Polovnikova M.G. Changes in the water regime of lawn grass in the urban environment / M.G. Polovnikova, O.L. Voskresenskaya // Individual and population – life strategy: Coll. Materials IX All-Russia population seminar (Ufa, 2 – 6 October 2006), Part 1, Ufa, Wiley Oksler 2006, pp. 398 – 402.

[18] Rostunov A.A. Influence of technogenic pollution on physiological characteristics of leaves of woody plants on an example of Arzamas / A.A. Rostunov, T.A. Konchina // Bulletin of Irkutsk State University. Series: Biology. Ecology, 2016, V. 15, pp.68 – 79.

[19] Rostunov A.A. The research project in the studies of the ecological state of the various areas of Arzamas / A.A. Rostunov, S.S. Kharitonov, M.V. Molkova // Young scientist. 2016, № 8 – 7 (112), pp. 27 – 29.

[20] Rostunov A.A. Research project activity of the future teachers in determining the degree of anthropogenic pollution of the various highways of Arzamas by methods of bioindication / A.A. Rostunov, S.S. Kharitonov, E.I. Norkina // Young scientist, 2016, № 8 – 7 (112), pp. 29 – 33.

[21] Tarchevsky V.V. Influence of smoke and gas emissions of the industrial enterprises of the Urals on vegetation / V.V. Tarchevsky // Plants and industrial environment. Sverdlovsk, 1964, pp. 5 – 9.

[22] Chukparova A.W. Study of state of pine plantations in terms of aerotehnichal pollution / A.U. Chukparova // Forest management, ecology and protection of forests: fundamental and applied aspects: Proceedings of the international scientific-practical conference. Tomsk, 2005, pp. 208 – 210.

[23] Shenher E. Penetration into the leaf, and the accumulation of organic compounds in the cuticle of plants / E. Shenher, M. Riderer // Pollution and Toxicology. Moscow, Mir, 1993, pp. 11 – 83.

[24] Zhestkova E.Specifics of educational activity antimotivation in future teachers subject to the training period / Assel Bakirovna Akpayeva, Natalia Valentinovna Ivanova, Tatiana Ivanovna Luchina, Elena Viktorovna Minaeva, Elena Alexandrovna Zhestkova // International Review of Management and Marketing. – 2016. - №3. – p.265-259.

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Indicators Affecting Vidzeme Region Smart Development

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Abstract. The study aims to determine the main indicators of rural smart development concept for territorial development analysis and decision-making in Vidzeme region (Latvia). In the framework of the study the theoretical literature and planning documents were analysed, focusing on the indicators of rural areas and sustainable development. For a long time the development was associated primarily with the economic growth - GDP, employment and income growth. In recent years, the economic dimension is supplemented with social, environmental, cultural and political aspects. A holistic approach interprets close relations and balanced integration between the economic, social, political, ecological and cultural dimensions of local and regional development. Such approach requires the search for new indicators that describe the development of rural areas and are directly relevant to each individual area. The results present that in the development of Vidzeme smart specialization, the local governments and the state has the greatest impact. It is most affected by the local government's capacity to develop cooperation with residents and entrepreneurs, and a stable and sustainable economic situation in the country.

Keywords: smart development, sustainable development, indicators.

I. INTRODUCTION

In public administration, the development towards evidence-based decision-making in economic sectors is being favoured. Informative evidence must become the centre of the policy development and implementation, but data quality is becoming one of the key prerequisites for this process.

From 2014 to 2018 within a subproject of National Research Program EKOSOC LV 5.2.3., the prerequisites of smart development of Latvian rural areas were examined in order to create a knowledge base for decision-making for economic transformation in the direction of smart development.

The aim of the research includes smart development concept which is defined as the main base for the economic development of a smart community. This model is based on several concepts – the promotion of sustainable development, an attractive environment for new businesses, innovation in business.

Europe 2020 strategy for a smart, sustainable and inclusive growth relies on three priorities, which are complementary to each other:

- Smart growth – the economic development based on knowledge and innovation;
- Sustainable growth – the promotion of more resource-efficient, greener and more competitive economy
- Inclusive growth – fostering an economy with a high employment level and ensuring social and territorial cohesion [1]

The compliance with the principles of sustainable development as the basic method for encouraging the development of Latvian municipal territories has been defined in a number of top-level laws of Latvia in the recent decades, of which the most important are "Regional Development Law" [2], "Spatial Development Planning Law" [3] "Development Planning System Law" [4], "Environmental Protection Law" [5], the Law "On local governments" [6], as well as a number of regulations of the Cabinet of Ministers and local governments related to the above mentioned laws.

Unfortunately, the principles and guidelines defined for the strategy "Europe 2020" are only partially observed in the strategy "Latvia 2030". According to Latvian and foreign studies [7], the requirements and regulations of the strategy "Latvia 2030" include less than 50% of the regulations of the strategy "Europe 2020". This means that in modelling a smart, sustainable, inclusive development process of Vidzeme region municipalities until 2030, the criteria and indicator range has to be significantly complemented in order to obtain the research results that are as close as possible to the reality.

In the scientific literature there is no single set of indicators that characterize the smart, sustainable, inclusive development. More common are indicators that characterize innovations, such as the Innovation Union Scoreboard [8].

In the research on the existing experience and tendencies in the smart, sustainable development process of territories, several foreign authors' research

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emphasizes the need to more extensively use the methods which are based on a quantitative data analysis, not just descriptive qualitative data analysis[7], [9]. In recent studies, a great importance in the development of rural areas is attached to local resources. This includes decentralised governance; collaboration of all stakeholders, different innovative operational approaches based on the identity of the place and highly developed human capital. Rural space development is determined by the ideas, activities and initiatives of the local residents promoting regional diversity and quality of services.

Both qualitative and quantitative indicators should be applied to regional development models. Different theories and development indices and indicators are applied in various countries. Most often, they are divided into four dimensions: economic, social, environmental-institutional and political.

This study specifically analyses the impact of institutional indicators since a number of respectable researchers have considered them as important and included them in their work. Institutional and political indicators include the opportunity to participate in decision-making, transparent work of a local government, sustainable authority and business management [10].

The study aims at measuring the impact of institutional indicators in Vidzeme region by defining impact instruments and their significance for each dimension.

II. MATERIALS AND METHODS

The methodological basis of the research consists of 3 research methods: the analysis of sustainable development strategies of Vidzeme municipalities, the survey of residents (n-250), AHP method for identifying the key factors of rural development for the concept of smart area development.

Evaluating the published strategic and operational planning documents of Vidzeme municipalities, it can be concluded that sustainability is usually referred to as a goal in itself, a result of a certain process, although it should be mostly regarded as an evaluation mechanism for a variety of other real-life processes, and a set of tools that can determine whether a particular region has the smart, sustainable development prospects and to what extent. The largest problem in the process of determining the sustainability is the assessment of such indicators which are characterized as "intangible measurements" - they are not found as numerical values in annual reports or statistical reports of municipalities, but at the same time they can be significant indicators that may indicate the future prospects [11]. Therefore, there is currently a variety of assessment methods practically developed for measuring the smart sustainable development indicators, but so far none of them has become a worldwide recognized standard or a generally accepted measurement system.

At the moment it is very important for the municipalities of Vidzeme region to identify the impact indicators in order to determine whether they function in accordance with the smart, sustainable development principles. After determining and measuring the weak points of a municipality, it is possible to significantly increase the operational efficiency. During the study, the authors summarized the institutional indicators of the smart, sustainable development by analysing the sustainable development strategies of the municipalities of Vidzeme region and by using the in-depth interviews of local government employees acquired during the preceding stage of the research. The employees were asked a question: Which indicators, in your opinion, have affected the economic activity in the territory administered during the last five years? The summary of the results is shown in Table 1.

Table 1
Labels for the Operation of Indicators

Indicators	Label
State as an institution	
a) Maintaining favourable economic situation in the country	V1
b) Maintaining the stability of legislation	V2
c) Development of a tax system that promotes the economic activity	V3
d) Ensuring the access to the EU funding	V4
e) Successful operation of the financial equalization fund	V5
f) Offers of earmarked subsidies	V6
Local governments as local power structures (deputies – employees)	
a) The skills of a municipality/ town local government to attract the EU structural funds and use them successfully	P1
b) Focused and concerted action of deputies in the development and implementation of a municipality/ town development strategy	P2
c) The competence of local government staff in municipality development planning and project management	P3
d) Municipality / town development programme implementation results are systematically assessed and residents are informed of this by way of direct contact or through the local information sources	P4
e) The local government maintains close working contacts with local businesses, addressing the key issues important to both sides	P5
f) The local government creates favourable conditions for the activities of NGOs and other groups of the society, and actively involves them in the discussion and implementation of important development issues	P6
Communities living in the territory of a municipality	
a) The interest of local residents to take part in solving practical issues of a municipality/ town by active participation	K1

b) The readiness of municipality/ town residents for economic activities in order to increase personal income	K2
c) Activities of particular groups of residents in acquisition and dissemination of ideas of innovative change	K3
d) The readiness of residents to acquire new knowledge by attending lectures, participating in seminars, joining courses	K4
e) Municipality / town residents cooperate not only in cultural and sports activities, but also through the economic cooperation chains or even cooperatives	K5
f) The residents show readiness to accept change in work, society, environment	K6

The authors conducted a survey of Vidzeme region residents in order to obtain the real assessment of the population indicators, and the real and optimal impact in Vidzeme of three active elements – the state, local governments and residents.

The survey involved 252 residents of Vidzeme from all municipalities and different population groups. Within the survey the indicators were evaluated from a 3-dimensional perspective proposed by the authors, and with 6 indicators in each dimension (see Table 1). In the survey the participants were asked, first, to assess each indicator on a scale of 0-4, where 4 - high, 3 - medium, 2 - low, 1- negative, 0- no opinion, and, second, to evaluate the real and optimal impact of three active elements in Vidzeme region – the state, the local government and the population.

In order to measure the influence of the population, the local government, the state and the EU policies on these indicators, the Analytic Hierarchy Process (AHP) method was used (the author – Thomas L. Saaty). It is an expert method, based on carrying out an expertise (expert assessment obtaining procedure), and the evaluation of its results using validated mathematical methods [12].

The hierarchy of the problem elements is made from the top - the aim, through intermediate levels containing groups of criteria and criteria, a list of alternatives can be found on the lowest level. It is so-called dominance hierarchy. The process of hierarchy can be seen in Figure 1.

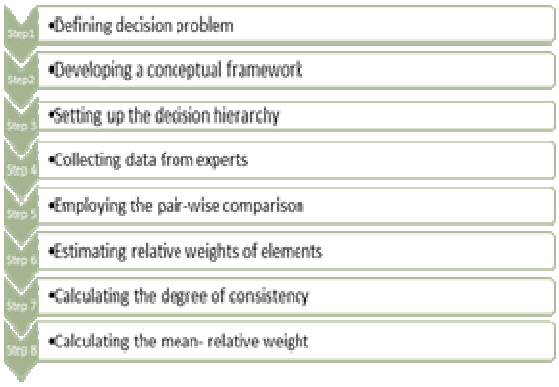

Fig. 1. AHP process

By using both of these methods, a qualitative analysis of the research object is achieved, including measurable qualitative indicators which significantly influence the development of the object, forecasting variants that can be ranked, grouping of different objects, indicators, ranking and prioritization, preparation of decisions.

The aim of the hierarchy analysis is the development of Vidzeme region smart specialization. 4 indicators were chosen: indicator A – the population impact characterized by activities of particular groups of residents in acquisition and dissemination of ideas of innovative changes, the involvement of residents in formal and non-formal education, residents' entrepreneurial ability and capacity, the use of residents' disposable resources for income generation; indicator B – the local government impact characterized by the skills of a local government to attract EU structural funds and use them successfully, the competence of employees in managerial decision-making and implementing for the municipality development, the role of a local government for effective use of resources; indicator C – the state impact characterized by maintaining a stable sustainable economic situation in the country, the state involvement in promoting innovative entrepreneurship, providing the availability of EU funding for the development of smart specialisation in the regions, a successful implementation of the financial equalisation and tax policy; indicator D - the EU impact characterized by the influence of cohesion policy and its orientation towards reducing EU regional disparities, the promotion of innovative processes in collaboration with EU member states and regions, the EU strategy and the conditions for the development of entrepreneurship and innovation, creating conditions for regional specialisation and building competitiveness in the EU policy.

As a result of the hierarchy analysis, there are 4 choices for the smart specialisation of Vidzeme region: 1) smart governance, 2) smart resources (natural and environmental resources), 3) smart population, 4) smart economy. 4 professionals were chosen as experts representing a local government, an NGO, Vidzeme Nature Conservation Agency and a scientific institution.

III. RESULTS AND DISCUSSION

The operation of indicators referring to the state as an institution in the assessment of residents

The sums of the residents' assessment in the dimension of state as an institution are shown in Figure 2. The residents have pointed out that in the state dimension ensuring the availability of EU funding is operating the best. On the contrary, the least successful is the operation of the financial equalization fund.

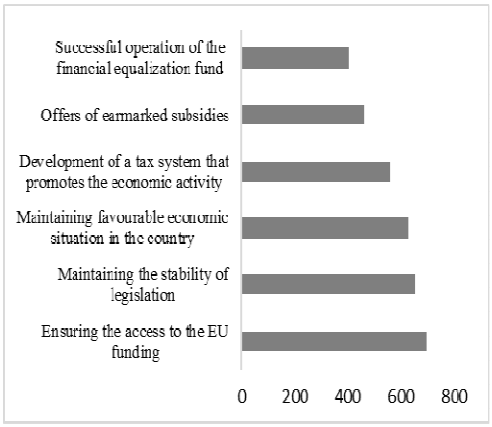

Fig.2. Operation assessment of indicators of state as institution
Source: Results of residents' survey

The operation of indicators referring to a local government as a local power institution in the assessment of residents

The sum of the residents' assessment in the dimension of a local government as a local power institution are shown in Figure 3.

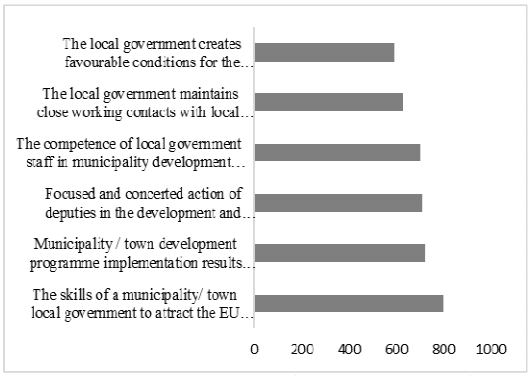

Fig.3. Operation assessment of the indicators of a local government as an institution
Source: Results of residents' survey

The residents have indicated that in the dimension of a local government, the most successfully operating indicators are the skills of a municipality or town local government to attract EU structural funds and use them successfully. In contrast, the least successful operation in the local government dimension is assigned to the ability of the municipality to create favourable conditions for the activities of NGOs and other groups of the society, actively involving them in the discussion and implementation of important development issues, the ability of the local government to maintain close working contacts with local businesses, addressing the key issues important to both sides.

The operation of indicators referring to communities living in the territory of a municipality in the assessment of residents.

The sums of the residents' assessment in the dimension of communities living in the municipality are shown in Figure 4.

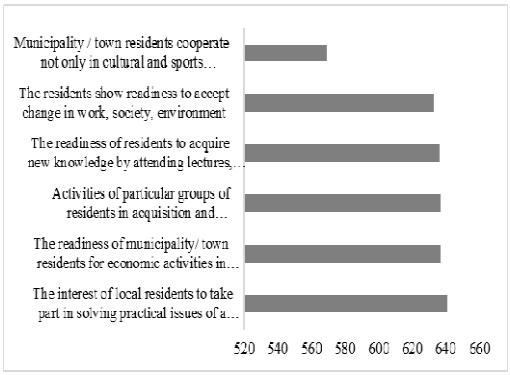

Fig.4. Operation assessment of the indicators of communities residing in the territory of a municipality
Source: Results of residents' survey

The residents have indicated that the most successful operation in the dimension of communities refers to the interest of local residents to take part in solving practical issues of a municipality/ town by active participation. On the contrary, the least successfully operating is the ability of municipality/ town residents to cooperate through the economic cooperation chains or even cooperatives, visible readiness to accept change in work, society, environment, the readiness of residents to acquire new knowledge by attending lectures, participating in seminars, joining courses.

On the whole, the municipality dimension has acquired the highest assessment of operation, but the state as an institution – the lowest assessment.

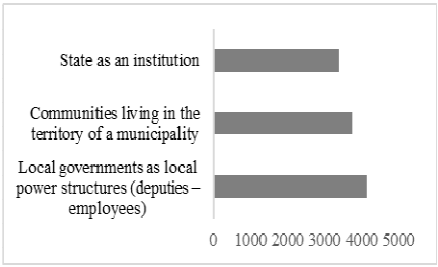

Fig 5. Operation assessment of the indicators of the state, the local government and communities
Source: Results of residents' survey

Residents assessed the state, local government and community real and optimal impact, giving weight or importance. The residents' assessment is shown in the Figure 6.

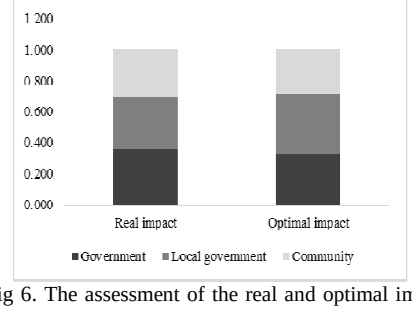

Fig 6. The assessment of the real and optimal impact of the state, the local government and communities.

In reality the state as an institution has the greatest impact according to the residents' assessment, but the smallest impact – the community. By contrast, the optimal greatest impact should be by the local government, but the smallest – the community.

During the next step the hierarchy analysis was carried out. The hierarchy analysis model as well as the residents' survey measured the state, the local government and the population dimension, with an addition of the EU dimension.

Each dimension was divided into four impact tools (see Table 2)

Table 2
Impact Dimensions and Impact Tools

Population impact a) Activities of particular groups of residents in acquisition and dissemination of innovative changes b) Involvement of residents in formal and non-formal education c) Residents' entrepreneurial ability and capacity d) Use of residents' disposable resources for income generation
Local Government impact a) Ability to attract EU structural funds and successfully use them b) Employees competence in managerial decision-making and implementing for the good of municipality development c) Ability to establish collaboration with residents and entrepreneurs d) Ability to efficiently use resources
State impact a) Stable and sustainable economic situation in the country b) State involvement in implementing innovative entrepreneurship c) Provision of the availability of the EU funding for the promotion of smart specialisation in the regions d) Successful implementation of financial equalisation and tax policy
EU impact a) Impact of the cohesion policy and orientation towards reducing the EU regional disparities b) Promotion of innovative processes in the collaboration with EU member states and regions c) The EU strategy and conditions for development of entrepreneurship and innovative activities d) Creating conditions for regional specialisation and building competitiveness in the EU policy

The results of the hierarchy analysis are shown in Figure 7. The graph shows that the local government has the greatest impact on Vidzeme region smart specialization development - a proportion of 0.28, and the state has the same impact. The EU impact proportion is 0.25, but residents have the least impact proportion – 0.19. The impact of the local government is most affected, first, by its ability to establish collaboration with residents and entrepreneurs, second, by the employees' competence in managerial decision-making and implementing for municipality development, third, by its ability to efficiently use resources, fourth, by the ability to attract the EU structural funds and successfully use them.

The state impact is most affected, first, by maintaining a stable and sustainable economic situation in the country, second, by provision of availability of the EU funding for the promotion of smart specialisation in the regions, third, by a successful implementation of financial equalisation and tax policy, fourth, by the state involvement in implementing innovative entrepreneurship.

The EU impact is most affected, first, by creating conditions for regional specialisation and building competitiveness in the EU policy, second, by the EU strategy and the conditions for development of entrepreneurship and innovative activities, third, by the impact of cohesion policy and the orientation towards reducing the EU regional disparities, fourth, by the promotion of innovative processes in collaboration with the EU member states and regions.

The impact of the population is most affected, first, by the activities of particular groups of residents in acquisition and dissemination of ideas of innovative changes, second, by the use of residents' disposable resources for income generation, third, by residents' entrepreneurial ability and capacity, fourth, by the involvement of residents in formal and non-formal education.

Thus, in the choice of smart specialization the smart governance direction prevails with the proportion of 0.28. Next is the smart population direction with a slightly smaller proportion of 0.26. The third is smart economy direction with the proportion of 0.26, while the fourth is the smart environment direction with the proportion of 0.22. Among the first three directions the difference is only 0.02, but the difference between the smart economy and smart environment direction is 0.04.

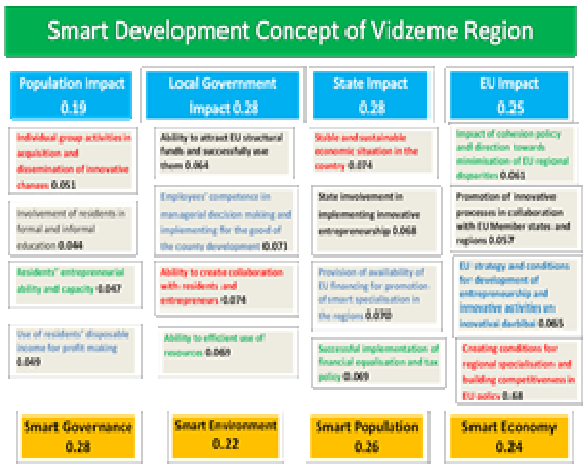

Fig 7. Smart development concept of Vidzeme region

IV. CONCLUSION

Evaluating the published strategic and operational planning documents of Vidzeme municipalities, it can be concluded that sustainability is usually referred to as a goal in itself, a result of a certain process, although it should be mostly regarded as an evaluation mechanism for a variety of other real-life processes, and a set of tools that can determine

whether a particular region has the smart, sustainable development prospects and to what extent.

In order to measure the impact of the population, the local government, the state and the EU policy on the smart development of Vidzeme region, the Analytic Hierarchy Process (AHP) method can be used.

The residents have indicated that in the state dimension the following indicators operate the most successfully: ensuring the availability of the EU funding, the maintenance of the legislative stability in the country. On the contrary, the least successful are: the successful operation of the financial equalization fund, earmarked subsidy offers, the development of a tax system that promotes the economic activity.

In the state dimension, the experts have recognized the following tools as significant: a stable and sustainable economic situation in the country and the provision of the availability of the EU funding for the promotion of smart specialisation in the regions.

The residents have pointed out that in the local government dimension the following indicators operate the best: the skills of a municipality or town local government to attract EU structural funds and use them successfully. In contrast, the least successful operation in the local government dimension is assigned to the ability of the local government to create favourable conditions for the activities of NGOs and other groups of society, actively involving them in the discussion and implementation of important development issues, the ability of a local government to maintain close working contacts with local businesses.

In the local government dimension, the experts have recognized the following tools as significant: the ability to establish collaboration with residents and entrepreneurs, and employees' competence in managerial decision making and implementing for the good of the municipality development, which have been evaluated by the residents as the least successfully applied instruments.

The residents have indicated that in the community dimension, the most successful operation is assigned to the interest of local residents to take part in solving practical issues of a municipality/ town by active participation, the readiness of municipality/ town residents for economic activities in order to increase personal income, activities of particular groups of residents in acquisition and dissemination of ideas of innovative changes. On the contrary, the operation is evaluated as the least successful in the following areas: the ability of municipality/ town residents to cooperate through the economic cooperation chains or even cooperatives, the readiness to accept change in work, society, environment.

In the population dimension, the experts have recognized the following tools as significant: activities of particular groups of residents in acquisition and dissemination of ideas of innovative changes, and residents' entrepreneurial ability and capacity.

In the EU dimension, the experts have acknowledged the most influential tools to be creating conditions for regional specialisation and building competitiveness in the EU policy.

The AHP hierarchy analysis shows that the local government and the state has the greatest impact on Vidzeme region smart specialization development, which is most influenced by the ability of the local government to establish collaboration with residents and entrepreneurs, and maintaining of a stable and sustainable economic situation in the country.

A significant influencing force is the EU with its most important instruments – its policy that creates conditions for region's specialization and competitiveness, and the strategy and conditions for business development and innovation.

According to the evaluation of experts, the choice of Vidzeme smart specialization is related to the smart governance direction.

V.ACKNOWLEDGMENTS

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REFERENCES

[1] Eiropean Commission, EIROPA 2020 EU's growth strategy Available: http://ec.europa.eu/europe2020/index_en.htm
[2] Reģionālās attīstības likums, LR Saeima 2002), Pieejams: https://likumi.lv/doc.php?id=61002
[3] Teritorijas attīstības plānošanas likums, LR Saeima 2011, Available: https://likumi.lv/doc.php?id=238807
[4] Attīstības plānošanas sistēmas likums, LR Saeima 2008, Available: https://likumi.lv/doc.php?id=175748
[5] Vides aizsardzības likums, LR Saeima, 2006, Available: https://likumi.lv/doc.php?id=147917
[6] Likums "Par pašvaldībām", LR Saeima, 1994, Available: https://likumi.lv/doc.php?id=57255
[7] Steurer, R., & Hametner, M. Objectives and indicators in sustainable development strategies: similarities and variances across Europe. // Sustainable Development, 21(4). 2013, pp. 224-241.
[8] EK European Innovation Scoreboard 2016, Available: http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_en
[9] Wheeler, S. M., & Beatley. T. Sustainable Urban Development Reader. , Routledge. Park, 2014.
[10] Shen, L.Y., Ochoa, J.J., Shah, M.N. and Zhang, X. The application of urban sustainability indicators–A comparison between various practices. Habitat International, 35(1). 2011, pp.17-29.
[11] Engardio P., Capell K. Beyond The Green Corporation. Business week, 50. 2007, pp.1 – 6 .
[12] Saaty T.A., Penivati K. Group Decission Making Draving out and Reconciling Differences. United States of America. 2013.

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Inventory of the Most Invasive Alien Plant Species of Latvia in the "Daugavas loki" Nature Park

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Abstract. During the realization of the scientific research program for mapping of the most invasive plant species of Latvia in the "Daugavas Loki" nature park (NP) field surveys were carried out during spring, summer and autumn seasons in 2016. In total 100 quadrats were surveyed. Invasive alien plants are species that are non-native to an ecosystem, and may cause a negative effect on environmental quality or human health. The obtained results indicate that the number of invasive alien plants species identified in 2016, i.e. 32 species, considerably increased in comparison with data about the distribution of invasive species given in the nature management plan of the "Daugavas Loki" NP in 2010, when only three species were mentioned. Many invasive plant species have been found in the ruderal biotopes – roadsides in the territory of nature park. The species with the highest number of localities are Acer negundo L., Sambucus racemosa L. and Rumex confertus Willd. The monitoring of certain most invasive species makes it possible to assess the changes in species number and occupied area.

Keywords: invasive alien plant species, "Daugavas loki" nature park.

I. INTRODUCTION

Alien species are species, which have been introduced to areas outside of their natural range because of direct or indirect human activities [1] - [3].

Neophytes are non-native species introduced in Europe after 1492 [4] and their distribution indicates of human transformed environment. Invasive are considered those neophytes which spreads rapidly in new areas, usually causing significant damage to biodiversity, ecosystem functioning, socio-economic values and/or human health [3]. However, not all neophytes are regarded invasive [5].

Invasive alien species are considered one of the essential component of global climate change [3], [6], leading to habitat homogenization, changes in ecosystem services and contributing to the extinction of certain species [7], [8].

The spread of invasive species depends on the type of habitat [9] and its disturbance regimes. The greater proportion of invasive species is found in heavily disturbed habitats [10]. Invasive species have specific spread patterns: have no natural enemies; is able to occupy a vacant niche and are not affected by local biotic factors in their new habitat [11].

The flora list of Latvia contained 1937 plant species: 1304 were of local origin, 633 were alien species [12]. According to NOBANIS (2014) data, 36 plant species are considered invasive, 12 are potentially invasive and 176 are not considered invasive in Latvia. The information about 192 species has not been established [13]. The main pathways for alien species introduction in Latvia are Baltic Sea coast and river valleys (particularly the Daugava River valley), anthropogenic pathways - roads, railways and seaports [2].

Latvia is bound to implement the Convention on Biological Diversity (1992) and participate in an international project NOBANIS (Nordic-Baltic Network on Invasive Species), the aim of which is to create an electronic database of alien species.

Several studies shown the increase in the number of invasive species in protected areas [14].The spread of alien plants into protected areas is strongly influenced by the presence of trails or roads [15], [16] and by the number of visitors [17], [18].

"The impact of biological invasions can even be worse in protected areas than elsewhere, because these areas preserve key elements of global biodiversity, ensuring the maintenance of essential services for the livelihood of many communities" [8], [19].

In Europe, most protected areas have been influenced by human, including the introduction of alien species and close location to landscapes with little limitations for alien species introduction. Plant invasion in protected areas are significantly related with human activity, density, and native species richness [19], [20]. Protected areas are significant for biodiversity conservation therefore special attention

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should be devoted to the investigation of invasive alien species in these territories.

Study area

The "Daugavas Loki" nature park (NP) is located in the southeastern part of Latvia in the valley of the Daugava River. Park has been established in 1990 to preserve the unique landscape, biological diversity as well as cultural and historical monuments in the valley of the Daugava River. The territory covers an area of 12562 hectares: forest cover 57.3%, agricultural lands - 36.31%, water bodies - 6.28%, quarries - 0.11% [21].

In total 1016 vascular plant species listed in the Daugava River valley in the period 1976 - 1983 including 76 adventive species and 68 species, which naturalize [22]. The information contained in the nature management plan (2010) shows that more than 800 vascular plant species (50 specially protected plant species) are recognize in these territory.

The distribution of some invasive species as *Acer negundo* L., *Solidago Canadensis* L. s.l., *Echinocystis lobata* (Michx.) Torr. Et A. Gray etc. is the significant problem in Daugava floodplains [21].

K. Kupffer was one of the first who emphasized the importance of Daugava in species distribution [23] and it is shown that the Daugava River valley function as corridor for invasive plant species distribution [24], [25], [26]. The depopulation process is observed in the territory of NP in the recent years – only 8599 inhabitants in 2016) [27]. It should be noted that the population and the economic activity are factors affecting the distribution of invasive species [28]. There are also varieties of roads that may contribute to the spread of invasive species.

II. MATERIALS AND METHODS

Fifteen most invasive plant species were inventoried in the "Daugavas loki" NP (Table 1) and *Heracleum sosnowskyi* Manden. - only one species defined as invasive species in Latvia: Regulations of the Cabinet of Ministers No. 468 "List of Invasive Alien Plant Species" [29]. Other invasive species were recorded during field surveys.

Field research

The distribution of invasive plant species were recorded in the territory of the "Daugavas loki" NP. Inventory of invasive species was done in 2016 (summer - autumn period).

The methodology of Institute of Life Sciences and Technology of Daugavpils University were used (The Project No.7.7/103/2105-P „The development of invasive species monitoring programme").

The territory of the "Daugavas loki" NP was divided into 386 regular grid quadrats of 500 x 500 m (25 hectares), but only 100 quadrats were selected for field studies using ArcGIS program „Random selection" tool. Each plot was assigned individual identification numbers. The inventory of invasive species was done using route method. The routes were designed so that each territory was inspected as detailed as possible and the maximum distance between two routes in one quadrate does not exceed 100 m. However, it does not provide complete survey of the territory. Special attention was paid to potential invasion territories of alien plants – roadsides, riverbanks, cemeteries, allotments, degraded territories etc. Quadrats, which geographically coincide with water reservoirs and watercourses, were not surveyed, as well as areas without public access or closed, for example, private property etc. Samples of plants were collected for herbarium.

Latvian classifier of habitats [30] was used for detection of invaded habitats. Nomenclature of vascular plant species was done according to Gavrilova and Šulcs, 1999 [12].

Application of Geographic Information Systems (GPS and GIS)

GPS was used to map the species in the territory of the "Daugavas loki" NP. Field data, obtained with GPS, were converted into a point **.shp* file. Further data processing took place in ESRI ArcGIS Geographic Information System software ArcView 10.0. Results were sorted in attribute table in the following order: Species common name, Latin name and biotope. Maps were created using ArcGis program, ArcMap.

Orto-photo maps in 1:10 000 scale, made according to data of areophotographying, done in 2014 by Latvian Geospatial Information Agency were used as the base for vectorization: no. 3422-15, 2443-44, 2443-45, 2443-54, 2443-55, 2444-41, 2444-42, 2444-43, 2444-44, 2444-45, 2444-51, 2444-52, 2444-53, 2444-54, 2444- 55, 3421-14, 3421-15, 3422-11, 3422-12, 3422-13, 3422-14.

III. RESULTS

Thirty-two invasive alien species in 1224 localities were recorded during the study (Table 1).

Heracleum sosnowskyi Manden.

H. sosnowskyi it is considered one of the most invasive plant species in Europe [31] by the impact on ecosystems [32], [33] and human health [32] - [35].

H. sosnowskyi is biennial or perennial plant, height is usually 1-3 m, plant seed germination remains for a long time and a single plant can develop more than 3-15 thousand seeds. Ripe seeds easily segregate from plant [32], which contributes to the ease of movement, for example, seeds stick to tires and spread far from the place of origin. Wind and watercourses also play an important role in seed dispersal [31].

H. sosnowskyi originates in the central and eastern Caucasus [31] and was first introduced for agricultural purposes into Latvia in 1965 in Madona district, Barkava parish. The first field was sown in 1965 [36].

The species is naturalized in the European part of Russia, in Baltic States, Belorussia, Ukraine and Poland [31], [35]. One of the main negative impacts of *H. sosnowkyi* is on native plant communities. The plant forms dense monodominant stands and thus contribute the disappearance of ground-level vegetation species [32], [33]. Therefore, the spread of *H. sosnowskyi* in protected area may lead to extinction of protected species.

According to the nature management plan of the "Daugavas loki" NP (2010 – 2022), *H. sosnowskyi* was almost not found in this territory, however, species was found in 15 localities during studies in summer 2016 (Table 1). Large *H. sosnowskyi* stands were not detected – only one plant/ specimen or small stands were found in 13 localities. Published study results [31], [32], [35] indicate, that this plant is able to spread very rapidly - several tens of kilometers away from the existing plantations. Based on the results obtained during this study, it can be concluded that the species introduction and invasion process started relatively recently in the territory of NP. However, taking into account the fact that all 15 localities were fixed in five quadrats, distribution of *H. sosnowskyi* in the territory of NP is unequal and plant specimens spread close to initial invasion sites. *H. sosnowskyi* spread analysis in habitat aspect, represent that the most invaded habitats are moderately moist meadows (six localities from 15) and roadsides (five localities).

The fact, that *H. sosnowskyi* successfully spread across roadsides, also are most often mentioned in the scientific literature [31], [32], [37]. Two localities were found in shrubland, one in dry meadow and one in the weedy place. During the study and contrary to other authors [31] localities were not found along the watercourses.

Table I
Invasive alien plant species detected in the "Daugavas loki" nature park.

No.	Latin name	Number of localities	Number of invaded quadrats	No.	Latin name	Number of localities	Number of invaded quadrats
Invasive plant species (in accordance with Regulation No. 468: List of Invasive Alien Plant Species)				17.	Other recorded invasive alien / potentially invasive plant species		
1.	*Heracleum sosnowskyi* Manden.	15	6	18.	*Aronia prunifolia* (Marshall) Rehder.	4	3
Monitoring of the priority plant species (in accordance with the contract No.7.7/103/2105-P data)				19.	*Bunias orientalis* L.	17	7
2.	*Acer negundo* L.	296	52	20.	*Caragana arborescens* Lam.	17	3
3.	*Amelanchier spicata* (Lam.) K. Koch	55	15	21.	*Caragana frutex* (L.)C. Koch	1	1
4.	*Aster x salignus* Willd.	5	3	22.	*Helianthus tuberosus* L.	12	4
5.	*Cotoneaster lucidus* Schltdl.	3	3	23.	*Hippophae rhamnoides* L.	1	1
6.	*Echinocystis lobata* (Michx.) Torr. Et A. Gray	31	8	24.	*Malus domestica* Borkh.	84	35
7.	*Impatiens glandulifera* Royle.	26	10	25.	*Parthenocissus quinquefolia* (L.) Planch.	8	4
8.	*Impatiens parviflora* DC.	79	17	26.	*Petasites hybridus* L.	6	2
9.	*Lupinus polyphyllus* Lindl.	53	17	27.	*Populus alba* L.	7	6
10.	*Reynoutria japonica* Houtt.	1	1	28.	*Populus balsamifera* L.	5	3
11.	*Reynoutria sachalinensis* (F. Schmidt) Nakai	4	1	29.	*Rumex confertus* Willd.	167	50
12.	*Rosa rugosa* Thunb.	2	2	30.	*Sambucus nigra* L.	19	5
13.	*Sambucus racemosa* L.	186	45	31.	*Spiraea chamaedrifolia* L.	1	1
14.	*Solidago canadensis* L. s.l.	74	23	32.	*Spiraea x billardii* Herincq	3	1
15.	*Solidago gigantea* Ait.	0	0	33.	*Symphoricarpos albus* (L.) S.F. Blake	1	1
16.	*Sorbaria sorbifolia* (L.) A. Braun	3	2	34.	*Syringa vulgaris* L.	36	15

Species with priority monitoring status

A. negundo is considered as one of the most invasive plant species in Latvia and the highest number of localities (296) was discovered during field research.

A. negundo is a medium-size tree (about 15 m in height) with sparse crown from the family Aceraceae. It was introduced into Europe as an ornamental plant and it is considered invasive in Austria, Czech Republic, European part of Russia, Lithuania and Poland [38]. As invasive weed, plant widely spread in degraded habitats and riverbanks in many European countries [38], [39].

The distribution of *A. negundo* in the territory of NP was observed in different biotopes - forests (23% of localities, including mixed-wood forests, coniferous forests and black alder stands), meadows (18%), shrublands (11.5%) and banks of the Daugava River (8%). Some stands also in quarries, weedy places, below power lines etc. However, this species was observed most often in roadsides (25%). The proportion of localities in the Daugava riverbanks and roadsides shows that wind is an important factor contributing the distribution of *A. negundo* in the "Daugavas loki" NP and this fact also has been found by other European researchers [26], [38], [40], [41].

However, these results are only partially consistent with the results by Mędrzycki, 2011, where rivers have been mentioned as an important pathway for the introduction of *A. negundo* in several countries. Sikorski and Sikorska, 2016 noted that species reaches a significant level of invasion in riverbanks. The Daugava River is an important factor for plant seed distribution in the territory of NP. It is indicated by stands, located parallel to the river coastline coinciding with the maximum flood level in the river. Stands are large but not dominant, however, *A. negundo* permanent vegetative regrowth can lead to dominance in the flood-plain forests during a period of time [42].

Sambucus racemosa L. is the second most common invasive plant found in the "Daugavas loki" NP in 185 localities in 45 quadrats.

S. racemosa is a tall (up to 5 meters) deciduous shrub or small tree from the family Adoxaceae [43]. It was found in the western part of Latvia in the end of 18 century (in 1899) [44], but in the eastern part in 1895 [45]. It was introduced as ornamental plant and it was also used for medicine purposes [46]. The fruits are a bright red and looks especially decorative [43].

Species distributions in different habitats show that plant have broad ecological plasticity and the ability to adapt to various growing conditions [47]. *S. racemosa* was found in meadows, abandoned buildings, weedy places, under power line rotes, in clearcuttings etc.

Although studies shows that *S. racemosa* is not common in forest communities because it is only moderately shade tolerant [48], it was most often found directly in forest and underbrush areas in the territory of NP (49% of all localities). This once again only proves the invasive features of alien plant species. Roads and roadsides are the second most invaded habitats (38%) and again, describe it as typical invasive plant species, specific to disturbed biotopes [2], [43]. However, according to the authors, the frequent species occurrence in study area is relatively less associated with human activity – birds and animals distribute plant [43], and *S. racemosa* is evenly spread throughout the territory.

Other identified invasive alien / potentially invasive plant species

Rumex confertus Willd is a large (60-150 cm), perennial plant from the Polygonaceae family, which produce a large amount of reproductive seeds [49].

It is an invasive plant in Latvia and its natural range occur south-eastern Europe and western Asia [50]. Plant become established outside it original range due to grain transport (grass seed material from Russia), as well as imported accidentally with the development of transport [2]. It is possible that transportation of soldiers and military equipment (in 1920) contributed to the movement of plant seeds to Latvia. The most rapid spread of *R. confertus* observed in the middle of the 20th century [50], [51]. Plant spreading was recorded in East Asia, around Vladivostok, North Russia, Baltic region, Poland, East Slovakia, the Czech Republic, Austria, Germany, Finland, Norway, Sweden and the United Kingdom [52].

The largest number of localities (167) was found in the territory of "Daugavas loki" NP (Table 1). This species is common throughout the Latvia [51] and was uniformly found in the territory of NP in 50 quadrats.

The research data shows that the distribution of *R. confertus* has little relation with forest areas. It prefers open and sunny places, often forming sparse stands. Such distribution of localities could be explained by the fact that, natural seed dispersal occurs by wind [49], therefore, it requires areas with unrestricted wind flow. It is also approved by the fact that the largest share of *R. confertus* localities in the territory of the "Daugavas loki" NP were found along roadsides - 47%, where vehicles creates specific effects of the wind in addition to the natural wind flow.

R. confertus is widely adapted to grow in different moisture conditions – dry meadows, ponds and riverbanks. However, the places more vulnerable to invasion are habitats with sufficient moisture content - moderately moist meadows (27% of localities), moist meadows (16%), shrublands (2%) and ditch edges (1%). These results are also consistent with results from other research studies [2], [26].

Based on the results of other studies [50], [52], distribution of *R. confertus* may cause the essential negative impact on natural territories and protected species, especially in meadows. Native species often get squeezed out and hay quality may deteriorate significantly. In addition, the study results show that in 14% of localities *R. confertus* are dominant and may form monostands.

Biotopes

By analysing the distribution of species and habitat types in the territory of the "Daugavas loki" NP, data shows that invasive plants most frequently occur in ruderal biotopes, mainly along roads (found 39% of all localities. Roads function as corridors for invasive plant species and can contribute the spread of these species inside protected areas [53], [54]. The largest proportion of some invasive plants was found directly along roads. For example, *R. confertus* and *Syringa vulgaris* L. (47%), *Lupinus polyphyllus* Lindl. (68%), *Malus domestica* Borkh. (43%), *A. negundo* (35%) and *Impatiens glandulifera* Royle. (65%).

Great proportion of localities were found also in forests and shurblands (28% of the total number), but meadows, mainly moderately moist, represents about 25% of inventoried localities. Although forests are considered to be relatively stable ecosystems

however, rapid increase of number of invasive species is observed in forests of Lithuania [55]. *S. racemosa* (41%) and *Amelanchier spicata* (Lam.) K. Koch (45%) were the most commonly reported plants in forest in the territory of the NP. *A. spicata* regarded as one of alien naturalized woody species, widely distributed in the forests of Lithuania [56]. *S. racemosa* is common in many forest communities and it occurs in scattered patches or as individuals [43].

Species most often found in moderately wet meadows is *S. canadensis* (48%). Usually this species found growing in damp meadows, waterways, and in roadsides along ditches [57].

Such biotopes as fields and gardens, banks of artificial water bodies and regulated watercourse, parks and greeneries each accounted for only one percent of the total number of localities.

IV. CONCLUSIONS

Only *H. sosnowskyi* is officially recognized as an invasive plant in Latvia. According to nature management plan of the "Daugavas loki" NP, *H. sosnowskyi* was almost not found in this territory in 2010, however, 15 localities were found during research in summer 2016, confirming plant invasive nature.

A. negundo and *S. racemosa* are considered as most invasive plant species in Latvian and they were found in the largest number of localities.

A. negundo was observed in different biotopes, but most often in roadsides and in the Daugava riverbanks, approving the role of wind and watercourses in the distribution of plant seeds.

In addition, the distribution of *S. racemosa* is related with different habitats and confirms plant adaptation ability to various growing conditions. As *S. racemosa* grows mostly as one specimen, it would be easier to manage this plant, compared with plants producing root sprouts and making stands.

R. confertus was most often found from the list of other identified invasive plant species. The distribution of *R. confertus* has little connection with forest areas and plant prefers open and sunny places. *R. confertus* is widely adapted to different soil moisture conditions – dry meadows, ponds and riverbanks.

The survey results show significant changes in the number of invasive species in the territory of NP. Only three invasive plants were mentioned in the nature management plan of the "Daugavas Loki" NP in 2010 and 32 invasive plant species were identified in 2016.

This fact demonstrates ecological flexibility of invasive plant species, their ability to propagate rapidly and to spread in new areas, hence exposing threats for local and protected plant species. The additional risk factor is overgrowing of meadows and pastures in the NP. In such places the changes of existing plant communities occur, thereby developing favourable conditions for invasion by alien species.

Data obtained by implementation of research program of invasive species can help to manage invasive species in the early stages of invasion.

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REFERENCES

[1] P. Pyšek, D. M. Richardson, M. Rejmánek, G. L. Webster, M. Williamson, J. Kirschner, „Alien plants in checklists and floras: towards better communication between taxonomists and ecologists", Taxon, vol. 53, no. 1, pp. 131-143, 2004b.

[2] A. Priede, „Invazīvie neofīti Latvijas florā: izplatība un dinamika". Promocijas darbs. Rīga, LU, 2009, 125 lpp.

[3] P. E. Hulme, P. Pyšek, V. Jarošík, J. Pergl, U. Schaffner, M. Vilà, „Bias and error in understanding plant invasion impacts," Trends in Ecology and Evolution, vol. 28, no. 4, pp. 212-218, 2013.

[4] P. Pyšek, Z. Chocholoušková, A. Pyšek, V. Jarošík, M. Chytrý, L. Tichý, „Trends in species diversity and composition of urban vegetation over three decades," Journal of Vegetation Science, , vol. 15, pp. 781-788, 2004a.

[5] P. Pyšek, On the terminology used in plant invasion studies. In: P. Pyšek, K. Prach, M. Rejmánek, M. Wade (eds.). Plant invasions - General aspects and special problems. Amsterdam: Academic Pulblishing, 1995, pp. 71-81.

[6] F. Essl, D. Moser, T. Dirnböck, S. Dullinger, N. Milasowszk,y, M. Winter, W. Rabitsch, „Native, alien, endemic, threatened, and extinct species diversity in European countries," Biological Conservation, vol. 164, pp. 90-97, 2013.

[7] M. A. Schlaepfer, D. F. Sax, J. D. Olden, „The potential conservation value of nonnative species," Conservation Biology, vol. 25, 428-437, 2011.

[8] A. Monaco and P. Genovesi, European guidelines on protected areas and invasive alien species, 2014. Available: https://portals.iucn.org/library/sites/library/files/documents/2014-070.pdf [Accessed: Feb. 13, 2017].

[9] M. Chytry, L. C. Maskell, J. Pino, P. Pyšek, M. Vilà, X. Font, S. M. Smart, „Habitat invasions by alien plants: A quantitative comparison among Mediterranean:Subcontinental and oceanic regions of Europe," Journal of Applied Ecology, vol. 45, pp. 448–458, 2008.

[10] P. Pyšek, M. Chytry, J. Pergl, J. Sádlo and J. Wild, „Plant invasions in the Czech Republic: Current state, introduction dynamics: Invasive species andinvaded habitats," Preslia, vol. 84, pp. 575–629, 2012.

[11] L. Souza, W. A. Bunn, D. Simberloff, R. M. Lawton, N. J. Sanders, „Biotic and abiotic influences on native and exotic richness relationship across spatial scales: favourable environments for native species are highly invasible," Functional Ecology, vol. 25, no. 5, pp. 1106-1112, 2011.

[12] Ģ. Gavrilova and V. Šulcs, Latvijas vaskulāro augu flora. Taksonu saraksts. Rīga: Latvijas Akadēmiskā bibliotēka, 1999, 136 lpp.

[13] NOBANIS (The European Network on Invasive Alien Species). Available: http://www.nobanis.org. [Accessed: Feb. 2, 2017].

[14] P. E. Hulme, P. Pyšek, J. Pergl, V. Jarošík, U. Schaffner and M. Vilà, „Greater focus needed on alien plant impacts in protected areas," Conservation Lettters, vol. 7, pp. 459–466, 2014.

[15] R. Otto, M. A. Arteaga, J. D. Delgado, J. R. Arévalo, C. H. Blandino and J. M. Fernández-Palacios, „Road edge effect and elevation patterns of native and alien plants on an oceanic

island (Tenerife, Canary Islands)," Folia Geobotanica, vol. 49, pp. 65–82, 2014.
[16] J. R. Arévalo, R. Otto, C. Escudero, S. Fernández-Lugo, M. Arteaga, J. D. Delgado, J. M. Fernández-Palacios, „Do anthropogenic corridors homogenize plant communities at a local scale? A case studied in Tenerife (Canary Islands)," Plant Ecology, vol. 209, pp. 23-35, 2010.
[17] J. A. Allen, C. S. Brown and T. J. Stohlgren, "Non-native plant invasions of United States national parks," Biological Invasions, vol. 11, pp. 2195–2207, 2009.
[18] C. Pickering and A. Mount, "Do tourists disperse weed seed? A global review of unintentional human-mediated terrestrial seed dispersal on clothing, vehicles and horses," Journal of Sustainable Tourism, vol. 18, pp. 239–256, 2010.
[19] L. C. Foxcroft, P. Pyšek, D. M. Richardson, P. Genovesi, Plant invasions in protected areas: patterns problems and challenges, 2013, 661 pp.
[20] P. Pyšek, P. Genovesi, J. Pergl, A. Monaco, J. Wild, Plant invasions of protected areas in Europe: an old continent facing new problems. In L. C. Foxcroft et al. (eds.), Plant invasions in protected areas: patterns problems and challenges, 2013, pp. 209–240. http://dx.doi.org/10.1007/978-94-007-7750-7 .
[21] Dabas parka "Daugavas loki" dabas aizsardzības plāns, 2010. Available:https://www.daba.gov.lv/upload/File/DAPi_apstipr in/DP_Daugavas_loki-10.pdf [Accessed: Feb. 15, 2017].
[22] И. Фатаре, Флора долины реки Даугавы. Рига, Зинатне, 1989, 168 стр.
[23] K. Kupffer, Grundzüge der Pflanzengeographie des ostbaltischen Gebietes. Rīga: Abhandlungen des Herder-Instituts, vol. 1, no. 6, pp. 1-224, 1925.
[24] I. Fatare, Daugavas ielejas flora. Rīga: Zinātne, 1987, 80 lpp.
[25] M. Laiviņš, Robežsugu horoloģiskā analīze un veģetācijas migrācija. Latvijā. Grām.: Latvijas veģetācija, 18. Rīga: Latvijas Universitātes Bioloģijas institūts, 2009, 89.-105. lpp
[26] S. Rutkovska, I. Pučka, I. Novicka, P. Evarts-Bunders, „Relationship of geographic distribution of the most characteristical invasive plant species in habitats adjacent to the river Daugava within the territory of Daugavpils city," Acta Biologica Universitatis Daugavpiliensis, vol. 11, no. 2, pp. 163-175, 2011.
[27] Central Statistical Bureau of Latvia, „Resident population by sex in cities under state jurisdiction, counties, towns and parishes at the beginning of the year", 2016. Available: http://data.csb.gov.lv/pxweb/en/Sociala/Sociala__ikgad__iedz__iedzskaits/IS0042.px/?rxid=cd [Accessed: Feb. 20, 2017].
[28] R. Meffin, R. P. Duncan, P. E. Hulme, „Landscape-level persistence and distribution of alien feral crops linked to seed transport," Agriculture, cosystems and Environment, vol. 203, pp. 119-126, 2015.
[29] Regulations of the Cabinet of Ministers No. 468 "List of Invasive Alien Plant Species" (Invazīvo augu sugu saraksts) ("LV", 100 (3884), 02.07.2008.) [stājas spēkā 03.07.2008.]
[30] I. Kabucis, Latvijas Biotopi. Klasifikators. Rīga: Latvijas Dabas Fonds, 2001, 96 lpp.
[31] N. Kabuce and N. Priede, NOBANIS – Invasive Alien Species Fact Sheet – Heracleum sosnowskyi. – From: Online Database of the European Network on Invasive Alien Species – NOBANIS www.nobanis.org, 2010. [Accessed: Feb. 19,2017].
[32] C. Nielsen, H. P. Ravn, W. Nentwig and M. Wade (eds.). The Giant Hogweed Best Practice Manual. Guidelines for the management and control of an invasive weed in Europe. - Forest and Landscape Denmark, Hoersholm, 2005, 44 pp.
[33] A. Feher, Biological invasions of plants in Slovakia, Environment and Sustainable development, Rīga, University of Latvia, 2010, pp. 164-165.
[34] O. Jakubowicz, C. Żaba, G. Nowak, S. Jarmuda, R. Żaba, J. T. Marcinkowski, „*Heracleum sosnowskyi* Manden," Annals of Agricultural and Environmental Medicine, vol. 16, no. 2, pp. 327–328, 2012.
[35] P. Rzymski, P. Klimaszyk, B. Poniedziałek, „Invasive giant hogweeds in Poland: Risk of burns among forestry workers and plant distribution," BURNS, vol. 41, pp. 1816-1822, 2015.
[36] A. Bērziņš, A. Oļukalns, D. Lapiņš, A. Lejiņš, A. Sprincina, Ģ. Gavrilova, V. Liguts, "Latvānis (Heracleum) un tā izplatība Latvijā", Agronomijas Vēstis, vol. 5, pp. 86-93, 2003.
[37] M. Laiviņš and Ģ. Gavrilova, "Heracleum sosnowskyi in Latvia: sociology, ecology and distribution", Latvijas veģetācija, 7, Rīga, LU, 2004, 45. - 65. lpp.
[38] P. Mędrzycki, NOBANIS – Invasive Alien Species Fact Sheet – Acer negundo. – From: Online Database of the European Network on Invasive Alien Species – NOBANIS www.nobanis.org, 2011. [Accessed: Feb. 21, 2017].
[39] P. Sikorski and D. Sikorska, „The role of habitat factors in successful invasion of alien plant Acer negundo in riparian zones", EGU Gerneral Assembly, vol. 18, 2016. Available: http://meetingorganizer.copernicus.org/EGU2016/EGU2016-16056.pdf [Accessed: Feb. 16, 2017].
[40] L. Udvardy, Boxelder (*Acer negundo*). In The most important invasive plants in Hungary (Eds. Botta-Dukát, Z. & Balogh, L.). Institute of Ecology and Botany, Hungarian Academy of Sciences, Vácrátót, Hungary, 2008, pp. 115–120.
[41] V. Batanjski, B. Bokić, V. H. Širka, M. Radanović, EPPO Prioritisation Process for Acer negundo L. for North Part of Serbia (Vojvodina), EPPO Training, Belgrade 8.-11. July, 2013. Available: http://www.izbis.com/pdf-2013/priorizacija-na-izabrane-vrste/Acer%20negundo%20L.%20SERBIA.pdf [Accessed: Feb. 27, 2017].
[42] P. Künstler, "The role of *Acer negundo* L. in the structure of floodplain forests in the middle course of the Vistula river," Proceedings of the 5th International Conference on the Ecology of the Invasive Alien Plants, October 13–16, 1999, La Maddalena, Sardinia, Italy.
[43] J. L. Fryer, „*Sambucus racemosa*. In: Fire Effects Information System", 2008 [Online]. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Fire Sciences Laboratory (Producer). Available: https://www.feis-crs.org/feis/ [Accessed: Feb. 4, 2017].
[44] K. Kupffer. Beitrag zur Kenntnis der Gefasspflanzenflora Kurlands. Korr. Bl. d. Naturforscher-Vereins zu Riga, 42, 1899: pp. 100–140.
[45] E. Lehmann, Flora von Polnisch – Livland der Florengebiete Nordwestrusslands, des Ostbalticums, der Gouvernements Pskow und St. Petersburg. Jurjew: Dorpat, 1895, 430 p.
[46] Y. G. Tutin, V. H. Heywood, N. A. Burges, D. M. Moore, D. H. Valentine, S. M. Walters, D. A. Webb, Flora Europaea. Vol. 4. Cambridge University Press, Cambridge, 1976.
[47] USDA NRCS Corvallis Plant Materials Center, 2014. Available: http://plants.usda.gov/java/ [Accessed: Feb. 28, 2017].
[48] J. Kollmann, S. A. Reiner, Light demands of shrub seedlings and their establishment within scrublands. – Flora. 1996, pp. 191-200.
[49] T. Raycheva, „*Rumex confertus* (Polygonaceae) in the Bulgarian flora," Botanica SERBICA, vol. 35, no. 1, pp. 55-59, 2011.
[50] Z. Gudžinskas, M. Kazlauskas, D. Pilāte, M. Balalaikins, M. Pilāts, A. Šaulys, I. Šauliene, L. Šukiene, Lietuvas un Latvijas pierobežas invazīvie organismi. BMK Leidykla, Vilnius, 2014, lpp. 91. – 139.
[51] A. Priede, "Invazīvo svešzemju augu sugu izplatība Latvijā". Grām.: Latvijas veģetācija, 17. Rīga: Latvijas Universitātes Bioloģijas insitūts, 2008, 148 lpp.
[52] V. Jehlík, J. Sádlo, J. Dostálek, V. Jarolímová, L. Klimeš, „Chorology and ecology of *Rumex confertus* Willd. in the Czech Republic,"Botanica Lithuanica, vol. 7, no. 3, pp. 235-244, 2001.
[53] G. Meunier and C. Lavoie, "Roads as Corridors for Invasive Plant Species: New Evidence from Smooth Bedstraw (Galium mollugo)," Invasive Plant Science and Management, vol. 5, no. 1, pp. 92-100, January-March 2012.
[54] P. A. Dar, Z. A. Reshi, M. A. Shahr, „Roads act as corridors for the spread of alien plant species in the mountainous

regions: A case study of Kashmir Valley, India," Tropical Ecology, vol. 56, no. 2, pp. 183-190, 2015.

[55] R. Dobravolskaitė, „Development and Age of *Amelanchier spicata* shrubs," Acta Biol.Univ. Daugavp., Suppl., vol. 2, pp. 145 – 152, 2010.

[56] Z. Gudžinskas, Lietuvos flora. Lietuva, Vilnius, vol. 1, pp. 96–103, 2008.

[57] P. L. S. Pavek, Plant guide for Canada goldenrod (*Solidago canadensis*). USDA-Natural Resources Conservation Service. Pullman, WA, 2011.

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Context of Trade Canal and Industrial Heritage in Liepaja

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Abstract. Today, the historic Trade Canal in Liepāja begins to rapidly recover the character of an outdoor public space of an aesthetically high quality. After the two devastating world wars, the industrial heritage has only remained along the left bank of the canal, requiring a very gentle treatment of the cultural and historical values. The new industrial building that has occupied both banks of the canal from the 60s-70s of the 20th century strongly contrast with the historic building scale, materials, and the application of the architecturally compositional elements. The modern construction technologies can build powerful allegoric comparisons in the language of the architectural form building. This applies both to the wide glazing of the building facade, the curved facade shapes, the structure of the covering material, the green areas, etc.. The revival of the left bank of the canal is a good challenge to also recover the historic urban space on the right bank of the canal or at the side of Jaunliepāja. Currently, this waterfront of the canal, which is untouched by the war, consists of a circumferentially dense production area.

Keywords: urban structure, language of the form creation, urban scale and space, industrial heritage.

I. INTRODUCTION

On the canvas of the urban constructed space in Liepāja, the Trade Canal plays an essential role. Around the second half of the 19th century, the creation of an intensive production area was commenced. The building character of the northern side of the canal is readable in 1871 in the design drawn by P. M. Bertschy (Krastiņš, 2015). The area was also surrounded by a railway line located between the canal and the area of the cemetery on the right bank of the canal and on the left bank of the warehouse building. The railway and the sea route were the only ones which in the second half of the 19th century provided the import of raw materials and export of the finished products. The author of several buildings of the industrial and residential building in Jaunliepāja is Bertschy himself and in many places, the buildings are built from the red brick.

The factory was one of the most vibrant visual indicators of the urban economic development and prosperity indicators of the first half of the 19th and the 20th centuries. Today, the historic factories where the production is stopped, as well as their equipment and products serve as an evidence that may help to understand the life and culture of the past. In the early 21st century, the industrial heritage in many parts of Europe has become a recognized and protected part of the cultural heritage.

Industrial facilities of a high architectural quality, located in city centers in Europe, are mostly converted into public facilities. It is important not only to transform and regenerate but also to save the material evidence of the city's economic and cultural growth in the form of industrial facilities. (figure 3). The provision of this aim will depend not only on the economic development in the early 21st century, but also of the city's political and economic power and the desire to recognize and appreciate the city's most important historical phases of growth (Antenišķe, 2002).

The preservation of the industrial landscape space in many European countries is already dealt with in the framework of urban planning and in designing special programs for the heritage protection. For instance, already in 1976 in Norcheping the decision of the City Council included to:

- Maintain the characteristic features of the industrial landscape;
- Open areas with public access and build sidewalks, public places, and public buildings within the boundaries of these zones;
- Maintain the water flow and increase open water sites;
- Build a zone in an attractive and significant part of the city.

Norcheping is described by a situation where the factories and plants on the banks of the Strommen river together with the waterfalls, dams, and reflections in the water have created a unique urban environment, which is a composition comparable to the landscape space of the Trade Canal in Liepaja

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where the industrial coloring stands out in the vibrant environment of the natural elements.

Fig. 1. Fishing boats on the left bank of the canal.
30s of the 20th century. (Museum of Liepaja)

Fig.2. Boats on the right bank of the canal.
30s of the 20th century. (Museum of Liepaja)

At the same time, the decision of 1976 provided, "... to create by the river such an industrial landscape that could become a significant component of the environment" (Bredin, 2002). The postindustrial use of the factory environment in Finland dates back to the early 90s of the 20th century. All activities take place knowing the neighborhood's history, and the industrial heritage is also apprehended, which is an essential component of the cultural heritage (Sivula,2002).

Why is the industrial heritage so important (for science, history of science)? Because it embodies, materializes the scientific advances, technological advances. Sometimes the empirical, elsewhere - the theoretical, analytical, knowledge comes into the human, nation's, society's, public, and everyday life, cities and the state history. In a sense, this heritage is a live history of science, condensed in cars, buildings, and other facilities (Stradiņš,2002). The industrial heritage is an important part of the history of the society, an element of a growing city. And nothing is over yet - the industrial development is still keeping pace together with the development of the information society. The industrial heritage is not only real estate. It also includes a tremendous progress in the development of transport, communications, connecting people, lifestyle, traditions, the lost era, and the goodwill spirit (Wennerholm,2002).

The technical monuments or the industrial heritage is telling a story not only of the level of the public material welfare, types of mutual communication but also of the human spiritual perception, emotions, feelings, ideals, and the criteria of values. Every scientific and technical discovery affects individuals and the society as a whole, its economic, social, and psychological content. The human intellect produces a myriad of novelties that change the life of the society, creating around itself a field of new power, operation, and understanding. Therefore, the industrial heritage is considered to be a unique witness of the humanity's spiritual, creative, and material history (Lastovecka, 2002).

II. MATERIALS AND METHODS

A vivid example of the above is the dense position in the areas of the historic production and Liepāja, including the port along the right side of the Trade Canal (figure 1, 2). Part of the area actively functions and in addressing the infrastructure of tourism attraction, it has to be considered. This is especially true for the public access to the building of the end of the 19th century at O. Kalpaka street where architecturally and artistically brilliant works of architect Bertschy are located. The density of the historic building of the two waterfronts of the canal is in a dramatical contrast. It is based on the devastation of the Second World War as alongside with burning down of the building on the left bank until Rožu Square free areas were created. In the postwar years, they were filled up with the scale and structure alien to the historical urban environment. Only in the last twenty years, a major reconstruction of the old levee was commenced which allowed to solve the issues of the recently created promenade zone, the new concert hall, and the high-rise residential building built in the Soviet times which held the scale in a dramatical contrast with the proportions of the historical building of the city and the language of the form creation.

Today, any planning of the urban space and development are increasingly targeted to arrange it from the economic, functional, and architectural point of view. (Brinkis,2008). It is based on the development of production processes, improving the living conditions of the population, rational use of natural resources and protection. One of the key aspects is the awareness and protection of the cultural and historical heritage, promoting the development of tourism infrastructure and creating the recreation area, allocating modern functions, reviving the abandoned areas of factories as the commerce and trade, business centers, the sports, health care, and hotel sector or the exhibition and arts complex where it is likely that the functions will be fused.

An essential role in this context is played by the modern scientific and technical progress, which

makes an avant-garde contribution to the technological processes of the design of the urban space and the construction. In the planning model of Liepāja, it is clearly readable that in creating a single system of the space development or a canvas, its detail elements are closely related to individual, small architectural, and spatial issues.

Fig.3 Exposure points of Trade canal of Liepaja (modified of authors)

The research includes several criteria that have influenced the transformation processes of the landscape space of the Trade Canal from the 70s of the 19th century up to the present day. This includes the time frame when the city planning was started by architect Paul Max Bertschy. Liepāja is a relatively new city as the city rights were granted to it in 1625 by Frederick, Duke of Courland (Krastiņš, 2015)

At the end of the 19th century, Liepāja - a non-freezing port city of the Courland governorate was already established as a powerful industrial center with a cast iron and steel foundry, oil factory, aniline color factory, steam mills, cork factory, linoleum factory, brewery, etc. (Krastiņš,2015).

It allowed solving issues of the new promenade zone, the new concert hall, and the high-rise residential building built in the Soviet times which held the scale in dramatic contrast with the proportions of the historical building of the city and the language of form creation.

The newly built railway and the historic sea route were the only ones which in the second half of the 19th century provided import of raw materials and export of finished products. The rapid boom of the city's infrastructure, the subsequent devastation of both wars, the postwar totalitarianism permanently deprived the city of architecturally excellent buildings, and the city skyline along the waterfront of the canal. Layering of the extremely complex structure of the building along the waterfront of the canal area serves as a vivid page of our history where the economic, industrial and cultural phases are readable.

The research aims to examine the context of the waterfront of the canal, the green areas, and the form creation of the architecture of the industrial heritage of the cultural landscape of the Trade Canal.

The assignment of the research is to assess the nature of the two waterfronts of the canal which consist of several sections of the waterfront of the canal areas, their different building scale, density and the spatial volume of the green structure.

Two main methodological approaches are used in the research:

- The comparative method - the study of the development of the area based on the study of the historical and the current situation, and analysis of the processes in certain periods of time.
- The complex method, by synthesizing the scenic, cultural environment, economic, and architecturally spatial aspects.

III. RESULTS AND DISCUSSIONS

Termination of production in the historical industrial buildings and the lack of regular new users or investors are the reasons why the degradation and devastation of industrial monuments or even destruction accelerate. In the areas of a developed industrial heritage, the industrial landscape is a site that symbolizes knowledge and culture (Sivula,2002).

In urban planning, separate building nodes or centers as architecturally spatial landmarks are functionally arranged with a particular architectural and artistically compositional value. The groups of settlements are not a sum of mechanical components but an architecturally and artistically synthesized quality. In the urban space perception, separate static points of sight are not so crucial as a visual image perceived in movement. The analysis of the silhouettes of the historic sites shows that the verticals always bring out the main node points of the architectural space. This is attributable to the landscape space of the industrial heritage before the flow of the Trade Canal into the sea, where the vertical accents of its left bank highlight two dominants - the wind rotor, symbolizing the beginning of the 21st century, and the nearby sea lighthouse, marking the start of the 20th century. Both have a symbolic importance in the history of Liepāja and in the context with the left bank pedestrian promenade it is playing a compositionally strong role in the perception of the landscape space of the canal. The expression of the canal is increased by the form creation of the adjacent industrial building and coloring, attributable to the clay brick masonry. The perception of the landscape space is best readable: 1) In the near sight lines, mainly perceived by pedestrians, users of certain areas; 2) In the long distance sight lines, which allows reading the silhouette of certain areas.

The canal serves as the city's “blue” backbone which connects the left bank streets and the narrow driveways with tree lines and individual groups or lines of shrubs. As previously mentioned, the city was burnt down from the old levee to Rose Square. Especially, it is noticeable today where the building is formed, alternating between the prewar and postwar

stylistics of construction volumes, proportion, and structure. In the city plan of 1935, the building character, the dense street connection to the levee, and the rail line along it are clearly readable. With disappearing of the fine building structure in the urban planning along Spīķeru and Graudu streets (Kaula, Olu, Kuģinieku, Dzirnavu, Putekļu, Veru, Ķēniņu, Enkuru, Zviedru, Miķeļa streets), a monotone unwieldy postwar building has appeared instead of it. The mosaic-type fine break up of the historic urban space in the design and facades is in sharp contrast to the exaggerated volumes of the production buildings (the 70s of the 20th century, at Spīķeru street 19/24, O. Kalpaka street). Evening out of the different character of the building is successfully launched with the creation of the wedge-type character of the elements of the green outdoor space at the levee. The production buildings made from impersonal reinforced concrete panels, suppression of the facade with a wide dogwood line, the colorfulness of which is read even in the winter are a good example (the 70s of the 20th century). The place of the connection of Celtnieku street to the waterfront of the canal is enriched by the plantation of a line of linden trees. In turn, the connection expression of the narrow Zviedru street to the waterfront of the canal is decorated by the pine plantation row that in the summer merges with the low plantation belt along the warehouse at Vecā ostmalā 51. In small sections, Fr. Brīvzemnieka street is the makeup of different paving materials - forged cobble, small shape granite stones, clinker patterns, concrete bricks. The pavement structure and color game compositionally create the street "flow into" the canal, so increasing linking of the adjacent historic industrial building with the waterfront (figure 4)

Fig. 4. The character of the paving structure
at Fr. Brīvzemnieka iela 7 (photo by authors, 2017.)

Fig.5. A linden row at Vecā ostmala
(photo by authors, 2017.)

Individual islands of the plantation along the waterfront of the canal are formed by the ground-cover pines that emotionally powerfully tune with the wild rose plantation group adjacent to the line of vessels along the waterfront of the canal. The rose thorns, the ferocity of the sea wind, the green deck of pines, and the metallic luster of vessels create a strong philosophical site and a sight point at the waterfront. As the culmination in the landscape space of the left bank of the promenade, 150 m in length there is an inclined plank stay, imitating the ship's gangway. This leads to the Dzintara Concert Hall, built in the brown-yellowish tone. The feeling of the presence of giant sea vessels in the urban space is increased in a compositionally powerful and successfully pictorial language. In the language of form creation, a metaphor is used, imitating the concert hall as an amber vessel stuck ashore between the houses (figure 6).The powerful comparison made architecturally and artistically in high quality is a good contribution to any urban space.

The verticals of vessels against the horizontal flow of the industrial canal and the horizontal line of the building silhouette create contrastingly strong closing of the western edge of the city's skyline.

The building line of the industrial heritage also continues upstream the canal. Three parallel compositional axes which consist of the industrial building, the street, the linden plantation row, the canal and its coastline are a picturesque and powerful sight point in the urban space (figure 5). Each of these axes creates its own colorful line: the industrial building - the vertical plane of the red bricks, the driveway - the gray-tone horizontal plane, the tree row - an array of the green foliage, the grassy area along the bank and finally - the blue-gray tone of the canal. The above 100 m long waterfront creates the richest expression in coloring and form creation. The same applies to the tree line at Vecā ostmala 16/18. Here, the waterfront keeps the slope of the historic canal and it has no concrete borders, showing of the historic landscape space shortly before the outlet of the canal from Lake Liepāja. The featured waterfront section 1.5 km in length is concluded by a vertical dominant - the water tower opposite the railway bridge over the canal.

The right bank of the canal consists of several picturesque spots. One of them is the intersection of O. Kalpaks and Kaiju streets. At this point in terms of the architectural expression, a powerful building (arch. M. Bertschy) meets with an extensive green area, consisting of the burial area of the Catholic cemetery. Alongside, there locates the other grave area – the Old Liepāja Cemetery, readable from the left bank of the promenade which in the sight lines during the summer time create a picturesque green park feeling adjacent to the waterfront. It is possible to obtain an aesthetically high visual quality if behind the closed burial area along the waterfront of the canal a walking park will be created in the perspective.

The old cemetery – possibly a place where Liepāja started to grow. By creating a walking park/promenade accessible to the general public along the cemetery mound, the view on the panorama of Old Vecliepāja, the old levee with yachts, sailing and fishing boats, openness towards the southern sun would make the site one of the best in the city.

The analysis of the points of sight.

The visually aesthetic quality and variability of the banks of the Trade Canal are readable when taking a walk and in some sight points where particularly stand out the picturesqueness of the longitudinal axis of the canal and the harmony of the elements of the composition. Thanks to the landscape space of the canal, the city's silhouette is brightly marked by the left bank of the canal and the spire of Ann's church in the background.

The expression of the silhouette in the sight point of Tramvaja Bridge consists of two angles of sight:

The downstream of the canal – *on the left bank*, a developed area with strong accents opens, by means of merging together of the historical and postwar building of the 19th century, with a compositionally balanced walking promenade saturated with art-sculpture-small forms of architecture. The light gray-green waves of the waters of the canal and water masses emotionally intensify the feelings. As the dominant, in the sight point, the new concert hall appears rising above the bank-line building and attracting with the contrasting colorfulness of the exterior decoration of the facade. The sight point is characterized by a dense building, wide bank square of the promenade area, the gray water masses of the canal, the changing silhouettes of vessels, greenery. At the sight of *the right bank of the canal,* expressive red brick warehouse buildings built in the 19th century can be viewed in the compositions with the mound of the Old Graveyard ingrown in large trees. From the side of the bridge, the present function of the current building in the close-up vision is unreadable, both areas are partially or completely closed, their attractiveness should be developed.

The sight point of Tramvaja Bridge to the lakeside **upstream the canal** allows to watch the flat city's landscape with a smooth, groomed linden plantation, a walking trail with benches, a wide indentation to the building that hides behind a tree line, however at the background it creates a common building belt of the facade, including the buildings of the historical industrial heritage. The sight point is concluded by New Bridge. Watching the left bank of the canal toward the lake, a broad green belt and the street front repeat, which on the whole form a large indentation from the canal where the trees of the waterfront of the canal are reflected in the water. The facilities of the industrial heritage are well readable - the warehouse near the canal, the nearby former liqueur factory buildings, and its area. The former Workers House, also the guard house, and the customs house magnificently stand out in the close-up. In the center position of the sight point between these volumes, the bright volumes of the supermarket and the petrol station are positioned, revealing the current events and the value of life of the modern townspeople. In the central part of the city, a certain disproportion of accents can be observed.

Secondly, the sight points at Jaunais Bridge and the former railway bridge should be noted as being expressive and active where the gently sloping banks of the canal with a smooth willow row, the Latvian Gas building complex in the red brick architecture fit in the viewing landscape, the expressiveness of which is sharpened by the modern mirror facades of the adjacent buildings, reflecting the historical building. The water tower built in the 19th century rises as a dominant surrounded by Ganību and Ezermalas streets on the right bank of the canal which visually successfully links the memory story of the industrial heritage of the two banks.

One of the most expressive sight points - the Liepāja old burial mound which offers the city panorama with a blue-green line of waters of the Trade Canal at the forefront, the promenade in the middle and a story of a rich architectural heritage and creativeness behind it. The area of the cemetery is partially closed, the walking trail around it should be developed to make the sight points available towards the south and towards the urban landscape at the Trade Canal.

The sight points from the factory areas of O. Kalpaka street towards the left bank of the canal and vice versa are inaccessible to the residents of the city and tourists but they are expressive. The facilities of the industrial heritage designed by P. M. Bertschy in this place should be developed, giving new functions, creating valuable points of sight towards them.

The third important aspect is the rhythm of the seasons and its impact on the changes of the picturesqueness of the landscape space.

The visual attractiveness of the Liepāja canal, thanks to the green or colorful foliage is revealed fully during the ascetic autumn and winter time when

the trees create clear graphic images and the urban structure is readable up to minute details (figure 7).

During the winter period, the tree graphics, snow white, the frozen water plane of the canal create a calm background for the expressive - especially characteristic to Liepāja - red brick buildings of the industrial heritage.

Fig. 6. Dzintara Concert Hall in urban silhouette. (photo by authors, 2017.)

Fig.7. The harmony of the bank building and the Vessels silhouette (photo by authors, 2017.)

IV. CONCLUSION

The transformation of the landscape space on the banks of the Trade Canal has been affected by a number of rising up and down periods of history - the successful activities of P. Bertschy (1871 - 1902), the devastating years of the wars (1914-1920, 1941-1945), the years of independence (1918-1940), the period of socialism (1945-1990), the contemporary view on the matters of the cultural heritage. Each of the periods brings along the change of the structure, the compositional structure, or the purpose. By studying separately each of these criteria for the waterfront of the canal, we can conclude that : 1)The structure of the urban space under the study and the building scale as the most sensitive elements of the space design have created a vivid reflection of its time in each of the above periods; 2)The sharp change of the compositional structure of the levee in the race of over one hundred years characterizes each period of the economic and political situation;3) The canal has not changed its functional significance since the time of its construction. It is not changed into a site of an intensive industrial and military significance or a narrow tourism-owned site. The only thing that has changed is the importance of the waterfront of the canal. From a dense fish stall, it has transformed into an elegant space of historical reference with a readable urban identity. 4)The green belts of the waterfront are fragmented and they do not have a harmonious context with the architectural shape of the building on the waterfront of the canal. The evaluation of the landscape space for the waterfront of the canal in Liepāja is one of the most important parts of the city planning. The winding of the left bank of the canal is marked by an expressive silhouette line of the city which is readable in the long distance points of sight. By contrast, the silhouette of the right bank is readable in the near sight lines. The changing point of sight lengths and angles make up a multi-faceted urban perception. This is an important contribution to the city's architectural and spatial form.

REFERENCES

1. Antenišķe, A. (2002). Industrial heritage of Riga in the European context. "Industrial heritage in the modern urban environment", International conference Riga.Riga city council, 2003, 26-32 p. ISBN 9984-31-288-7
2. Bredin, G.(2002). From Paper mill to concert hall industrial and cultural heritage in Norrkōping. "Industrial heritage in the modern urban environment", International conference Riga. Riga city council, 2003, 36-39 p. ISBN 9984-31-288-7
3. Briņķis,J., Buka,O. (2008). Reģionālā attīstība un prognostika pilsētplānošanas kontekstā. 195 p. ISBN 978-9984-32-255-1
4. Krastiņš,J. (2015). Liepāja. Jūgendstila arhitektūra.376 p.ISBN 978-9934-14-464-6
5. Lastovecka, L. (2002). Industrial heritage in the electric power industry. "Industrial heritage in the modern urban environment", International conference Riga. Riga city council, 2003, 65-69 p. ISBN 9984-31-288-7
6. Sivula, A. (2002.) Pori cotton factory as a case of industrial heritage in modern urban environment. "Industrial heritage in the modern urban environment", International conference Riga. Riga city council, 2003, 44-50 p. ISBN 9984-31-288-7
7. Stradiņš, J. (2002). Industrial heritage of Riga and the history of sciences. "Industrial heritage in the modern urban environment", International conference Riga. Riga city council, 2003, 7-13 p. ISBN 9984-31-288-7
8. Wennerholm, A. (2002). Industrial heritage as a force in the democratic society."Industrial heritage in the modern urban environment", International conference Riga. Riga city council, 2003, 19-20 p. ISBN 9984-31-288-7
9. Zbiegieni, A.(2002). The current problems of renovation and integration the industrial heritage sites in the modern urban environment in Warschaw agglomeration. International conference Riga. "Industrial heritage in the modern urban environment", International conference Riga. Riga city council, 2003, 40-43 p. ISBN 9984-31-288-7

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Distribution and Population Structure of the Invasive Amphipod *Gmelinoides fasciatus* (Stebbing) in Lake Onego

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Abstract. Since the middle of the XX century, the rapid spread of exotic species and their successful penetration in natural and artificial ecosystems has led to significant environmental changes all over the world [1, 2]. As it was pointed out by many researchers, biological invasion by alien species is one of the main threats to biodiversity [3, 4, 5, 6, 7]. Gmelinoides fasciatus (Stebbing 1899) attracts special attention due to the fact that it is the most successful alien species among other invaders in aquatic ecosystems in Eurasia. This invasive amphipod of Baikalian origin was first recorded in Lake Onego in 2001 by Berezina and Panov [8]. The results of the present study indicate that the invader significantly expanded its areal in Lake Onego during the last 15 years. At present amphipod G. fasciatus is dominant on the biomass among macrozoobenthos community in littoral biotopes of some islands and east part of the Lake. In Lake Onego the invader has a one-year life cycle with the generations of the previous and current year. Seasonal dynamics of the amphipod abundance in Lake Onego has two peaks during the vegetation period. According to our data G. fasciatus successfully reproduces in the new environment and shows stable sexual structure with sex ratio of approximately 1:1. Female fecundity of the amphipod in the Lake varied from 3 to 22 eggs per female, the average variation of fertility is 9 eggs per female. Revealed data of G. fasciatus abundance and biomass in Lake Onego are comparable with those for other water bodies where this amphipod species was successfully established earlier.

Keywords: age structure, distribution, Gmelinoides fasciatus, Lake Onego.

I. INTRODUCTION

Since the middle of the XX century, the rapid spread of exotic species and their successful penetration in natural and artificial ecosystems has led to significant environmental changes all over the world [1, 2, 9, 10, 11]. As it was pointed out by many researchers, biological invasion by alien species is one of the main threats to biodiversity [3, 4, 5, 6, 7, 12, 13].

Range extensions of aquatic macroinvertebrate species in Europe have mainly been facilitated by the interconnection of river basins through man-made canals and intentional introductions [14, 15]. Four water corridors which have been traced between the southern and the northern European seas [14, 16], made possible the migration of alien species to new habitats. The largest corridor, comprising 6.500 km of main waterways and 21 inland ports of international importance, is the "northern corridor". This corridor route includes the Volga River → Lake Beloye → Lake Onego → Lake Ladoga → the Neva River → the Baltic Sea [14]. Among the species which are thought to have penetrated new environments through the northern corridor, many have reached high abundance and biomass and at present play a significant role in the functioning of recipient ecosystems [16, 17].

Gmelinoides fasciatus (Stebbing 1899) attracts special attention due to the fact that it is the most successful alien species among other invaders in aquatic ecosystems in Eurasia. In the 1960-70s, it has been intentionally introduced from Siberia into lakes and reservoirs in the former USSR with the purpose of enhancing fish production. During the 1960s – 2000s this species colonized the coastal zone of some large and small lakes and artificial reservoirs of European Russia [17, 18, 19, 20, 21, 22, 23].

This amphipod of Baikalian origin was first recorded in Lake Onego in 2001 by Berezina and Panov [8]. Their research was carried out on the southwestern shore of the Lake and showed that *G. fasciatus* population was characterized by high abundance (1.7-8.3 thous. ind. m^{-2}) and biomass (3.9-40.3 g m^{-2}). Further investigations showed that till 2006 the northern border of amphipod areal in Lake Onego was expanded and reached 63º N [24]. According to new estimations *G. fasciatus* abundance and biomass values ranged from 1.16 to 12.38 thous. ind. m^{-2} and 0.64-9.34 g m^{-2}, correspondently [24]. Previous studies [8, 24] were devoted to description of abundance and biomass values of *G. fasciatus* populations in the different parts of Lake Onego, however population characteristics such as seasonal

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dynamics of abundance and biomass, reproduction and life cycle specifics of this species in the Lake were poorly studied. Taking into consideration that at present the Lake is the northern border of the invader areal in the European part of Russia and this species inhabits the littoral zone of almost whole Lake Onego, there is a pressing need to study biological and ecological characteristics of *G. fasciatus* in this environment. The aim of the study is: 1) to determine spatial distribution of this alien amphipod in littoral zone of the east part of the Lake and littoral zone of some islands; 2) to characterize reproduction and life cycle and investigate the dynamics of the size-age and sexual structure of *G. fasciatus* during the vegetation period.

II. MATERIALS AND METHODS

Study area. Lake Onego is one of the great lakes of the world and the second-largest European water body. With the exception of several bays, the water body still preserves its natural state and high water quality [25]. The Lake is invaluable ecological resources and very important for aquatic biodiversity in the region.

To investigate the current borders of *G. fasciatus* areal in Lake Onego, in 2014 samples were collected in the littoral zone of the east part of the Lake and littoral zone of some islands (Fig. 1). To study the life cycle of the crustacean, samplings were carried out in the northernmost point of invader areal in European part of Russia – the Povenets Bay of Lake Onego. The Bay is 64 km long and 21 km wide with 36% of shoreline marked by many indentations and shallow harbors [26]. Three sampling sites which represent a range of environmental conditions were selected in the Kumsa area of Povenets Bay (KB1, KB2, KB3) for detailed seasonal dynamics analysis. Samplings were collected in open-type slime bottom littoral biotopes with macrophyte beds from late May to early October 2011 at 10-day intervals in duplicate. Each studied site had some distinct characteristics, thus KB1 is known to be under the influence of strong wind-induced waves; KB2 is located in still water area; and KB3 can be considered as anthropogenically modified area, contaminated by waste water discharges from the Pindushi village and colophony-extraction plant.

Methods. Benthos samples were taken at each station by a plastic tube with working area 0.07 m^2 of modified Panov-Pavlov sampler [27]. Sampling and analysis was carried out in accordance with standard guidelines for the collection of freshwater benthos [28] at a depth of 0.4 m, where the abundance of amphipods was the highest [29]. The length of the individuals was measured under binocular microscope using and eyepiece micrometer with 0.1 mm precision. According to the size, 6 groups were distinguished: (1) ≤1.5 mm, (2) 1.6–3.0 mm, (3) 3.1–5.0 mm, (4) 5.1–7.0 mm, (5) 7.1–9.0 mm and (6) ≥9.1 mm. For ovigerous females, the reproductive capacity was measured (eggs per female). Statistical analysis was performed using the STATISTICA program. Data on abundance, biomass, specimen length and female frequency are presented as means, medians ± standard deviation (SD). χ^2-test was used to compare frequency distribution between the sites and analysis of sex ratio ($p<0.05$).

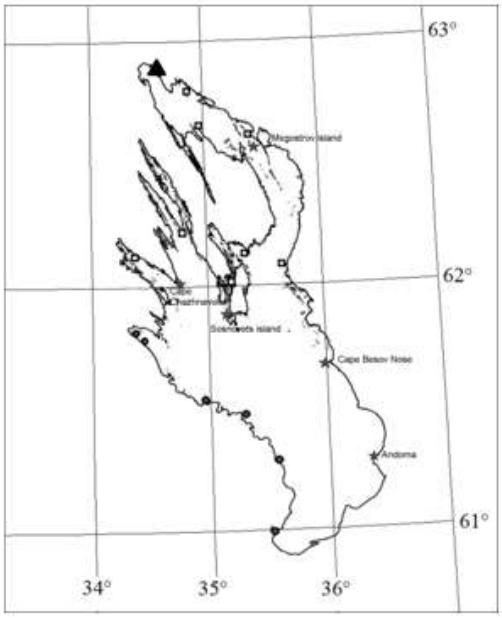

Fig. 1. Distribution of *G. fasciatus* in Lake Onego. Circles indicate presence of *G. fasciatus* in 2001 [8]; squares indicate presence of *G. fasciatus* in 2006 [24]; stars – new data. Black triangle - the location of the monitoring stations in the Povenets Bay of Lake Onego

III. RESULTS AND DISCUSSION

Invasion success is related to both abundance and distribution of alien species in the new environment. The results of the present study revealed that *G. fasciatus* significantly expanded its areal in Lake Onego during the last 15 years. Surveys carried out in 2014 indicate that *G. fasciatus* established permanent population in the east part of Lake Onego and some islands and was the only species of amphipod in littoral zone. The invader abundance varied between 14 and 2264 ind. m^{-2}, biomass – from 0.021 to 3.86 g m^{-2} (Table 1). In relation to biomass, the amphipod was dominant among other groups of macrozoobenthos (51-94%) in all studied locations, with the exception of Cape Chazhnavolok biotope, where the species prevalence reached only 34%.

The data on the population characteristics of *G. fasciatus* in the Povenets bay of Lake Onego revealed that mean values of invader abundance varied among the studied sites from 1202 to 2970 ind. m^{-2}, while mean values of biomass ranged from 1.9 to 5.6 g m^{-2} (Table 2).

Table I
Abundance (ind. M^{-2}) and Biomass (G M^{-2}) of Macrozoobenthos

Location site	Cape Chazhnavolok		Megostrov island		Sosnovets island		Besov Nose		Andoma	
Group	N, ind. m^{-2}	B, g m^{-2}	N, ind. m^{-2}	B, g m^{-2}	N, ind. m^{-2}	B, g m^{-2}	N, ind. m^{-2}	B, g m^{-2}	N, ind. m^{-2}	B, g m^{-2}
Oligochaeta	155.7	0.03	2151.5	0.57	3411.2	0.24	14.2	0.002	84.9	0.024
Chironomidae	226.5	0.01	594.5	0.10	580.3	0.05	-	-	141.5	0.003
Bivalvia	42.5	0.10	-	-	-	-	-	-	-	-
Gastropoda	14.2	0.24	14.2	0.00	127.4	0.20	-	-	-	-
Hydracarina	-	-	113.2	0.02	141.5	0.08	-	-	28.3	0.003
Amphipoda	863.4	1.73	835.1	1.17	2264.7	3.86	14.2	0.021	877.6	2.190
Ephemeroptera	410.5	0.10	99.1	0.02	750.2	0.30	-	-	113.2	0.058
Trichoptera	42.5	0.11	212.3	0.22	1075.7	0.42	-	-	42.5	0.014
Coleoptera	-	-	70.8	0.01	28.3	0.07	-	-	-	-
Diptera	-	-	42.5	0.06	28.3	0.00	-	-	-	-
Hirudinea	56.6	2.46	-	-	-	-	-	-	-	-
Plecoptera	42.5	0.15	169.9	0.02	14.2	0.00	-	-	14.2	0.020
Heteroptera	-	-	127.4	0.01	-	-	-	-	-	-
Isopoda	70.8	0.13	-	-	-	-	-	-	-	-
Total	1925.0	5.06	4430.3	2.22	8421.8	5.22	28.3	0.03	1302.2	2.31

Table II
Abundance, Biomass, Fecundity and Body Sizes of G. Fasciatus in Three Monitoring Stations of the Povenets Bay of Lake Onego

Stations	Characteristics	Mean ± SD	Median ± SD	min	max
KB1	N, ind. m^{-2}	2970±196	1819±204[ab]	859	4885
	B, g m^{-2}	5.6±0.6	3.1±0.5[b]	1.2	14.0
	L_{males},mm	6.0±0.2	6.2±0.2 [b]	3.1	11.5
	$L_{females}$, mm	4.8±0.1	4.6±0.1[a]	3.1	10
	E, eggs per female	8.8±0.4	8±0.6	4	19
KB2	N, ind. m^{-2}	2236±251	2864±268[a]	842	6468
	B, g m^{-2}	3.5±0.4	5.3±0.6	465	7.6
	L_{males},mm	6.3±0.2	6.3±0.2	3.1	15
	$L_{females}$, mm	5.0±0.1	5±0.1[a]	3.1	11
	E, eggs per female	9.2±0.4	8±0.3	3	22
KB3	N, ind. m^{-2}	1202±155	1044±136 [b]	320	3234
	B, g m^{-2}	1.9±0.2	1.6±0.2[b]	0.4	4.2
	L_{males},mm	5.3±0.1	5.5±0.1 [b]	3.1	9.6
	$L_{females}$, mm	4.8±0.1	4.9±0.1	3.1	9.3
	E, eggs per female	9.0±0.4	8±0.9	4	19

Note: N– Abundance; B – Biomass; L – Body size; E – Fecundity; a - Represent Significant Differences Between KB1 and KB2; b - Represent Significant Differences Between KB1 and KB3

Revealed data of the invader abundance and biomass in Lake Onego are comparable with those for other water bodies where this amphipod species were successfully established earlier (Table 3). The closest values of *G. fasciatus* abundance and biomass observed in the Lake were detected in Gulf of Finland Baltic Sea (Table 3).

At present *G. fasciatus* wildly distributed on the littoral zone of Lake Onego [30, 31], however the invader abundance in the different biotopes significantly varied from 1.22 to 18.79 thous. ind. m^{-2} [24]. The reasons of high variability of the amphipod abundance in the Lake were unknown. According to the results of the present study in the Povents Bay, median values of abundance and biomass was about 2 times higher in KB2 compared to KB1 (Table 2). Observed differences can be explained by contrast in relation to wind conditions, which probably led to concentration of individuals in areas with the absence of wind-induced waves. Similar tendencies were detected by Bekman [32] in *G. fasciatus* native area – Lake Baikal. The absence of significant differences in relation to individuals length and female fecundity between two stations also allows us to conclude that the feeding conditions do not limit the development of *G. fasciatus* population at KB1 station. Thus, higher values of biomass and abundance medians of the amphipod in KB2 are probably related to its horizontal migration to more favorable environmental conditions. In littoral biotope of KB3 station values of *G. fasciatus* abundance and biomass were significantly lower compared to KB1 station. At this station significant decrease in male length was observed compared to KB1, however similar tendency in relation to female length and fecundity was not found. Presented data indicate that among 3 studied sites, assemblage

associated with contaminated area (KB3 biotope) was characterized by lowest values of biomass and abundance.

Table III
Population Characteristics of G. Fasciatus in Different Water Bodies

Water bodies		Abundance, ind. m^{-2}	Biomass, g m^{-2}	Fecundity, eggs per female	References
Posolsk Sor Bay of Baikal Lake		10000–20000	63–100	3–32	32
Lake Pepsi		50–17300	0.1–102	–	19
Lake Otradnoe		26–692	–	3–34	33
Lake Ladoga	1988-1990	8–53800	0.02–158.60	–	34
	1992	6000-7000	80-100	-	35
	2004-2005	936–3141	4.2–10.3	3–35	17
	2006	9090±2024	18.65±3.61	-	36
	2009	8–7160	0.024–15.3	–	37
Gulf of Finland Baltic Sea		300–3000	0.4–8.8	3–46	38
Rybinsk Reservoir		6800	19.8	3-20	39
Gorky Reservoir		15000	66	–	21
Western shore of Lake Onego (2001)		1696–8256	3.9–40.3	8–18	8
Petrozavodsk Bay of Lake Onego (2005)		132–462	0.2–6.2	4–15	30
Northern part of Lake Onego (2006)		310–18740	0.2–12.2	–	24

Size and age structure dynamics. Analysis of seasonal abundance dynamics of *G. fasciatus* revealed similar tendency in all studied stations of the Povenets Bay of Lake Onego (Fig. 2a). In the beginning of the vegetation period (the end of May) *G. fasciatus* population was represented by individuals of overwintered generation (Fig. 2b). The appearance of first occasional juveniles (body length less than 1.5 mm) was registered in early June. Females released high number of juveniles in the last decade of June and early July. During that period the number of the juvenile amphipods reached 4 thousand ind. m^{-2} and significantly contribute (85%) to the first peak of abundance. In July and August newborn specimens (less than 1.5 mm) demonstrated decrease in prevalence (from 65% to 15%) whereas individuals with body size 1.6-3 mm showed the opposite tendency (from 15% to 50 %). In the first half of September specimens of all size groups (1.2-9 mm) were found but at the end of the month crustaceans with a body length less than 1.5 mm were not detected. Therefore, seasonal dynamics of *G. fasciatus* abundance in Lake Onego has two peaks in July and August (Fig. 2a), which were formed by individuals of different size groups. Observed seasonal changes in size structure of population can be related to juvenile recruitment and old individuals elimination as well as horizontal migration of individuals [38].

There are 4 different types of *G. fasciatus* life cycles in relation to the amphipod life duration and number of generations per season [21]. According to presented data, in Lake Onego Baikalian invader has a one-year life cycle with the generations of the previous and current year, i.e. similar to those found in Lake Ladoga, Lake Otradnoe and the Neva Bay [17, 39, 40]. The appearance of first occasional juveniles in early June indicates that the reproduction of invader in Lake Onego begins in May while absence of specimens with a body length less than 1.5 mm at the end of September indicates the termination of amphipod reproduction.

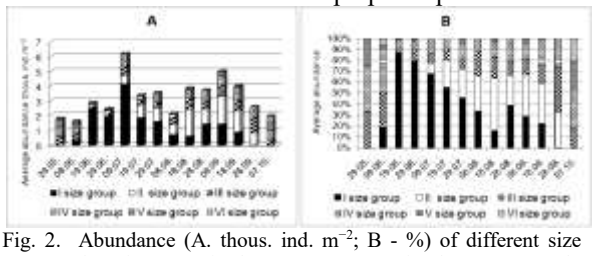

Fig. 2. Abundance (A. thous. ind. m^{-2}; B - %) of different size groups of *G. fasciatus* in the Povenets Bay of Lake Onego. Body length, mm: (1) ≤1.5; (2) 1.6–3.0; (3) 3.1–5.0; (4) 5.1–7.0; (5) 7.1–9.0 and (6) ≥9.1

Sexual structure. It is well known, that amphipod population often shows seasonal fluctuations in the sex ratio and generally, female outnumber males [41, 42, 43]. The sexual structure of *G. fasciatus* population was stable and during the vegetation period sex ratio rarely deviated from approximately 1:1 ratio. On several occasions during the investigation period, there was a significant imbalance in the sex ratios: in the third decade of July and the first decade of August prevalence of female individuals reached 80 and 90%. However, in the end of May and the begging of October the dominance of males was observed. Thus, in the Lake the domination of females in sexual structure of population was observed during the reproduction period (so called "harem" formation) and promoted fast increasing of population abundance [22]. Similar cases of female domination in *G. fasciatus* populations were observed in other freshwater (e.g. Ladoga Lake) and brackish water (e.g. the Neva Bay) ecosystems [38, 17].

The length of females in the Povenets Bay varied between 4.8 and 5.0 mm and 5.3-6.3 mm for males, while the maximum values of the female individuals length reached 11 mm, male – 15 mm (Table 2).

Fecundity. Fecundity of organisms should be considered as the most significant factor that determines the dynamics of species population abundance [44]. Thus, in order to reveal potential reproductive capacity of the organisms, information concerning reproductive parameters of species is required. According to our estimations, during vegetation season female fecundity ranged from 3 to

22 eggs per female and usually reached 9 eggs per female (Table 4). Females with maximum fecundity (10.2 eggs per female) were predominant in the begging of June and belonged to the generation of the previous year (Table 4). From the end of July and till September females of new generation progressively started to reproduce. This fact was confirmed by significant decline of female individuals length: at the end of May it reached 5.4±0.2 mm; in August the length decreased to 4.6±0.2 mm due to the gradual substitution of previous year generation by females of new generation.

Table IV
Seasonal Changes in Length and Fecundity of Ovigerous Females of G. Fasciatus During Vegetation Period in the Povenets Bay of Lake Onego

Month	Number of samples	Mean body length, mm (mean ± SD)	Fecundity, eggs per female (mean ± SD)	Fecundity, eggs per female	
				min	max
May	167	5.4±0.2	8.0±0.7	4	16
June	95	5.4±0.2	10.2±0.8	4	19
July	50	5.2±0.1	8.8±0.8	4	15
August	65	4.6±0.2	9.2±1.1	3	22
September	43	5.1±0.2	8.4±1.2	4	14

Our data correspond to the results of the previous studies carried out in Lake Onego southwestern shore: in 2001 the values ranged from 8 to 18 eggs per female [8]. On the whole, observed in Lake Onego parameters of *G. fasciatus* fecundity are close to those detected in other recipient areas. It should be noted, that in native area (Lake Baikal) the fecundity was higher compared to Lake Onego and reached 32 eggs per female [32], however maximal fecundity was observed in the Neva Bay of the Gulf of Finland and reached 46 eggs per female [38].

Detected changes in mean length of reproducing females were also revealed in other water bodies. Due to the gradual substitution of previous year generation by females of new generation, significant decline of female individuals length was detected during vegetation season. Similar changes were shown for the Rybinsk Reservoir (ovigerous female length in spring varied from 5 to 9 mm, in summer was about 4 mm, and reached 5-6.5 mm in autumn) and the Neva Bay of the Gulf of Finland (mean length was about 7 mm in May, 6 mm in August and increased to 7 mm till the end of September) [38, 39]. This data confirm the connection revealed by Alimov [44] between the water temperature and individuals maturation period and sexual maturity.

IV. CONCLUSIONS

The results of the present study clearly demonstrate that the Baikal invader successfully established in the new conditions on the northern border area of the European part of Russia. At present amphipod *G. fasciatus* is dominant on the biomass among macrozoobenthos community in littoral biotopes of some islands and east part of Lake Onego. *G. fasciatus* of the Lake has a one-year life cycle with the generations of the previous and current year. According to our data the invader successfully reproduces in new environment and shows stable sexual structure with sex ratio of approximately 1:1. Female fecundity of the amphipod in the Lake varied from 3 to 22 eggs per female, the average variation of fertility is 9 eggs per female. Revealed data of it abundance and biomass in Lake Onego are comparable with those for other water bodies where this amphipod species was successfully established earlier. It should be noted that *G. fasciatus* continues to expand its areal and according to some estimations has ability to enter in Great Lakes in Northern America from the Gulf of Finland in Baltic Sea [21] and inland Finland lakes through the Saimma channel [45] due to the intensive shipping. Moreover, some researchers pointed out, that the amphipod from Lake Onego is capable to enter the White Sea through the second branch of invasive corridor (Lake Onego → the White Sea – Baltic Sea Channel → the White Sea) [10].

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REFERENCES

[1] D. Strayer, *Alien species in fresh water: ecological effects, interactions with other stressors, and prospects for the future.* Freshwater Biology. 55 (Suppl.1): 2010, pp.152–174

[2] R. Keller, J. Geist, J. Jeschke and I. Kühn, *Invasive species in Europe: ecology, status, and policy*. Environmental Sciences Europe 23: 2011, pp. 1–17

[3] J. McNeely, *Invasive species: a costly catastrophe for native biodiversity*. Land Use and Water Resources Research 1: 2001, pp. 1–10

[4] M. Davis, *Biotic Globalization: Does competition from introduced species threaten Biodiversity?* BioScience 53: 2003, pp. 481–489

[5] H. Charles and J. Dukes, *Impacts of Invasive Species on Ecosystem Services.* In: Nentwig (ed), Biological Invasions. Ecological Studies 193, 2007, pp. 217-237

[6] J. Molnar, R. Gamboa, C. Revenga and M. Spalding, *Assessing the global threat of invasive species to marine biodiversity*. Marine invasive species. The Ecological Society of America: 2008, pp. 1–34

[7] G. Walther, A. Roques, P. Hulme, M..Sykes, P..Pyšek, I. Kühn, M. Zobel, S. Bacher, Z. Botta-Dukát, H. Bugmann, B. Czúcz, J. Dauber, T. Hickler, V. Jarošík, M. Kenis, S. Klotz, D. Minchin, M. Moora, W. Nentwig, J. Ott, V. Panov, B. Reineking, C. Robinet, V. Semenchenko, W. Solarz, W.Thuiller, M.Vilà, K.Vohland and J. Settele, *Alien species in a warmer world – risks and opportunities*. Trends in Ecology and Evolution 24: 2009, pp. 686–693

[8] N. Berezina and V. Panov, *Establishment of the Baikalian Amphipod Gmelinoides fasciatus (Amphipoda, Crustacea) In Lake Onega*. Zoologichesky Zhurnal 82: 2003, pp. 731–734 (In Russian)

[9] M. Orlova, I. Telesh, N. Berezina, A. Antsulevich, A. Maximov and L. Litvinchuk, *Effects of nonindigenous species on diversity and community functioning in the eastern Gulf of*

Finland (Baltic Sea). Helgoland Marine Research 2: 2006, pp. 98–105

[10] V. Panov, Y. Dgebuadze, T. Shiganova, A. Filippov and D. Minchin, *A risk assessment of biological invasions: inland waterways of Europe – the northern invasion corridor case study*. In: F. Gherardi (ed) Freshwater bioinvaders: profiles, distribution, and threats. Invading Nature, Springer Series in Invasion Ecology 2: 2007, pp. 639–656

[11] V. Panov, Alexandrov B., K. Arbačiauskas, R. Binimelis, G. Copp, M. Grabowski, F. Lucy, R. Leuven, S. Nehring, M. Paunović, V. Semenchenko and M. Son, *Risk Assessment of Aquatic Invasive Species Introductions via European Inland Waterways*. In: J. Settele, L. Penev, T. Georgiev, R. Grabaum, V. Grobelnik, V. Hammen, S. Klotz, M. Kotarac, I. Kuhn (eds) Atlas of Biodiversity Risk, 2010, pp. 140–143

[12] K. Park, *Assessment and Management of Invasive Alien Predators*. Ecology and Society 9(2): 2004, pp. 1–12

[13] M. Schlaepfer, D. Sax and J. Olden, *The Potential Conservation Value of Non-Native Species*. Conservation Biology 25: 2010, pp. 428–437

[14] A. Bij de Vaate, K. Jażdżewski, H. Ketelaars, S. Gollasch and G. Velde, *Geographical patterns in range extension of Ponto-Caspian macroinvertebrate species in Europe*. Canadian Journal of Fisheries and Aquatic Sciences 59: 2002, pp. 1159–1174

[15] K. Holeck, E. Mills, H. Macisaac, M. Dochoda, R. Colautti and Ricciardi, *Bridging troubled waters: biological invasions, transoceanic shipping, and the Laurentian Great Lakes*, BioScience 54: 2004, pp. 919–929

[16] Y. Slynko, L. Korneeva, I. Rivier, V. Papchenkov, G. Scherbina, M. Orlov and T. Therriault, *The Caspian-Volga-Baltic invasion corridor*. In: E. Leppäkoski et al. (eds). Invasive Aquatic Species of Europe, 2002, pp. 399–411

[17] D. Barkov and E. Kurashov, *Population characteristics and life cycle of the Lake Baikal invader Gmelinoides fasciatus (Stebbing, 1899) (Crustacea: Amphipoda) in Lake Ladoga*. Inland Water Biology 4. 2011, pp. 192–202

[18] V. Panov, *Baikalian endemic amphipod Gmelinoides fasciatus Stebb. in Ladoga Lake*. Doklady Academii Nauk 336: 1994, pp. 279–282 (In Russian)

[19] V. Panov, T. Timm and H. Timm, *Current status of an introduced Baikalian amphipod Gmelinoides fasciatus Stebbing in the littoral communities of Lake Peipsi*. Proceedings of Estonian Academy of Sciences. Biology. Ecology 49: 2000, pp. 71–80

[20] O. Timoshkin, *Lake Baikal: diversity of fauna, problems of its immiscibility and origin, ecology and "exotic" communities. Index of animal species inhabiting Lake Baikal and its catchment area*. Novosibirsk, 2001, pp. 174–116 (In Russian)

[21] V. Panov and N. Berezina, *Invasion history, biology and impacts of the Baikalian amphipod Gmelinoides fasciatus (Stebb.)*. In: E. Leppäkoski, S. Olenin, Gollasch, S. Dordrecht (eds). Invasive Aquatic Species of Europe, Kluwer Publisher, 2002, pp. 96–103

[22] N. Berezina, *Causes, characteristics and consequences of non-indigenous amphipod species dispersal in aquatic ecosystems of Europe*. In: A. Alimov, N. Bogutskaya (eds) Biological invasions in aquatic and terrestrial ecosystems, Moscow – St. Petersburg, 2004, pp. 254-268 (In Russian)

[23] N. Berezina, *Changes in aquatic ecosystems of the north-western Russia after introduction of Baikalian amphipod Gmelinoides fasciatus.* In: F. Gherardi (ed) Biological invaders in inland waters: profiles, distribution, and threats. Springer, Dordrecht, The Netherlands, 2007, pp. 479–493

[24] V. Kukharev, T. Polykova and A. Rybinkin, *The distribution of the Baikalian amphipod (Gmelinoides fasciatus, Ampipoda., Crustacea) in Lake Onega*. Zoologichesky Zhurnal 87: 2008, pp. 1270–1273 (In Russian)

[25] *Lake Onego. Atlas*. In: N. Filatov (ed), Petrozavodsk, 2010 (In Russian)

[26] V. Kirilova, *Morphology and morphometry of the Povenets Bay. Preliminary results of a comprehensive study on the expedition of Lake Onego*, Petrozavodsk, Vol. 3, 1969, pp. 63–65 (In Russian)

[27] V. Panov and A. Pavlov, *Guide the quantitative determination of aquatic invertebrates in the reeds and rushes*. Hydrobiological journal 22: 1986, pp. 87–88 (In Russian)

[28] *Guidelines for the collection and processing of materials in the conduct of monitoring of biological pollution in the Gulf of Finland*. In: A. Alimov, T. Florinskaya (eds), St. Petersburg, 2005 (In Russian)

[29] A. Sidorova, *Structural and functional characteristics of Baikalian invader Gmelinoides fasciatus Stebbing (Crustacea: Amphipoda) population on the north border of its areal (Lake Onego).* PhD thesis. Petrozavodsk, 2013, 25 p. (In Russian)

[30] N. Kalinkina, M. Syarki and A. Fedorova, *The dynamics of population indices of invasive species Gmelinoides fasciatus (Stebbing) in the Petrozavodsk Bay of Lake Onego*. Northern Europe in the XXI century: nature, culture, economy, 2006, pp. 269–271 (In Russian)

[31] T. Polyakova, *"Biological" pollution of aquatic ecosystems*. In: T. Regerand, V. Kukharev, N. Filatov, M. Potahin, L. Nazarova, T. Polyakova (eds) Aquatic environment: an integrated approach to study, conservation and use. Petrozavodsk, 2008, pp. 26–31 (in Russia)

[32] M. Bekman, *Ecology and production of Micruropus possolsii Sow. and Gmelinoides fasciatus Stebb*. Proceedings of Limnological Institute 2: 1962, pp. 141–155 (In Russian)

[33] O. Nilova, *Some features of ecology and biology of Gmelinoides fasciatus Stebb. acclimatized in Lake Otradnoye in Leningrad region*. Izvestiya GOSNIORCH 110: 1976, pp. 10–15 (In Russian)

[34] V. Panov, *Establishment of the Baikalian endemic amphipod Gmelinoides fasciatus in Lake Ladoga*. Hydrobiologia 322: 1996 , pp. 187–192

[35] T. Slepukhina, I. Belyakova, Y. Chichikalyuk, N. Davydova, G. Frumin, E. Kruglov, E. Kurashov, E. Rubleva, L. Sergeeva and D. Subetto, *Bottom sediments and biocoenoses of northern Ladoga and their changes under human impact*. Hydrobiologia 322: 1996, pp. 23–28

[36] M. Barbashova and E. Kurashov, *Macrofauna of littoral zone of Lake Ladoga*. In Kurashov E (ed) The littoral zone of Lake Ladoga, Saint Petersburg, 2011, pp. 219–251 (In Russian)

[37] E. Kurashov, M. Barbashova and V. Panov, *First finding of Ponto-Caspian invasive amphipod Chelicorophium curvispinum (G.O. Sars, 1895) (Amphipoda, Crustacea) in Lake Ladoga*. Russian Journal of Biological Invasions 1: 2010, pp. 282–287

[38] N. Berezina, *Seasonal dynamics of structure and fertility of the population of the Baikal amphipod (Gmelinoides fasciatus, Ampipoda, Crustacea) in the beds area of the Neva Bay*. Zoologichesky Zhurnal 84: 2005, pp. 411–419 (In Russian)

[39] I. Skal'skay, *The settlement of Baikal amphipod Gmelinoides fasciatus (Stebbing) in the Rybinsk Reservoir*. Inland Water Biology 96: 1994, pp. 35–40 (In Russian)

[40] N. Berezina and V. Panov, *Distribution, population structure and salinity tolerance of the invasive amphipod Gmelinoides fasciatus (Stebbing) in the Neva Estuary (Gulf of Finland. Baltic Sea)*. Hydrobiologia 514: 2004, pp. 199-206

[41] A. Vlasblom, *A study of a population of Marinogammarus marinus (Leach) in the Oosterschelde*. Netherlands Journal of Sea Research 4: 1969, pp. 317–338

[42] R. Powell and P. Moore, *The breeding cycles of females of seven species of amphipod (Crustacea) from the Clyde Sea area*. Journal of Natural History 25: 1991, pp. 435–79

[43] R. Cardoso and V. Veloso, *Population biology and secondary production of the sandhopper Pseudorchestoidea brasiliensis (Amphipoda: Talitridae) at Prainha Beach, Brazil*. Marine Ecology Progress Series 142: 1996, pp. 111–119

[44] A. Alimov, *Introduction to Production Hydrobiology*. Leningrad. 1989 (In Russian)

[45] M. Pienimaki and E. *Leppäkoski, Invasion pressure on the Finnish Lake District: invasion corridors and barriers*. Biological Invasions 6: 2004, pp. 331–346

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Exploring Spatial Patterns of Urban Brownfields: the Case of Daugavpils City

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Abstract. Deindustrialization has been an important process in transforming the urban regions in Central and Eastern Europe. In Daugavpils, there is a long history of industry dated back to the 19th century. The massive deindustrialization of the 1990s caused increased concentrations of brownfield localities within the city. Previous studies have demonstrated that the geographic location of urban brownfields is an important factor affecting brownfields regeneration. The aim of the current study is to explore the characteristics of the brownfield sites and their spatial patterns in the city of Daugavpils. The analysis is based on a data obtained during the fieldwork. The results presented in this paper depends on survey of 61 brownfield sites in Daugavpils. Majority of local brownfields are abandoned buildings previously used for industrial and commercial activities and unevenly distributed within the city. Higher number of brownfield regeneration have been detected in densely built-up areas close to the inner-city areas, while lower rates were found for areas with low population density at the periphery of the city. The findings also suggest that urban brownfield regeneration increases the attractiveness and livability of a particular locality.

Keywords: brownfield regeneration, Daugavpils city, deindustrialization, urban brownfields.

I. INTRODUCTION

During the last decades of the 20th century Europe experienced geopolitical and socioeconomic changes, including processes as of demilitarization, deagriculturization and deindustrialization [1]. While in the Western Europe these processes started to appear in the early 1970s as a result of economic restructuring and progressed slowly, in many countries of Eastern and Central Europe they occurred rapidly in beginning of the 1990s due to collapse of socialism and the centrally planned economy [2] - [4]. As a result of these processes, increasing number of abandoned sites so-called brownfields appeared [1], [4] - [9].

In recent decades' brownfields (derelict, underused, abandoned and/or contaminated sites) has gained high attention and this term has become recognized worldwide [2], [4]. Considering reducing availability of vacant developable lands in urban areas, brownfield regeneration has become significant aspect of sustainable urban development [5], [10] – [12]. Latvia is no exception and the issue of brownfield regeneration and redevelopment remain one of the greatest challenges for local municipalities. Over the last decade, the regeneration of abandoned, derelict and often contaminated territories, has become essential to improve the quality of urban environment and to ensure sustainable development strategy of the Daugavpils city.

Indisputable, existence of brownfields on the administrative area makes it unattractive for investors and residents, but as redevelopment of such sites are not possible without significant investments, they are rarely being re-used. Despite this fact, recent economic growth and access to the European Union structural funds has result in risen interest to regeneration processes in Baltic States. [6]

As pointed out by several authors, location related aspects of brownfield sites (geographical location, existence of transportation links, socio-demographic structure of locals, economic potential, economic activity and unemployment rate etc.) plays an important role in their regeneration processes [1], [9], [13]. Nevertheless, such site-specific factors as size of brownfield, its previous use, number of buildings, ownership relations etc. also are crucial for planning brownfield redevelopment projects in administrative territory [1], [13].

Many authors emphasized various benefits of brownfield redevelopment, including improvement of city attractiveness and livability, increase in tax incomes and property value, as well as, reducing level of crime and others [2], [20], [21].

This paper analyses the spatial patterns of post-socialist deindustrialization and brownfield regeneration in Daugavpils city. The aim of the current study is to explore the characteristics of the brownfield sites and their spatial patterns in Daugavpils. Thus, the research contributes to an understanding of post-socialist urban transformations by clarifying the spatial patterns of urban brownfields behind the massive deindustrialization of the 1990s. The paper addresses two main research questions. First, how the brownfield sites are spatially

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distributed across the city? Second, what are the characteristics of the surveyed sites in terms of current use? The second question draws particular attention on urban brownfields regeneration

II. MATERIALS AND METHODS

Since the paper aims to explore the characteristics of the brownfield sites and their spatial patterns, the research calls for use of various information sources and methodological approaches, from spatial analyses to qualitative investigation. Methodologically, the paper emphasizes case study research, which illustrates distinct types of brownfield sites in the city.

Study area

Daugavpils, the second-tier city in Latvia, is the case study for analyzing the post-socialist deindustrialization and spatial patterns of urban brownfields. In Daugavpils, there is a long history of industry dated back to the 19th century, but in the Soviet Union the city was strongly industrialized. During the Soviet-era industrialization and in-migration, Daugavpils had grown conspicuously. After the collapse of the Soviet Union, many industrial enterprises were forced to close production, simultaneously, large number of construction projects remained unfinished [14]. Nowadays, most of industrial territories in the city remain abandoned. [15] The city's population has declined from over 126,000 in 1990 to approximately 85,000 inhabitants in 2016. However, Daugavpils today still is an important industrial center and transportation hub with regional administrative and servicing functions.

Inventorying

Previous studies indicate [2], [13], that brownfield management in any particular area begins with inventorying of the brownfields and creation of database followed by processes of brownfield assessment and classification according to regeneration options, environmental risk and other criteria. Most common way of brownfield identification process depends on available data sources, such as inventories of contaminated and abandoned territories, property tax records or existing redevelopment projects [16]. Within this research a request for the relevant information has been sent to the local municipality. As a result, information about potential brownfield sites was compiled from Daugavpils City Urban Planning and Construction Department's list of 50 abandoned properties. However, the data gained from the municipality were updated several years ago and did not include all the potential brownfield sites. Therefore, detailed inventory of the most densely populated neighborhood *Jaunā Forštate* was implemented. During the survey 11 additional brownfield sites were identified.

In summary, analysis was based on the following data sources: (1) Daugavpils City Urban Planning and Construction Department's list of 50 abandoned territories, created in 2013 year and updated in 2014; (2) data gained from detailed inventory of the neighborhood *Jaunā Forštate* implemented in the end of 2015. All previously mention data was updated during fieldwork in 2015/2016 study year, as well as by gathering information from database of contaminated territories, cadastral systems and during the meetings with local government experts.

Additional information about regenerated brownfield was gained from analysis of Google View images taken in years 2011 and 2012. Most often these images helped to identificate redevelopment option of specific site.

Site survey and creation of database

The present paper and data analysis is based on information obtained during the fieldwork. Unlike similar studies [2], [3], which were based on existing inventory data, this research includes identification of potential brownfield sites within the city during the field work and creation of database, including all necessary data for further spatial analysis. All the identified potential brownfield sites were surveyed during the fieldwork. Assessment criteria were in line with previous research [17], which is modified by taking into account relevant literature [16], [18] and expert opinion obtained during the interviews with local government experts. As a result, all the 61 surveyed sites are classified as existing or regenerated brownfields. Property are identified as brownfield based on four criteria: hazard, efficiency of the use, negative impact on the landscape and pollution.

Spatial analysis of the data

Geographic information systems has been widely used for spatial analysis and management of brownfields, evaluation of regeneration projects and creation of cartographic material for informative purposes. Within the current research the geodatabase of brownfield sites was created based on field work and various secondary data sources.

Geographic information system software ArcGIS ESRI™ 10 is used for collection, processing and compilation of the database. For visualization of these data and it further analysis following layers were used: spatial structures of Daugavpils city, city neighborhoods, city boundary, main transportation axes and main railways conducted in previous study by Sergejs Trošimovs [19].

Spatial analysis of the data relies on information gathered in the database. Brownfield spatial patterns were evaluated depending on their site- specific characteristics, such as classification, location in Daugavpils city districts, ownership, previous use, planned use, number of buildings etc.

III. RESULTS AND DISCUSSION

According to the data gained form local government and fieldwork, there is at least 61 brownfield sites in the city of Daugavpils. Eleven of

them are successfully regenerated, while 50 remain abandoned (classified as existing brownfields). Study results indicates that existing brownfields covers 36 ha or 0.5% of total city area. It is significant, that almost half of the Daugavpils city territory consists of water and green spaces, respectively brownfield areas cover 1% of the Daugavpils city built-up areas.

The distribution of analyzed brownfields is spatially uneven (Fig. 1). In relation to spatial structures of the city, 2/3 of both existing and regenerated brownfields are located in residential areas, while reminding number of territories is evenly distributed among industrial zones and downtown area. Regardless the fact that 62% of existing brownfields are located in residential areas, the biggest coverage (70% or 26 ha) of brownfield sites are detected in industrial zones of the city.

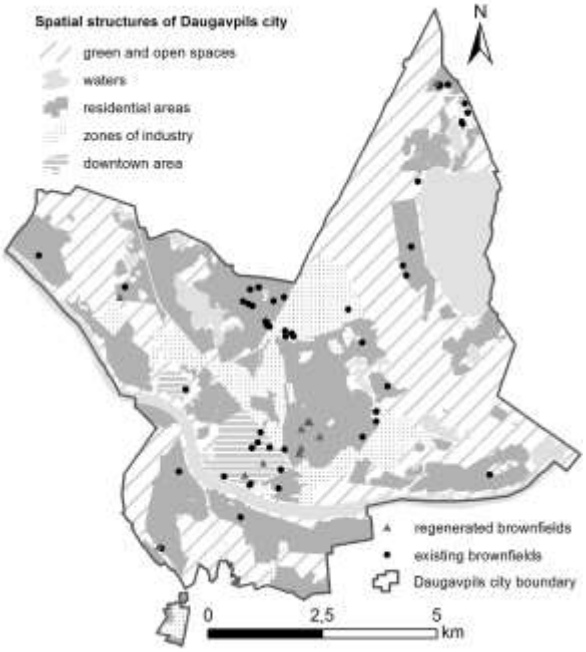

Fig. 1. The location of surveyed brownfield sites in spatial structures of Daugavpils city. Graphic elaboration by author.

While analyzing size and structure of the brownfields, becomes clear, that, the biggest and the most complex sites are located exactly in industrial zones, contrariwise, in residential and downtown areas mostly are positioned relatively small sites or even individual buildings. Research indicates, that size and complexity of the brownfield site is one of the important factors in brownfield revitalization process in Daugavpils, as most of regenerated brownfields are demolished or restored sites with total area less than 0.2 ha, while none of previous industrial sites and vacant factory complexes was fully regenerated.

In regard to further revitalization projects, it is important to state that 2/3 of analyzed existing brownfields are relatively small and covers less than 0.5 ha. Most of these territories are individual buildings (30%) or small cadastral units with some build-up area (61%). In total, build-up area covers half of existing brownfield territory and 82% of it is located in industrial zones. As industrial sites include plenty of supporting constructions, brownfields of this type consists of multiple buildings (at this research number of building in industrial sites vary from 1 to 9).

During the research, there were identified 112 abandoned buildings in existing brownfield sites. Despite the fact that time period when these buildings were put into exploitation vary from beginning of 19th century till the early 2000s, significant majority (72%) were constructed in the period of Soviet Union. This highlights fact already pointed out by several authors [4] - [9], that recent societal and economic transitions in the city result in increasing number of brownfields.

Original use of brownfield sites in Daugavpils city also reflects to changing economic situation in the city. With transition from post-soviet economic model, large factories were closed, what alongside with migration of workers caused abandonment of sites used for housing (38%), industry (20%) and commercial (20%) purposes (Table 1).

Table 1.
Original use of brownfields in Daugavpils city

Original use	Number of brownfields			
	Total	Downtown	Residential areas	Industrial zones
Housing sites	23	6	17	0
Commercial sites	12	2	9	1
Industrial sites	12	2	1	9
Sites of public importance	9	1	8	
Information is not available	5			
Restored sites	11	2	9	0

Results of the study indicate that brownfields located in downtown were previously used for diverse purposes. Residential areas concentrate biggest number of brownfields, that originally was used for housing, though number of sites constructed for commercial and public use are also significant. In context of brownfield revitalization, it is important to mention, that 9 from 11 analyzed regenerated brownfields included buildings previously used for housing purposes. Revitalization of these sites mostly was conducted in the most primitive way - 8 from these sites were demolished and only one multi-storey building in city center were restored for further commercial purpose.

One more important site-specific factor, connected with planning revitalization options for the brownfield in Daugavpils city is ownership [1], [2].

According to legislation, owner is responsible for maintenance and management of brownfields in the administrative territory, so realization of any potential revitalization projects depends on owner's engagement. Collapse of socialism and following privatization processes during the end of 20th century resulted in diverse structure of brownfield ownership in Daugavpils city (Table 2). Most of existing and regenerated brownfields (36%) covering large areas in the city of Daugavpils are owned by legal person, these mostly are industrial and commercial sites.

Table 2.
Ownership relations of brownfields in Daugavpils city

Ownership	Number of brownfields			
	Total	Existing brownfields	Regenerated brownfields	Brownfield area (ha)
Foreigner	1	1	0	0,05
Individual	10	7	3	2,2
Mixed status of co-ownership	11	7	4	0,9
Legal person	22	19	3	23,8
Municipality	11	10	1	2,4
State	6	6	0	8,0

Significant number of brownfield (15%) has mixed status of co-ownership, which usually results in difficulties during revitalization processes, as there appears need in owners' collaboration and common brownfield management vision. Despite this fact, exactly these brownfields mostly are regenerated, that can be related to relatively small area of these sites. However, territories or their undivided shares owned by foreigners represents a regeneration barrier. Generally, connection between ownership and location of brownfields within the city has been not found, nevertheless, sites owned by municipality and state mostly are located in residential (65%) or industrial (29%) areas.

From spatial development perspective, it is easier to attract investors for the brownfield there mixed type of construction is permitted, thereby investors have freedom to choose further usage of the site. According to data gathered during this research, significant number (20%) of both existing and regenerated brownfields in Daugavpils are located in the area for mixed constructions (Table 3), however, regenerated was mostly territories located in residential areas. This can be explained by the fact, that complex regeneration projects in Daugavpils has been conducted rarely, instead, revitalization is simply organized by demolishing low-rise residential buildings or renovation of individual buildings for further commercial use. Near-future challenge is to encourage complex revitalization of industrial and commercial territories which occupied more than half of total brownfield area.

Table 3.
Planned/allowed use of brownfields in Daugavpils city

Planned/allowed use	Number of brownfields			
	Total	Existing brownfields	Regenerated brownfields	Brownfield area (ha)
Area for residential buildings	30	20	10	4,0
Area for mixed construction	12	11	1	8,6
Area for business object	7	7	0	3,4
Area for industrial objects	6	6	0	18,4
Area for objects of public importance	5	5	0	2,9
Area for transport maintenance objects	1	1	0	0,001

The distribution of brownfields reflects to both historical development of the city and proximity to city center and main transportation axes.

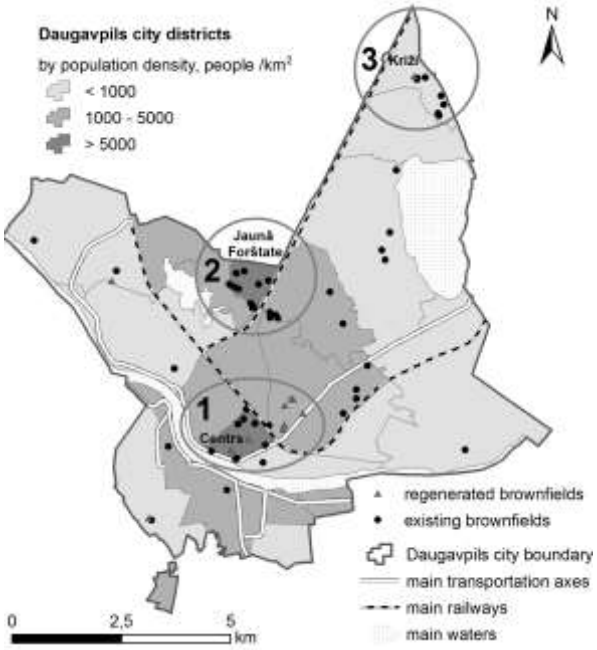

Fig. 2. The location of surveyed brownfield sites depending on population density and main transportation corridors. Graphic elaboration by author.

Three main clusters of brownfields can be identified (Fig. 2): (1) central and wider inner-city area concentrates most of brownfields with various types of use, including two thirds of all regenerated sites; (2) as a result of detailed inventory of the most densely populated neighborhood *Jaunā Forštate*, significant number of brownfields are located there; (3) remarkable number of brownfield sites is situated in the most remote city neighborhood *Krīži*. While brownfields previously used for housing and commercial use or as public facilities are mostly located in densely populated neighborhoods of the

city, location of post-industrial brownfields is influenced by proximity of transportation axes. Fact mentioned above also reflects to recent transition from soviet economic model based on economic collaboration with other post-soviet countries and widely developed transportation network.

As mentioned above, regenerated sites are mostly located in densely populated areas within wider inner-city (Fig. 2) Local authorities recognizes, that most of regenerated sites were demolished or renovated due to complains of local residents, that lead to the fact, that locals are willing to increase livability of a particular neighborhood by engaging in urban spatial development planning.

IV. CONCLUSION

Results of this study indicates, that Daugavpils, as most of post-soviet cities, have a great influence from collapse of Soviet Union. As a consequence of economical and societal changes in the city during the 1990s, a lot of brownfield sites emerge. More than half of area covered by brownfield sites have post-industrial origin and is situated in industrial zones in direct proximity to transportation corridors. Alongside with a rapid decrease in population in the end of 20th century [19] in downtown and residential areas of Daugavpils city a lot of abandoned and/or unfinished housing, commercial and public facilities remained. Original use of brownfields in Daugavpils city stipulates uneven distribution of these sites in the city, as most of them are abandoned buildings previously used for industrial and commercial activities substantially located in densely populated or industrial part of the city.

As evidenced in many studies, location of brownfield sites directly affects their redevelopment potential [1], [2], [13]. This study emphasizes that brownfields located in more attractive central areas of the city with good transportation links and economic potential are most likely to be regenerated thanks to both involvements of local residents and attraction of investors.

However, engagement of investors in redevelopment projects also highly depends on such site-specific factors as size, complexity and original use of the brownfield, ownership relations, as well as planned/allowed use of the site. While smaller housing or commercial properties with less complex ownership status makes regeneration process more likely to be implemented, huge industrial complexes usually privatized by several owners by definition have difficulties with revitalization processes. As these post-industrial sites are mostly located in industrial zones of the city surrounded by transportation axes, stimulation of regeneration processes can be implemented by creating favorable conditions for further investors, for example, by allowing wider possibilities for further use of the site. With transition from secondary to tertiary economic investors are most likely to invest in commercial or sites with mixed use, rather than in industrial zones.

Higher number of brownfield regeneration have been detected in densely built-up areas close to the inner-city, while lower rates were found for areas with low population density at the periphery of the city. As indicated by local authorities, redevelopment of brownfields often is an initiative of local residents willing to improve attractiveness and livability of a particular neighborhood. As noted by several authors, revitalization of brownfields sites results in already mentioned benefits, as well as in reducing level of crime and increasing property value [20], [21].

The results presented in this paper are based on survey of 61 brownfield sites in Daugavpils, which reflects only part of real situation within the city. Detailed inventory of all neighborhoods with following update in database of existing and regenerated brownfields is necessary for more detailed study.

REFERENCES

[1] J. Hercik, P. Šimáček, Z. Szczyrba, I. Smolová, “Military brownfields in the Czech Republic and the potential for their revitalisation, focused on their residential function,” Quaestiones Geographicae, vol. 33, pp. 127–138, Mar. 2014.

[2] B. Frantál, J. Kunc, E. Nováková, P. Klusáček, S. Martinát, R. Osman, “Location matters! Exploring brownfields regeneration in a spatial context (case study of the South Moravian Region, Czech Republic),” Moravian geographical reports, vol. 21, pp. 5–19, 2013.

[3] J. Kunc, S. Martinat, P. Tonev, B. Frantal, “Destiny of urban brownfields: spatial patterns and preceived consequences of post-socialistic deindustrialization,” Transylvanian Review of Administrative Sciences, vol. 41, pp. 109–128, 2014.

[4] R. Osman, B. Frantal, P. Klusacek, J. Kunc, S. Martinat, “Factors affecting brownfield regeneration in post-socialist space: The case of the Czech Republic,” Land Use Policy, vol. 48, pp. 309–316, Jun. 2015.

[5] Y. Liu, F. van Oort, S. Geertman, Y. Lin, “Institutional determinants of brownfield formation in Chinese cities and urban villages,” Habitat International, vol. 44, pp. 72–78, May 2014.

[6] J. Tintera, A. Ruus, E. Tohvri, Z. Kotval, “Urban brownfields in Estonia: scope, consequences and redevelopment barriers as perceived by local governments,” Moravian Geographical Reports, vol. 22, pp. 25-38, 2014.

[7] E. Rizzo, M. Pesce, L. Pizzol, F. M. Alexandrescu, E. Giubilato, A. Critto, A. Marcomini, S. Bartke, “Brownfield regeneration in Europe: Identifying stakeholder perceptions, concerns, attitudes and information needs,” Land Use Policy, vol. 48, pp. 437–453, Jun. 2015.

[8] L. Pizzol, A. Zabeo, P. Klusacek, E. Giubilato, A. Critto, B. Frantal, S. Martinat, J. Kunc, R. Osman, S. Bartke. “Timbre Brownfield Prioritization Tool to support effective brownfield regeneration,” Journal of Environmental Management, vol. 166, pp. 178–192, 2016.

[9] S. Martinat, P. Dvorak, B. Frantal, P. Klusacek, J. Kunc, J. Navratil, R. Osman, K. Tureckova, M. Reed, “Sustainable urban development in a city affected by heavy industry and mining? Case study of brownfields in Karvina, Czech Republic,” Journal of Cleaner Production, vol. 118, pp 78–87, Jan. 2016.

[10] K. J. Doick, G. Sellers, V. Castan-Broto, T. Silverthorne, “Understanding success in the context of brownfield greening projects: The requirement for outcome evaluation in urban greenspace success assessment,” Urban Forestry & Urban Greening, vol. 8, pp. 163–178, 2009.

[11] M. Morio, S. Schädler, M. Finkel. "Applying a multi-criteria genetic algorithm framework for brownfield reuse optimization: Improving redevelopment options based on stakeholder preferences," Journal of Environmental Management, vol. 130, pp. 331–346, Oct. 2013.

[12] Z. Kramárová, "Brownfield Topic in the Czech Legislation," Procedia Engineering, vol. 161, pp. 290–293, 2016.

[13] B. Frantál, B. Greer-Wootten, P. Klusáček, T. Krejčí, J. Kunc, S. Martinát, "Exploring spatial patterns of urban brownfields regeneration: The case of Brno, Czech Republic," Cities, vol. 44, pp. 9–18, Jan. 2015.

[14] L. Kilevica, *Daugavpils.* Rīga: Jumava, 2006.

[15] "Daugavpils pilsētas attīstības programma 2014.-2020. gadam. Vides pārskats," [Online]. Available: https://www.daugavpils.lv/upload/2014_doc/Vides_parskats_RP_gala%2020%2002%202014.pdf [Accessed: Mar. 14, 2017].

[16] F. Cheng, S. Geertman, M. Kuffer, Q. Zhan, "An integrative methodology to improve brownfield redevelopment planning in Chinese cities: A case study of Futian, Shenzhen. Computers," Environment and Urban Systems, vol. 35, pp. 388–398, Jun. 2011.

[17] L. Žukovska, "Degradēto būvju un teritoriju novērtēšanas metodikas izstrāde un aprobācija Cēsu pilsētā", Maģistra darbs, Latvijas Universitāte, Rīga, 2013.

[18] M. Chrysochoou, K. Brown, G. Dahal, C. Granda-Carvajal, K. Segerson, N. Garrick, A. Bagtzoglou, "A GIS and indexing scheme to screen brownfields for area-wide redevelopment planning," Landscape and Urban Planning", vol. 105, pp. 187–198, Jan. 2012.

[19] Trošimovs, "Ieteikumi Daugavpils pilsētas telpiskās attīstības perspektīvas izstrādei," Maģistra darbs, Daugavpils Universitāte, Daugavpils, 2014.

[20] A. S. Abd Elrahman, "Redevelopment Aspects for Brownfields sites in Egypt," Procedia Environmental Sciences, vol. 34, pp. 25–35, 2016.

[21] L. Loures, E. Vaz, "Exploring expert perception towards brownfield redevelopment benefits according to their typology," Habitat International, to be published, pp, 1–11, 2016.

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Assessment of Geodiversity as Tool for Environmental Management of Protected Nature areas in South-Eastern Latvia

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Abstract. The environmental management and nature protection policy in Latvia is mainly focused on biodiversity and protected species, while a geodiversity is 'forgotten side' of nature conservation work. Such situation is associated with an absence of a unified methodology for assessment of geodiversity, which is a shortened version of the term 'geological and geomorphological diversity'. The concept of geodiversity, as well the quantitative assessment of abiotic nature values is successfully used in the last decade. However, it has not yet been applied in Latvia for purposes of environmental management. Considering that the aim of this study was to apply the methodology described in the scientific literature for the assessment of geodiversity index in the GIS environment. The estimating of geodiversity was performed in two protected nature areas in south-eastern Latvia, i.e. nature reserve "Pilskalnes Siguldiņa" and geological nature monument "Adamovas krauja". The calculations of geodiversity index were done based on the components as geological data, landform units, morphogenetic processes, hydrological features and terrain roughness. The input data were processed, and numerical methods that analyze spatial data in regular grid format were applied in ArcGIS. The output data on the spatial variability of geodiversity index were reclassified in three classes in order to identify areas with low, medium and high geodiversity respectively. The assessment of geodiversity by quantifying the spatial distribution of geodiversity index can be used as a tool for environmental management of protected nature areas and spatial planning, allowing to identify places with high potential value and to prevent their transformations.

Keywords: geodiversity, environmental management, protected nature areas, geodiversity index, GIS.

I. INTRODUCTION

Nature heritage and diversity including both biotic and abiotic components is the essential renewable resource of Latvia because it determines the wide diversity of physical backgrounds for development and evolution of landscapes. Simultaneously the geological and geomorphological settings, combined with the variability of hydrological features, soils and topography are at the basis of the ecosystem services [1]. This concept that diversity of abiotic elements is fundamental for many key ecosystem functions and underpins a variety of the different types of ecosystem service has been approved by scientists around the world [2] – [5].

Despite that recognition of the importance of geological and geomorphological diversity at a policy level in Latvia remains low, and so far it is insufficiently integrated within the environmental management and protection planning processes. Hence nature conservation measures in Latvia is mainly focused on biodiversity and protected species [6], [7] while a diversity of elements of abiotic nature figuratively is 'forgotten side' of nature conservation work. This situation is caused by several reasons, e.g. lack of data, insufficient "geo-literacy" of most policy makers and planners, deficiency of standardized criteria and absence of a unified methodology for assessment of geodiversity.

The term 'geodiversity' is a shortened version of 'geological and geomorphological diversity' and in such meaning was first used in 1993 [8], following the Rio Summit or United Nations Conference on Environment and Development in 1992, where international agreement on the Convention on Biodiversity was accepted. Subsequently, the term of geodiversity has been defined as "the natural range (diversity) of geological (rocks, minerals, fossils), geomorphological (landform, processes) and soil features" [9]. Later, the definition was broadened to include also hydrological and topographic elements [10], [11] and currently it is interpreted by the scientific community as the abiotic equivalent of biodiversity. Similarly to biodiversity, geodiversity belongs to Earth's nature heritage or geoheritage which must be protected and preserved for next generations [9], [11], [12].

The concept of geodiversity is successfully used in the last decade in many countries for developing a new paradigm in geosciences, and as a new domain of research, protection of abiotic nature values and

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conservation of geoheritage [10], [14], [15]. However, despite widespread use and recognition of the concept, less progress has been achieved in assessment, quantification, and mapping of geodiversity. Although a review of the literature indicates that many scientists have acknowledged the relevance of geodiversity evaluation [9], [16], [17], hitherto comparatively small amount of studies have been dealt with the methodological issues.

Assessment and mapping of geodiversity and its elements within particular areas have been performed for a variety of purposes, and therefore approaches and methods of visualization are rather manifold. Though, regarding the content of study presented in this paper, in the literature there are examples of the application of geodiversity mapping for the quantitative assessment and geospatial representing of abiotic nature values. Such an approach is useful in order to provide efficient management and planning of the geoconservation in protected nature areas [18] – [21]. At the same time, it is also an additional tool which can be in principle used both in protected nature territories and outside them to identify areas with a high value of the abiotic nature elements. It, in turn, can serve for purposes of territorial planning and management, allowing to highlight potential sites of geotourism and to improve the conservation of geoheritage. However, the studies on geodiversity and its quantification have not yet been applied in Latvia for purposes of environmental management of protected nature areas. Considering that the aim of this study was to apply the methodology described in the scientific literature for the assessment of geodiversity index in the Geographic Information Systems (GIS) environment.

II. MATERIALS AND METHODS

The results presented in this paper are based on data obtained in the course of desk-based studies, field surveys and application of GIS tools of geospatial analysis and visualization of georeferenced data. The estimating of geodiversity was performed in two protected nature areas in south-eastern Latvia, i.e. nature reserve “Pilskalnes Siguldiņa” and geological nature monument “Adamovas krauja” (Fig. 1). The selection of both areas as model territories for research purposes was determined by the following reasons: (i) diversity of geological, geomorphological, hydrological features and processes located within a small area; (ii) presence of abiotic nature objects and formations which correspond to the status of national or local geological-geomorphological nature monuments and (iii) availability of data for development of high-resolution digital elevation models (DEM).

Among others, one of the widely used methods for assessing the diversity of abiotic nature elements is based on calculations of geodiversity index (GI). Such an index indicates a geographic distribution of geodiversity on a particular territory, and at the same time implicitly provides the information for the evaluation of the variability of abiotic elements.

The most of the studies that apply GI as a quantitative and qualitative indicator of geological and geomorphological diversity are based on a concept originally published by Serrano and Ruiz-Flaño [22] and later developed by other geoscientists [23]. For purposes of GI calculations and visualization of obtained data, the application of GIS appears the most appropriate analytical tool that can compute the spatial relationships among abiotic elements of geodiversity, hence allowing to define indices in numerical form [24]. Considering that, the ESRI ArcGIS 10.0 software package with Spatial Analyst and 3D Analyst extensions was selected for processing of data and assessment o and visualization of GI values.

According to data given in the literature [20] the formula (1) for GI assessment is the following:

$$GI = \frac{\left[\left(\sum_{i=1}^{n} V_i\right) + \left(\sum_{i=1}^{n} Gm_i\right)\right]\left(\frac{S_a}{P_a}\right)}{\ln S_a} \qquad (1)$$

where V_i is variability of each abiotic element that contributes to GI assessment and has continuous character regarding its geospatial distribution, i.e. this element can be identified everywhere within the study site, covering entire area (e.g. soils, superficial sediments and rocks, topography); Gm_i is each geomorphological, hydrological or geological feature (object or process) that contributes to GI assessment and has discrete character regarding its geospatial distribution, i.e. this element is discontinuous – either presented or not at any given spot within the study site (e.g. erratic boulders, springs, streams, morphogenetic processes); S_a is surface area of the real topographic surface of DEM raster; P_a is planimetric area of projection of DEM raster to horizontal plane.

The input data used to calculate V_i in (1) include the following elements: geological data on the geographic distribution of Quaternary sediments; landform units; slope gradients and soils. The data on the geological substratum, geomorphology and soils were obtained during field surveys and manually digitised by ArcGIS tools. Each thematic layer in vector format was converted into ESRI format regular grid by cell resolution 1 x 1 m. Slope gradient data were calculated with the DEM using slope function in ArcGIS. Thereafter the geographic variability of the each continuous element was calculated in a moving window with a circle of radius 3 m, applying neighborhood analysis and a focal statistics functions in ArcGIS.

The input data used to calculate Gm_i in (1) include the following elements: places of occurrence of morphogenetic processes, e.g. gully erosion, lateral erosion, landslides, accumulation; outcrops of

Quaternary strata; erratic boulders; objects and formations corresponding to the status of national or local geological-geomorphological nature monuments, e.g. outcrop of interglacial peat, boulder pediments, outcrops of Devonian strata; hydrological objects – streams, lakes, springs; particular landforms – landslide cirques, gullies, glaciokarst kettles.

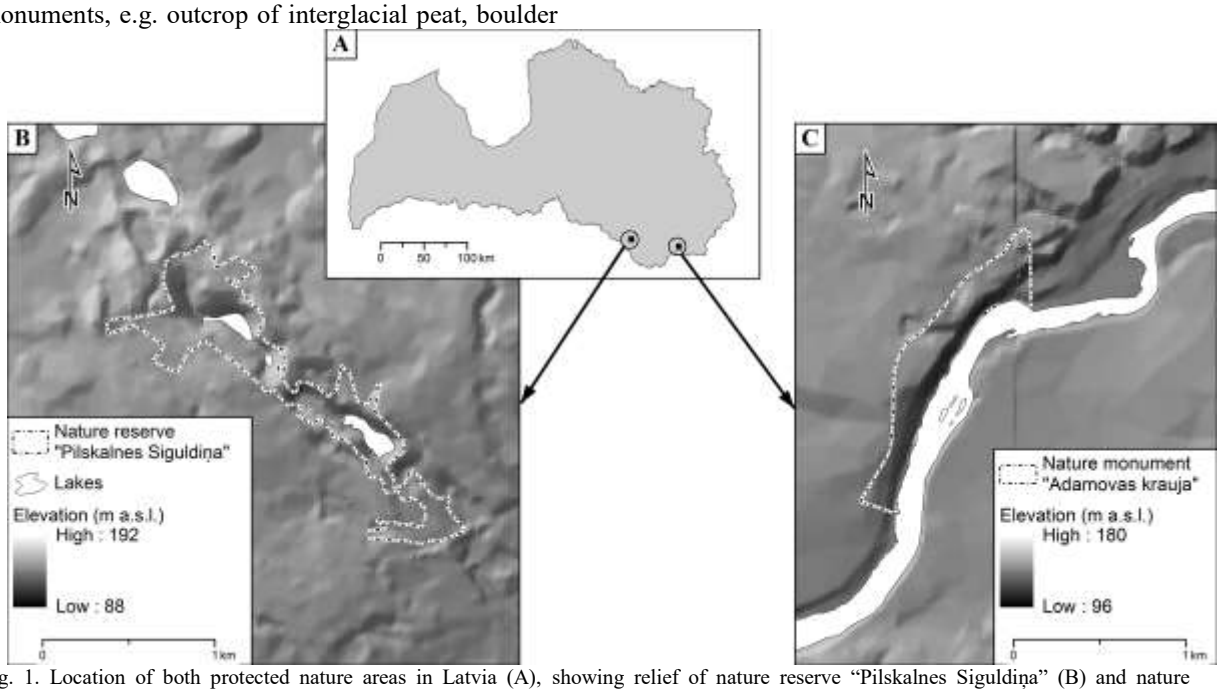

Fig. 1. Location of both protected nature areas in Latvia (A), showing relief of nature reserve "Pilskalnes Siguldiņa" (B) and nature monument "Adamovas krauja" (C) by a shaded DEM in the background.

The data on above-mentioned discontinuous geological and geomorphological elements of GI assessment were obtained during field surveys, and their position was recorded by high precision GPS TRIMBLE Pathfinder ProXRT. The GPS survey data were integrated into ArcGIS and converted to thematic layers. The data on hydrological elements were obtained from orthophoto maps and manually digitised at scale 1 : 500. Considering that some of the discontinuous elements regarding their geometric representation (i.e. points and polylines) in GIS environment have not area, before the spatial analysis of this kind of data the buffers were generated. The width of buffer zones was chosen according to requirements of national legislation and official regulations on protected nature objects, i.e. 10 m. It allows to obtain features of polygon type. Thereafter Gm_i elements were merged and similarly to V_i elements converted into ESRI format regular grid by cell resolution 1 x 1 m. Subsequently, the geographic variability of the discontinuous elements was calculated.

For the obtaining of S_a and P_a data, high-resolution DEM was developed, which was compiled both from topographic maps with contour interval 2 m (in a case of nature reserve "Pilskalne Siguldiņa") and airborne LiDAR data (in a case of nature monument "Adamovas krauja"). These both parameters enhance the role of terrain roughness in the assessment of geodiversity. In this case areas with high values of terrain roughness or ratio S_a / P_a allow to find places where the amplitude of elevation alternates in a short distance. Usually, it indicates a higher intensity of geomorphological processes, a higher density of erosion network, and as a result – higher values of geodiversity.

For quantification of terrain roughness, the S_a and P_a values for each cell of DEM grid were computed using the free tool "Surface Area and Ratio", which is developed for application in ArcGIS environment [25.] From these data topographic index was calculated as ratio S_a / P_a by raster calculator tool. This ratio is used by geoscientists as an indicator of topographical irregularity and density of landforms per unit area in given territory [22].

Considering that each element produces a variety raster with a range of values different from the ranges obtained for the other abiotic element, raster data of each element of GI calculation were reclassified into five classes according to Jenks' algorithm and relative values were attributed to provide the compatibility of different data layers. It was done also for purposes of better perception of visualized geospatial data in ArcGIS environment and more accurate recognition of possible regularities on the geographic distribution of all V_i and Gm_i variables.

After that the calculations of geodiversity index were done by applying the formula (1) in a procedure of spatial analysis, overlaying all the datasets and performing mathematical operations by raster calculator tool in ArcGIS. The output data and resulting maps on the spatial variability of geodiversity index were reclassified into five classes

in order to identify areas with very low, low, medium, high and very high geodiversity respectively.

Finally, the nature management plans and supplementary maps of nature reserve "Pilskalnes Siguldiņa" and geological nature monument "Adamovas krauja" were examined and compared with the obtained maps of GI of both territories in order to evaluate the conformity of environmental management issues with the real situation and location of areas characterised by high geodiversity.

III. RESULTS AND DISCUSSION

The results obtained by assessment and mapping of GI and associated field studies carried out in nature reserve "Pilskalnes Siguldiņa" and geological nature monument "Adamovas krauja" indicate that the both areas have high geodiversity and geoheritage potential, respectively, a high concentration of abiotic nature elements of geoheritage significance. A variety of landforms, geological and hydrological objects, processes, diversity of other factors in terms of their morphology, origin, intensity, structure and intrinsic scientific or scenic/landscape value are identified within relatively small areas.

Analysis of data and mapping results allow distinguishing in both protected nature areas among others two main landforms, which are the most remarkable and important as geodiversity determinants. In the nature monument "Adamovas krauja" it is the Upper Daugava spillway valley but in nature reserve "Pilskalnes Siguldiņa" – subglacial tunnel valley. Both aforementioned geomorphological features actually underpin geodiversity in the sites under study, because occurrence and location of all other elements are directly associated with these negative medium to large scale landforms.

The Upper Daugava spillway valley, as the largest and most complex geomorphic unit in the nature monument and, in a broader context, also in the "Daugavas loki" nature park, should be included in the list of objects of geoconservation significance. This terraced valley was initially formed by glacial meltwater streams towards the end of Late Weichselian deglaciation and subsequently modified by fluvial processes in the Holocene. Despite the fact that currently the spillway valley is located within protected nature area, existing protection regulations provide conservation mainly of elements of biodiversity, but not the valley in its entirety. The spillway valley is a significant geosite, and at the same time regarding its scientific and paleogeographic significance, as well as and scenic and landscape values, it is one of the most remarkable river valleys in Latvia.

Regarding their contribution to the geodiversity, particularly due to high impact on the terrain roughness, among second grade, smaller scale geomorphological elements permanent gullies should be noted. In both nature areas gullies are widely distributed and deeply dissect the slopes of larger landforms, creating dense erosion network of temporal watercourses. Although the topographical irregularity determined by linear erosion network, in general, is an important contributing factor to the geodiversity in both areas; nevertheless, gullies itself as landforms within areas under study do not correspond to the status of objects of geoconservation significance. Their importance, in this case, should be noted in another context, i.e. gullies underpin the development of protected habitats of EU importance (Fig. 2) and hence contribute to the biodiversity of protected areas.

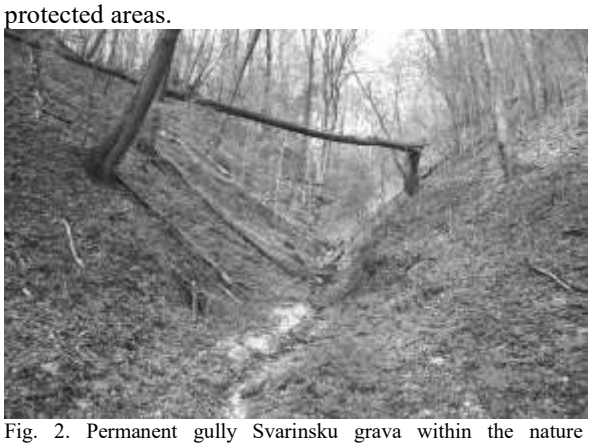

Fig. 2. Permanent gully Svarinsku grava within the nature monument "Adamovas krauja". Despite the comparatively low contribution to the geodiversity, such landforms have to be valued regarding biodiversity, e.g. due to the presence of protected habitats of EU of Habitats Directive like "9180 Tilio-Acerion forests of slopes, screes, and ravines".

All other geomorphological features as elements with intrinsic characteristics of spatial discontinuity, e.g. glaciokarst kettles, boulder pediments, places of groundwater outflow and springs, landslide cirques, etc. have no significant impact on the GI values. There is a twofold explanation for this established recognition: (i) one that these features have rare occurrence; hence they contribute to the geodiversity only in some particular locations; and, (ii) more feasible one that due to their small dimensions these features determines geodiversity indices only in some cells of maps; hence some tens of pixels even with high GI, in general, do not affect significantly the assessment of geodiversity at the scale used for elaboration of GI maps.

Analysis of the morphogenetic processes reveals that among others, development of mass movement processes is the most common ones both in nature reserve "Pilskalnes Siguldiņa" and geological nature monument "Adamovas krauja". Typically results of these processes can be observed as shallow and rotational landslides, earth-flows, and slumps on the slopes of river terraces and negative landforms (Fig. 3).

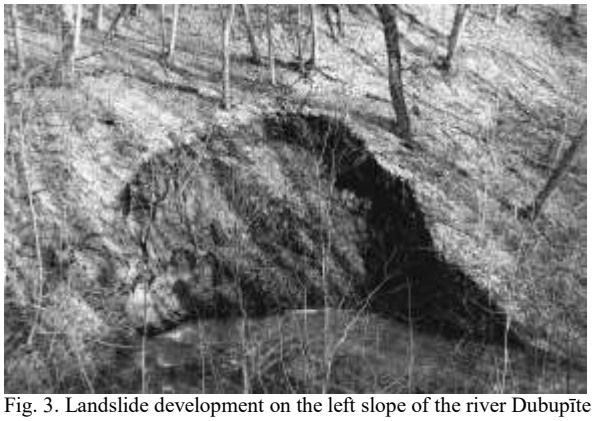

Fig. 3. Landslide development on the left slope of the river Dubupīte Valley, nature reserve "Pilskalnes Siguldiņa", as a typical example of morphogenetic processes contributing to the geodiversity.

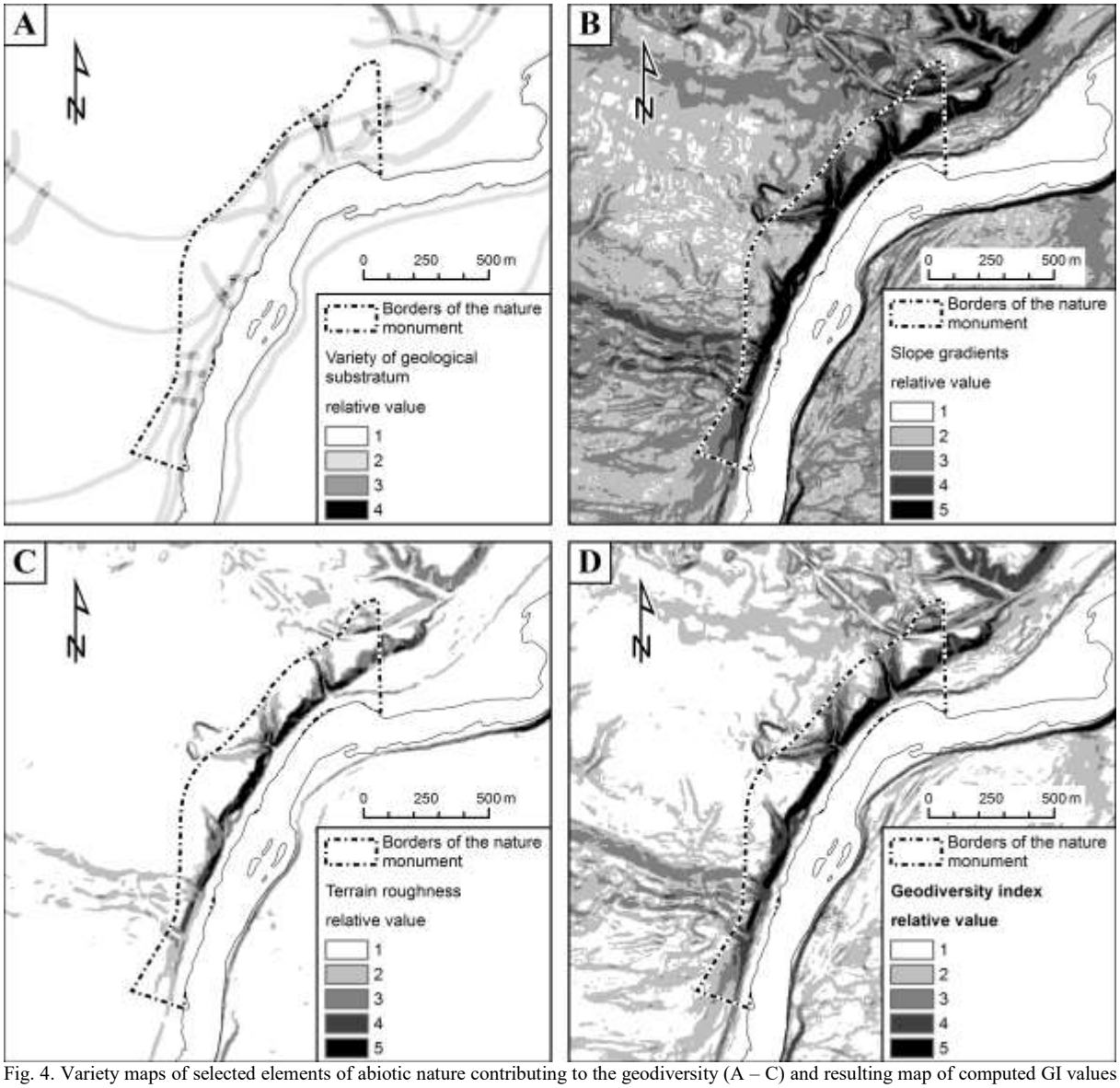

Fig. 4. Variety maps of selected elements of abiotic nature contributing to the geodiversity (A – C) and resulting map of computed GI values in grid format (D): an examples of nature monument "Adamovas krauja". Geographic distribution of geological factors (A), slope gradients (B) and terrain roughness indices (C) within the territory of the nature monument and areas adjacent to it. Geographic distribution of GI values, showing the results of quantification and assessment of geodiversity (D), colours indicate the variety, which increases from class 1 (the lowest values) to class 5 (the highest values).

The wide distribution of mass movement processes is an excellent mark of the past and present a geological and geomorphological evolution of landscapes in protected nature areas indicating that development of abiotic nature elements and diversification of environment is still active. Therefore, the geomorphological evolution contributes to the increase of GI within the sites under study.

The relatively small geological features contributing to the geodiversity like outcrops of Quaternary strata, erratic boulders, objects and formations corresponding to the status of national or local geological-geomorphological nature monuments, e.g. outcrop of interglacial peat and outcrops of Devonian strata, similarly to the most of discontinuous geomorphological features have no significant impact on the GI values at a scale of mapping (Fig. 4). It is not consistent with the uniqueness and very high scientific values of these features hence indicating the discrepancy between the expectations based on the traditional notion and the computed values of GI. However, this fact has the same feasible explanation as in a case of geomorphological features, which is discussed previously.

The geospatial analysis of variability of abiotic elements with characteristics of spatial continuity, i.e. geographic distribution of Quaternary sediments, surface roughness, slope gradients and soils as determinants of GI reveals, that the topographic factors have the highest relative weight as determinants of geodiversity, hence to the great extent affecting the assessment of GI (Fig. 4).

Geostatistical analysis of the geographic distribution of the high and very high values of GI indicate that areas of high geoheritage significance have rather low proportion in comparison to lower ones (Fig. 4).

Finally, the examination of existing documents of the nature management plans and supplementary maps of both nature reserve "Pilskalnes Siguldiņa" and geological nature monument "Adamovas krauja" show that environmental management issues in general outlines conform to the location of areas characterised by high geodiversity. However, there are GI high-valued spots which are located outside the protected areas; hence they have not protection status.

IV. CONCLUSIONS

The results of the studies presented in this paper permit to draw several important conclusions about the geodiversity of nature monument "Adamovas krauja" and nature reserve "Pilskalnes Siguldiņa", as well as about the assessment of geodiversity as a tool for environmental management of protected nature areas.

The most important abiotic elements with higher impact on the quantification of geodiversity are topographic factors, widely distributed landforms and morphogenetic processes, whilst many geomorphological and geological features with characteristics of spatial discontinuity are less significant.

The GI is the sum of the variety of each element taken into account in the process of raster calculation. However, in order to obtain a more reliable assessment of geodiversity, it is necessary to consider more complex mathematical apparatus instead of summing of inputs. It will allow taking into account also that features which have dimensions of only some meters or some tens of meters, but at the same time these features are the objects of geoconservation and geoheritage significance due to their uniqueness, paleogeographic, environmental or stratigraphic context. Otherwise, these discontinuous elements of geological and geomorphological diversity cannot be easily distinguished on the background patterns dependant mainly on the elements with characteristics of spatial continuity.

The obvious deficiency of the assessment of geodiversity by calculation and mapping of GI is that obtained results are dependent on scale, while *in situ* geodiversity of a particular location is scale independent.

Despite this imperfection, the method of GI quantification can be successfully applied for purposes of environmental management of protected nature areas, allowing to identify areas as targets for conservation and protection of geodiversity and geoheritage in Latvia. Hence such approach allows to come up with answers to key questions addressed by representatives of local authorities and decision makers to nature experts: what objects of abiotic nature, where and why should be protected.

REFERENCES

[1] R.S. De Groot, B. Fisher, M. Christie, J. Aronson, L. Braat, R. Haines-Young, I. Ring Integrating the ecological and economic dimensions in biodiversity and ecosystem service valuation. In: Kumar P.(Ed.), *The Economics of Ecosystems and Biodiversity (TEEB): Ecological and Economic Foundations*. London: Taylor & Francis. 2010, pp. 9-40.

[2] M. Gray Other nature: geodiversity and geosystem services. *Environmental Conservation* 38. 2011, pp. 271–274.

[3] M. Gray Valuing geodiversity in an 'ecosystem services' context. *Scottish Geographical Journal* 128. 2012, pp. 177–194.

[4] J.E. Gordon, H.F. Barron, J.D. Hansom, M.F. Thomas Engaging with geodiversity – why it matters. *Proceedings of the Geologists' Association* 123. 2012, pp.1–6.

[5] C.C.D.F. van Ree, P.J.H. van Beukering. Geosystem services: A concept in support of sustainable development of the subsurface. *Ecosystem Services* 20. 2016, pp. 30-36.

[6] E. Muižniece, J. Soms. A geomorphological approach for enhancing environmental management and conservation of landforms as protected nature objects in the Upper Daugava spillway valley. In: Proceedings of the 10th International Scientific and Practical Conference "Environment. Technology. Resources". Vol.2. 2015, pp.225-231.

[7] Soms J., Muižniece E. Landforms and Geological Objects of Geoconservation Significance in the Nature Park „Daugavas loki", Latvia. In.: Abstracts of the VIII International ProGEO Symposium 'Geoconservation Strategies in a Changing World'. Reykjavik, Iceland. ProGEO. 2015, pp.98-99.

[8] C. Sharples. A Methodology for the Identification of Significant Landforms and Geological Sites for Geoconservation Purposes. Report to Forestry Commission, Hobart, Tasmania. 1993, 31 pp.

[9] M. Gray *Geodiversity: Valuing and Conserving Abiotic Nature*. Chichester: John Wiley & Sons. 2004, 448 pp.

[10] M. Gray. Geodiversity: developing the paradigm. *Proceedings of the Geologists' Association* 19. 2008, pp. 287–298.

[11] M. Gray. *Geodiversity: Valuing and Conserving Abiotic Nature*, 2nd ed. Chichester: Wiley-Blackwell. 2013, 508 pp.

[12] ProGEO. Conserving our Shared Geoheritage – A Protocol on Geoconservation Principles, Sustainable Site Use, Management, Fieldwork, Fossil and Mineral Collecting. 2011, 10 pp.

[13] L. Erikstad. Geoheritage and geodiversity management – the questions for tomorrow. *Proceedings of the Geologists' Association* 124. 2013, pp.713-719.

[14] E. Reynard, P. Coratza. Geomorphosites and geodiversity: a new domain of research, *Geographica Helvetica* 62. 2007, pp. 138–139.

[15] M. H. Henriques, A.O. Tavares, A.L.M. Bala. The geological heritage of Tundavala (Angola): An integrated approach to its characterisation. *Journal of African Earth Sciences* 88. 2013, pp. 62-71.

[16] E. Reynard, M. Panizza. Geomorphosites: definition, assessment and mapping. *Géomorphologie: relief, processus, environnemen* 3. 2005, pp. 177-180.

[17] P. Pereira, D.I. Pereira, M.I.C. Alves. Geomorphosite assessment in Montesinho Natural Park (Portugal). *Geographica Helvetica* 62. 2007, pp.159-168.

[18] R. Pellitero, M.J. González-Amuchastegui, P. Ruiz-Flanõ, E. Serrano. Geodiversity and geomorphosite assessment applied to a natural protected area: the Ebro and Rudron gorges Natural Park (Spain). *Geoheritage* 3. 2011, pp.163–174.

[19] E. Serrano, J.J. González-Trueba. Assessment of geomorphosites in natural protected areas: the Picos de Europa National Park (Spain). *Géomorphologie: Relief, Processus, Environnement* 3. 2005, pp. 197–208.

[20] L. Melelli Geodiversity: a new quantitative index for Natural protected areas enhancement. *GeoJournal of Tourism and Geosites* 13. 2014, pp. 27-37.

[21] A.M. Martinez-Graña, J.L. Goy, C. Cimarra. 2D to 3D geologic mapping transformation using virtual globes and flight simulators and their applications in the analysis of geodiversity in natural areas. *Environmental Earth Sciences* 73. 2015, pp. 8023–8034.

[22] E. Serrano, P. Ruiz-Flaño. Geodiversity: a theoretical and applied concept. *Geographica Helvetica* 62. 2007, pp.140–147.

[23] Z. Zwoliński, A. Najwer, M. Giardino. Methods of geodiversity assessment and theirs application. Geophysical Research Abstracts Vol. 18, EGU2016-15434, 2016.

[24] L. Melelli, M. Floris. A new Geodiversity Index as a quantitative indicator of abiotic parameters to improve landscape conservation: an Italian case study. Geophysical Research Abstracts Vol. 13. EGU2011-13881, 2011.

[25] J.S. Jenness. Calculating landscape surface area from digital elevation models. *Wildlife Society Bullettin* 32. 2004, pp.829-839.

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Diseases Diversity for Flax Genetic Resources in Latvia

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Abstract. Flax (Linum usitatissimum L) yield of stem and seeds and them quality is influenced by a number of harmful diseases but investigation about pathogens in recent years have not been done in Latvia. Each stage of development of disease is important in the pathogen life cycle and requires certain condition. Goal of this study have identify possibilities of the pathogens and were assess disease severity depending on the genotypes on flax in variable environmental conditions. The resistance to the diseases for 24 flax genotypes and standard variety 'Vega 2' were evaluated. The field trials have been carried out over the period from 2015 to 2016 at the Research Centre of Priekuli, part of Vilani in Latgale. Disease progress was measured every week, and for each treatment, severity of diseases index and the area under the disease progressive curve (AUDPC) were calculated. The flow cytometry method for detection of flax pathogens was developed. The Fusarium avenaveum was dominating disease and statically significant in both vegetation periods. In 2015 were identified statically significant (p<0.001) highest AUDPC the casual agents powdery mildew (Oidium lini) and of stem break and browning caused by Polyspora lini but in 2016 anthracnose (Colletotrichum lini), pasmo (Septoria linicola) and fusarium wilt caused by fungus Fusarium oxysporum f. sp. lini. The resistance of Colletotrichum lini, Fusarium oxysporum f. sp. lini, Septoria linicola and Oidium lini have flax variety of 'Rezekne' in both years.

Keywords: AUDPC, diseases, flax, flow cytometry, pathogens.

I. INTRODUCTION

Flax (*Linum usitatissimum* L) is an important crop whose seed oil and stem fibre have multiple industrial applications.

Diseases of flax can be divided into two groups: the first group includes roots mycosis and diseases caused by soil resident fungi as *Fusarium oxysporum* f. sp. *lini*, *Fusarium avenaceum*, *Septoria linicola* as well *Polyspora lini*. The second group includes diseases of stems and leaves as *Oidium lini* and *Colletotrichum lini*. All detected fungus of flax is economically important diseases that can result in severe yield losses.

Fusarium wilt is the most frequently encountered disease in most countries in Europe, causing loss of 80 - 100% of yield [1], [2]. Another dangerous disease of fibre flax is anthracnose, which is caused by *Colletotrichum lini* [3]. It occurs all over the world in regions where flax is cultivated as Byelorussia, Czech Republic, Lithuania, Ukraine and France [4]. Occurrence of *Oidium lini* also known as powdery mildew was detected in 50 – 60% of cases in the last century in England and Germany especially connected with the decrease of yield in the range 5 - 20% [4]. Recently, pasmo caused by *Septoria linicola* and powdery mildew have been widespread causing local disease epidemics in Western Canada [5]. In Poland, pasmo was a quarantine disease until recently, and so does not occur there [6].

The most commonly practiced disease control method is the use of resistance varieties combined with effective crop rotations [7]. However, the resistance among varieties can differ due to the variability of pathogen races in different geographical regions with varying temperatures and environmental conditions [8]. High plant density on the field (1800 plants m^{-2}) creates microorganisms and promotes infections and the development of diseases [4].

Progress of disease on plants is usually observed several times during pathogen epidemics. Extent of disease is assessed at each observation using scales that are based on disease incidence, severity, or a combination of both. To combine these repeated observations into a single value, Van der Plank (chapter 12 of literature citation 13) proposed calculating the area under the disease progress curve (AUDPC) [9] for summarizing and comparing plant disease epidemics.

The flow cytometry has been applied to address questions in infection biology [10] and it is still a relatively new technique for plant disease detection application [11]. In this research used for analysed questions related to intracellular infection for cell counting and sorting, biomarker detection. This might be solution that could help them identify pathogen

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infections in crops in a rapid, real-time and non-destructive fashion so that timely intervention and preventative treatments can be performed to contain the infection and minimize the crop losses.

Aim of this study was to determine diseases diversity for flax genetic resources by used calculating the area under the disease progress curve for each causal agent and developed flow cytometry methods for detection of flax pathogens.

II. MATERIALS AND METHODS

A. Field experiments

The field trials were conducted over the period from 2015 to 2016 at the Research Centre of Priekuli, part of Vilani in Latgale. Plants were grown in random block plots 1 m^2 with a distance between rows 10 cm, 1700 flax seeds per 1 m^2 were sown by hand with sowing depth 1.5 - 2 cm. Prior to that sowing seeds' germination tests were performed for all used genotypes. Seeds were sown between 1st and 2nd decades of May. Flax was grown in humi-podzolic gley soil. The main agrochemical parameters of the arable soil layer were following: humus content – 6.5%, 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 (by results of State Plant Protection Service). Complex fertilizer NPK 16:16:16 - 300 kg ha^{-1} was applied after first soil cultivation. For plants' further development a surface fertilizer – ammonium nitrate 30 kg N ha^{-1} in "fir tree" phase was applied.

B. Evaluated diseases for flax varieties and lines

Experimental material for the present study consisted of 24 Latvian origins flax lines, varieties and all results was compared with standard variety 'Vega 2'.

The causal agent is the fungus were assessed for 30 plants of flax at the 1 m^2 plots, every seven days till flax pulling and by estimating the disease severity index. Disease incidence was estimated by visual symptoms. The affected plant parts were stored in a wet chamber, and after emergence of mycelium the samples were examined with light microscope methods. The disease severity was recorded by following a five-point scale: 0 – healthy plant; 1 – weakly affected; 2 – moderately affected; 3 – heavily affected; 4 – very heavily affected or dead plant. Disease severity index was calculated by applying formula (1):

$$I = \frac{\sum(ab) \times 100}{A \cdot S} \qquad (1)$$

Where I – disease severity index %, a – number of infected plants, b – degree of infection, A – total number of plant samples (healthy and infected), S – the highest degree if infection [12].

The combine these repeated observations into a single value have been calculated the area under the disease progress curve (AUDPC) by applying formula (2):

$$AUDPC = \sum_{i=1}^{n-1} \frac{y_i + y_{i+1}}{2} \times (t_{i+1} - t_i) \qquad (2)$$

Where yi is an assessment of a disease (percentage) at the ith observation, ti is time (in days) at the ith observation, and n is the total number of observations [9], [13].

C. Meteorological conditions

Agro-meteorological conditions determined by ADCON installed meteorological stations which are connected to the computer program Dacom Plant Plus. Facility provides information in direct nearby field trials.

The amount of precipitation in 2016 growing period was by 45% higher and in 2015 by 6% lower in comparison to the long-term average of 311 mm (by 1. Fig.). According to the air temperature in 2015 average air temperature was 13.26°C and in 2016, it was 14.00°C, respectively, while the long-term average result is 13.00°C.

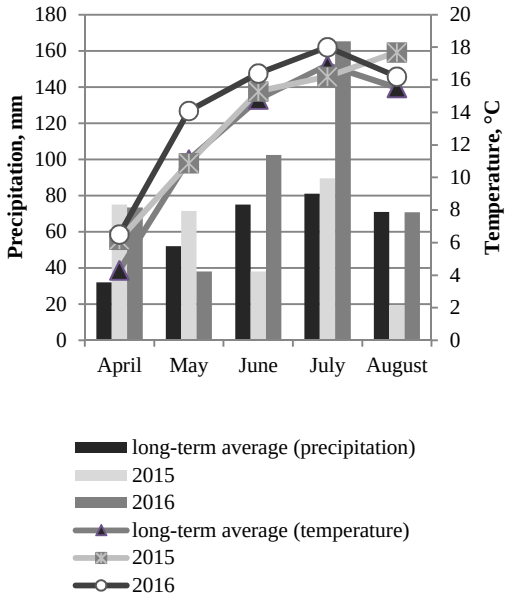

Fig. 1. 2015-2016 sum of precipitation (mm) and average of air temperature (C°) value in vegetation period of flax

D. Data analysis

MS-Excel software was used for data statistical analysis [14]. Used data analysis tools Descriptive Statistics, Anova: Single Factor and t-Test. Evaluated AUDPC for each flax disease were detected flax genotypes susceptibility level [9]. In Anova: Single Factor used Fisher's protected least significant difference (LSD) for the compare means AUDPC of genotypes.

E. Flow cytometry methods

Samples were prepared for flow cytometry with a DNA staining kit (SysmesPartec, PI Absolute, GmbH, Germany) according to protocol with some modifications. For each sample, approximately 50 mg

of dry leaf material was excised and placed into a glass Petri dish (60 x 15 mm). Dry material was chopped in 500 µL of +4 C0 cold extraction buffer. For removal of cell fragments the suspension was filtered through 40 µm filter (Falcon, USA) into a 5 mL polypropylene cytometry tube (Falcon, USA), and 1.5 mL of staining buffer was added. Cells nuclei were stained with 10 µl propidium iodide, and incubated in the dark for 24h at +4C0 before analysis by flow cytometry. BD FACSJazz® cell sorter (BD Biosciences, USA) with flow cytometer function was used to detect DNA content (C -value) of flax and flax pathogens. The device was equipped with 100 µm nozzle and used phosphate-buffered saline (BD PharmingenTM PBS, BD Biosciences, USA) as a sheath fluid. Cell counting events were triggered by forward- scattered signal. The excitation of the cell fluorescence was made by 488 nm Coherent Sapphire Solid State (blue) laser. Before measurements, flow cytometer was calibrated using SpheroTM rainbow calibration particles (3.0 – 3.4 µm, BD Biosciences, USA) in phosphate buffered saline (PBS). The calibration was considered as successful if the coefficient of variance (CV) of the calibration particles relative fluorescence did not exceed 3%.

III. RESULTS AND DISCUSSION

In the two flax sowing periods were detected six harmful flax diseases: Fusarium wilt *(Fusarium oxysporum* f. sp. *lini*) and *Fusarium avenaceum*, powdery mildew *(Oidium lini*) pasmo (*Septoria linicola),* anthracnose (*Colletotrichum lini*) and *Polyspora lini.* By Table 1 find out for *Fusarium avenaveum* and *Colletotrichum lini* statistical significant difference between genotypes but not between years.

The *Fusarium avenaceum* was observed in two vegetation period. The fungus of causal agent *Fusarium avenaveum* was dominating disease in both vegetation periods from all detected diseases of flax. The sum of AUDCP for causal agent have highest and statically significant between others diseases (at Fig. 2.). The lowest AUDCP value has flax line of 'T31-40-94' (by Table 1), who have good potential for moderately resistant. [15] reported that *Fusarium avenaceum* is a cosmopolitan plant pathogen with a wide and diverse host range and is reported to be responsible for disease on>80 genera of plants. That partially explains the high spread of diseases. By [16] the genetic foundation that allows *F. avenaceum* to infect such a wide range of host plant species and cope with such a diverse set of environmental conditions is currently not well understood.

The anthracnose (*Colletotrichum lini*) was observed in all vegetation period. The fungus of causal agent *Colletotrichum lini* was dominating disease in 2016 but for some genotypes in 2015. According [17], observation results showed that very rainy the flax stands were heavily lodged, and up to 35% of plants were affected by anthracnose.

Table I
The AUDPC average of flax lines and varieties for *Fusarium avenaveum* and *Colletotrichum lini*

No.	Variety/line	*Fusarium avenaceum*	*Colletotrichum lini*
1.	S13/5-7/5-93	168^{ab}	50^{ab}
2.	S32/4-8-93	270^{abcd}	90^{ab}
3.	S53/8-3-93	142^{ab}	5^{a}
4.	S64-17-93	204^{abc}	2^{a}
5.	T11-6/2-15-94	190^{ab}	146^{ab}
6.	T11-13/3-1-94	238^{abc}	27^{a}
7.	T25/5-33/12-8-94	175^{ab}	21^{a}
8.	T29-36/10-5-94	272^{abc}	68^{ab}
9.	T29-36/7-1-94	484^{bcd}	191^{ab}
10.	T31-40-94	136^{a}	139^{ab}
11.	T36-26/4-8-94	279^{abcd}	316^{b}
12.	K47-17/11-1-95	286^{abcd}	158^{ab}
13.	K47-17/11-6-95	219^{abc}	257^{ab}
14.	L2-14/6-97	253^{abcd}	104^{ab}
15.	L11-11/10-97	176^{ab}	231^{ab}
16.	L11-11/11-97	198^{abc}	247^{ab}
17.	L19-6/15-97	163^{ab}	155^{ab}
18.	L23-26/3-97	232^{abc}	155^{ab}
19.	L26-47/1-97	169^{ab}	205^{ab}
20.	Altgauzen	296^{abcd}	26^{a}
21.	Rezeknes	430^{bcd}	4^{a}
22.	Rota 1	375^{bcd}	70^{ab}
23.	Rota 2	219^{abc}	9^{a}
24.	Ruda 1	269^{abcd}	14^{a}
25.	ST Vega 2	230^{abc}	137^{ab}
$LSD_{0.05}$		236	259

^{abcd} Means followed by the same letters in each column are not statistically significant.

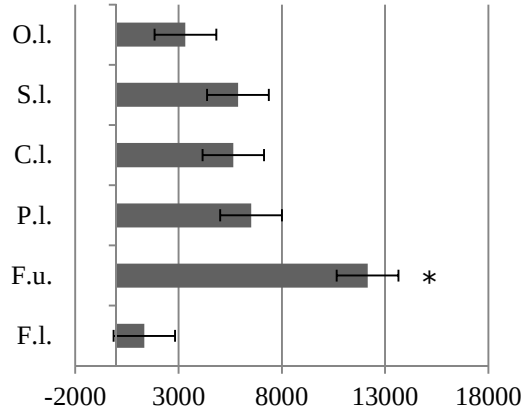

Fig.2. Summarized overview of AUDCP of 25 genotypes of flax by years. O.l. - *Oidium lini*, S.l. - *Septoria linicola*, C.l. - *Colletotrichum lini*, P.l. - *Polyspora lini*, F.u. - *Fusarium avenaveum*, F.l. - *Fusarium oxysporum* f. sp. *lini*.* - statistically significant $LSD_{0.05}$(5995)

In our case, due to the high moisture content in 2016 some genotypes by pathogens of the anthracnose had presented similar effect. By lowest AUDPC results was observed that resistant have flax line 'S64-17-93', 'S53/8-3-93' and variety 'Rezekne' in Table1.

As it is seen from Table 2 for casual agents caused by *Fusarium oxysporum* f. sp. *lini*, *Septoria linicola, Oidium lini* and *Polyspora lini* were showed

statistical significant level ($p<0.01$) between years but don't between genotypes.

The fusarium wilt *(Fusarium oxysporum* f. sp. *lini*) was observed in the germination stage during two growing periods. The weather conditions were favourable for the spread of fusarium wilt causal agent in 2016. In 2016 disease AUDCP detected statistically significant highest for all genotypes except flax variety of 'Rezekne'. That genotype shows the resistant in both years. Between diseases the pathogens has the least amount value of AUDCP.

The fungus of causal agent *Septoria linicola* was detected visual symptoms on the plants only in 2016. The disease occurred in the flowering stage. In this during of vegetation period characterized with high and of heavy rainfall by partially lodged of flax. The similar results find out [18]. By [9] flax is most susceptible to pasmo in the ripening stage under moist conditions. According to [19] pasmo is spread by pycnidiaspores that are moved primarily by splashing rain. The fungus casual agents started spread to the greens leaves and later to the stems.

Table II
The AUDPC average of flax lines and varieties for *Fusarium oxysporum* f. sp. *lini*, *Septoria linicola* *Oidium lini* and *Polyspora lini* in both years

No.	Variety/line	*Fusarium oxysporum* f. sp. *lini*	*Septoria linicola*	*Oidium lini*	*Polyspora lini*
1.	S13/5-7/5-93	12	136	33	110
2.	S32/4-8-93	23	195	60	169
3.	S53/8-3-93	42	157	85	123
4.	S64-17-93	16	104	96	179
5.	T11-6/2-15-94	14	196	60	144
6.	T11-13/3-1-94	18	117	77	126
7.	T25/5-33/12-8-94	27	27	65	189
8.	T29-36/10-5-94	12	77	96	150
9.	T29-36/7-1-94	18	214	60	91
10.	T31-40-94	34	149	69	205
11.	T36-26/4-8-94	21	23	109	170
12.	K47-17/11-1-95	23	43	97	185
13.	K47-17/11-6-95	41	174	79	118
14.	L2-14/6-97	36	112	72	124
15.	L11-11/10-97	16	19	98	100
16.	L11-11/11-97	50	41	73	87
17.	L19-6/15-97	62	121	50	70
18.	L23-26/3-97	42	95	33	58
19.	L26-47/1-97	40	14	35	54
20.	Altgauzen	36	349	68	124
21.	Rezeknes	0	0	0	141
22.	Rota 1	14	163	62	156
23.	Rota 2	11	341	49	111
24.	Ruda 1	12	34	61	137
25.	ST Vega 2	53	40	80	136
Years*		p<0.01	p<0.01	p<0.01	p<0.01

The [20] proved that the yield of susceptible varieties infected during flowering can be reduced by 75%. In our case resistant observed of flax variety 'Rezekne' in both years.

The powdery mildew *(Oidium lini*) occurred in the green ripening stage. The weather conditions were favourable for the development of fungus in 2015. In this period contributed to the spread of fungus high rainfall in June and the low and hot weather in August. By [21], [22] powdery mildew the symptoms observed in different environments alludes to the presence of different races of the pathogen. In our case, causal agent has presented similar effect. The fungus pathogen rapidly started spread at the greens leaves and later at the stems and bolls. The resistant observed for flax variety 'Rezekne' in both years. But resistant of variety 'Rezekne' is due to the short vegetation period and genotype reason. By [23] classical genetic studies identified several resistant cultivars in the European cultivars Atalante and Linda.

The fungus of causal agent *Polyspora lini* was dominating disease in 2015 which characterise most dried and highest temperature like 2016. The weather conditions were favourable for the spread of fungal in all vegetation period in both years. The fungus is slower growing and disease noticeable later when the

crop is on the advanced stage of growth [24]. The moderately susceptible has flax line of 'L26-47/1-97' and 'L23-26/3-97' against the disease.

Analysing the diverse infected parts of plants with flow cytometry method detected the presence of pathogens and their different cell size, number and position on the relative fluorescence graph. By Fig. 3 and Fig.4 find out that pathogen cells from flax infected plant material has haploid as well flax mixoploid. The specific pathogens of flax range on the graph (with P letter) by relative fluorescence units from 13^1 until 10^2 with different cell size in the Fig.3. and Fig.4.

The method for work in practice and to identify certain pathogens should to find out the specific fluorescence staining kits for identifies of the each disease characteristic position on the scale. Furthermore by [25], variations in genome size of plant pathogens can cause variation in pathogenicity and complicate the control of a disease. Our results are in agreement with [26] the correct expression of the genome size of fungi and fungus-like organisms is difficult, as they have complicated life cycles with different ploidy levels and the basic chromosome. Therefore important to take into account all of these to improve the method for flax pathogen detection.

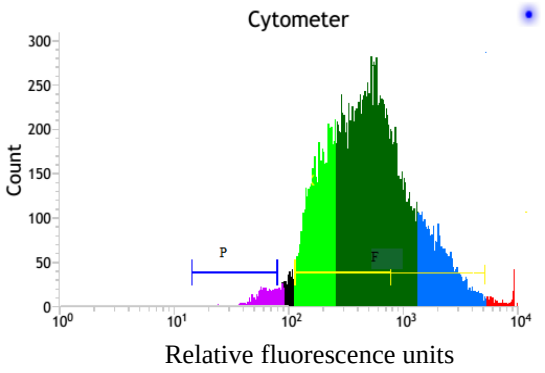

Fig 3. Graph derived from flow cytometry analysis showing relative fluorescence units (RFU) per cell. P range – pathogen and F range – flax line 'T11-6/2-15-94' plant material.

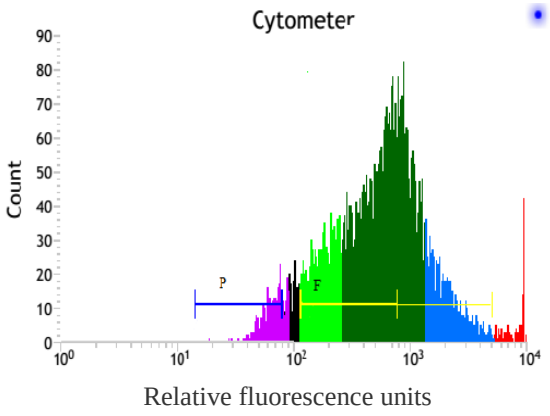

Fig 4. Graph derived from flow cytometry analysis showing relative fluorescence units (RFU) per cell. P range pathogen and F range flax line 'L2-14/6-97' plant material.

IV. CONCLUSIONS

Environmental conditions in both 2015 and 2016 were favourable for *Fusarium avenaceum* development by highest statistically significant AUDCP level between all the others diseases.

There are substantial differences in disease development and severity between years and fields due to differences in pathogen population structure, resulting variable results. By AUDCP results showed resistant from the *Colletotrichum lini*, *Fusarium oxysporum* f. sp. *lini*, *Septoria linicola*, *Oidium lini* the flax variety of 'Rezekne' by years.

Flow cytometry methods could decrease the time and effort necessary for the development of resistant genotypes in breeding programs. However, this conclusion needs to be critically tested by evaluating more comprehensive samples and varieties as well find out specific fluorescence staining kits for pathogens.

REFERENCES

[1] X. Beaudoin, Disease and pest control. In: G. Marshall (Ed.): Flax: Breeding and Utilisation. *Advances in Agricultural Biotechnology 25*, Kluwer Academic Publishers, the Netherlands, pp. 81-88. 1989.

[2] L. C. Sharma and R. L. Mathur, Variability in first single spore isolates of *Fusarium oxysporum* f.sp. *lini* in Rajastan. *Indian Phytopathology* 24:688-704, 1971.

[3] K. Y. Rashid, *Principal diseases of flax.* In: Muir, A.D., Westcott, N.D. (Eds.), Flax: The Genus Linum. Taylor and Francis Ltd, New York, NY, 2003 pp. 92–123.

[4] R. M. Kozlowski, *Hanbook of natural fibres.* Woodhead Publishing Series in Textiles: Number 118, Volume 1, 2012, pp 390 – 523.

[5] H. Booker, R. Bueckert, S. Duguid, J. Gavloski, R. Gulden, R. Dueck, … A. Ulrich, „Growing Flax Guide", 2014 Retrieved January 20, 2017from http://flaxcouncil.ca/growing-flax/growth-and development/

[6] K. Heller, *Crop management of fibre flax in Europe*, Presentation Summer school, Catania – Italy, 2013. Retrieved January 18, 2017 http://www.fibrafp7.net/Portals/0/06_Heller.pdf.

[7] L.M. Hall, H. Booker, R. M. P. Siloto, A. J. Jhala, R. J. Weselake, Flax (*Linum usitatissimum* L.) *Industrial Oil Crops*, First Edition, 2016, pp 157-194.

[8] K. Y. Rashid and E. O. Kenaschuk, *Effect of trifluralin on fusarium wilt in flax.* Can. J. Plant Sci. 1993, 73: 893-901.

[9] I. Simko and H. P. Piepho, The Area Under the Disease Progress Stairs: Calculation, Advantage, and Application *Phytopathology* Vol. 102, No.4, 2012 pp 381-389.

[10] V. Haridasa, S. Ranjbara, I. A. Vorobjevc, A. E. Goldfelda, N. S. Bartenevaa, *Imaging flow cytometry analysis of intracellular pathogens.* Methods. Volume 112, 1 January 2017, Pages 91–104 Flow Cytometry.

[11] L.G. Chitarra; van den Bulk, R.W. *The application of flow cytometry and fluorescent probe technology for detection and assessment of viability of plant pathogenic bacteria.* Eur. J. Plant Pathol. 2003, 109, 407–417.

[12] Н. И. Лошакова, Т. В. Крылова, Л. П. Кудрявцева, „Методические указания по фитопатологической оценке устойчивости льна-долгунца к болезням" – Москва,– 52 с. 2000.

[13] J. E. Van der Plank, „Plant Diseases: Epidemics and Control." Academic Press, New York. 1963.

[14] I. Arhipova, un S. Bāliņa, „Statistika ekonomikā. Risinājumi ar SPSS un Microsoft Excel." (Statistics in the economy. The solutions with SPSS and Microsoft Excel.) 2. iss. Rīga: Datorzinību Centrs, 2006, pp. 364. (in Latvian).

[15] M. C. Leach, S. L. A. Hobbs, „Plantwise knowledge bank: delivering plant health information to developing country users." Learned Publ 26: 180–185, 2013.

[16] E. Lysøe, L. J. Harris S. Walkowiak R. Subramaniam H. H. Divon E. S. Riiser C. Llorens T. Gabaldón H. C. Kistler W. Jonkers A. K. Kolseth K. F. Nielsen U. Thrane R. J. Frandsen „The genome of the generalist plant pathogen *Fusarium avenaceum* is enriched with genes involved in redox, signaling and secondary metabolism." PLoS One. 2014 Nov 19;9(11).

[17] K. Bačelis, E. Gruzdevienė, Resistance of fibre flax varieties to *Colletotrichum lini* Manns et Bolley // *Biologija*. – 2001. – Nr. 3, p. 4–7. (ISSN: 1392-0146) (http://www.elibrary.lt/resursai/LMA/Biologija/B-033.pdf).

[18] E. Gruzdevienė, The Peculiarities Of The Occurrence Of Pasmo Disease (*Septoria linicola*) In Central Lithuania *Zemdirbyste-Agriculture*, vol. 95, No. 3 (2008), p. 58–64.

[19] K. Y. Rashid, K. L. Bailey, B. D. Gossen, R. K. Gugel, and R. A. A. Morrall, Diseases of flax. Diseases of Field Crops in Canada, 3rd ed. eds. University Extension Press, Saskatoon, SK, Canada, 2003. Pages 147-154

[20] W. E. Saskston, „Pasmo – past, present, and future." In: Proceedings of the Flax Institute of the United States, November 19th, 1959, Fargo, North Dakota, U.S.A., 1959 pp. 3–5.

[21] R. E. Beale, „Studies of resistance in linseed cultivars to *Oidium lini* and *Botrytis cinerea*." Aspects Appl. Biol. 1991, 28:85–90.

[22] G. S. Saharan and M. S. Saharan, Studies on powdery mildew of linseed caused by *Leveillula taurica* (Lev.). Indian J. Mycol. *Plant Pathol*. 1994, 24:107–110.

[23] K. Rashid and S. Duguid., Inheritance of resistance to powdery mildew in flax. Can. J. *Plant Pathol*. 2005, 27: 404-409.

[24] E. Gruzdeviene, *General problems and control of fungal diseases of flax in Lithuania // Development of Environmentally Friendly Plant Protection in the Baltic Region: proceedings of the International Scientific Conference*. – Tartu, 2000, p. 40-42.

[25] R. T. Gregory, J. A. Nicol, H. Tamm, B. Kullman, K. Kullman, I. J. Leitch, B. G. Murray, D. F. Kapraun, J. Greilhuber and M. Bennet, „Eukaryotic genome size databases". Nucleic Acids Res. 35, (2007) 332– 338.

[26] L. D'Hondt, M. Höfte V. E. Bockstaele and L. Leus Applications of flow cytometry in plant pathology for genome size determination, detection and physiological status. *Molecular Plant Pathology.* 2011 pp 1-14.

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Railway Natural Industrial Complexes and their Impact on Waterbodies

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Abstract. The paper aims to investigate objects located in railway natural industrial complexes, e.g. the Kuybyshevskaya Railway within the boundaries of Samara region. The authors analyse its following characteristic properties: geometric (proximity to water bodies); intercepted (crossings with bridges or waterbodies); watercut (proximity to subsurface water outlets and high groundwater); hilly-mountainous terrain (washouts and washaways); violation of surface (water drainage from the walls, washaways of flood-prone slopes). The researchers studied a schematic map of the Kuybyshevskaya Railway and came to the conclusion that there is a considerable number of railways crossings with water objects in Samara region, Ulyanovsk region and the Republic of Tatarstan. Some of these railways crossings are located in close proximity to waterbodies. The average value of the crossings is 0.549 km for every 1 km, i.e. approximately every 500 m railway tracks cross at least one water object. It means that there is a surface run-off coming from railroad tracks and near-by territories into a waterbody every 500 m. Systematic monitoring of water pollution is performed by a considerable number (up to 20) of gauging stations located within all railroad tracks in Samara region.

Keywords: contamination, railway lines, surface runoff, water bodies crossing, spillways, bridges and river crossings.

I. INTRODUCTION

Human evolution and creation of industrial methods of economy management have led to the formation of the global technosphere, on of its elements is railway transportation. Natural environment when the elements of the technosphere are operating is the source of raw and energy resources and also space for infrastructure allocation [5]. Successful operation and development of the railway transportation depend on the condition of natural complexes, resource endowment, infrastructure development of induced environment and socio-economic environment. Joint study of the rail transport facilities and natural complexes can be defined as railway natural-technogenic complex (RNTC) followed by formation and impact on the environment [2,21,22].

Whereas, environmental conditions when dealing with RNTC objects depend on infrastructure of railways construction, production, repair and exploitation of railway equipment, manufacturing facilities, penetration level of railway equipment and other object on the railways, penetration of scholarly results in the enterprises and branch objects. Suffice to say that in the Russian Federation railway transportation use up to 7% of fossil fuels, 6% of electricity and 4,5% of timber [2,5, 11].

That is why RNTS effect level on the environment is sufficiently large. The nature of impact of transport on the nature is defined by formulation of technical factors, intensity of their impact, ecological weightage of these impacts on the environment elements [3,19,20]. Railway pollution is imposed on pollution from agro-industrial activity of enterprises and public utilities. But because of the fact that normally discharge of agro-industrial wastes is occasional and it is forbidden without purification by the Water Code of the Russian Federation and all enterprises are obliged to create and get approval for projects on the Permissible Discharge Standards into Water Bodies. Therefore, it is conceivable that impact from agro-industrial wastewaters discharge on water courses takes place, but insignificant. The calculations are usually performed according to the fishery claims taking into account water down or without it.

In this respect, technogenic impact on the environment can be local (singular factor) or complex (group of various factors) in nature. It is important to make a point of RNTC infrastructural facilities, that have constant, long-lasting-omnipresent effect on water course of the water bodies through surface plate. These effects generally characterized by different ecological hazard coefficients according to type of impact, its character and target exposure [7,9,12,18].

II. MAIN BODY. THEORY

As the major object of RNTC research the part of the Kuibyshev railway that is located in the Samara Region is considered. These parameters are shown according to specification: geometrics (proximity to water bodies); river crossings, bridges (water bodies crossing), water-flooded (proximity to subsurface

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water outlet and high subsurface water); hilly-highland country (ablations, erosions); surface drainage violation from the walls, ablations of flooded slopes.

By analyzing schematic map of the Kuibyshev railway it may be concluded that, there is a great number of railway line and water body crossings and also a close proximity of them to the water bodies in the Samara and Ulyanovsk Regions and in the Republic of Tatarstan.

For studying the fluid circuit pollution form close to the railway lines in the Samara region (figure 1) the following five directions (table 1) and groups of railway lines were selected.

According to the proposed directions consider the following parameters of these directions [10,13]: direction length across the Samara Region, number of railway line and water body crossings (including: crossing, bridges, proximity to water body, water cut, hills, slopes, highland country). (Table 2); the watercourse length along the railway lines, km; Catchment area, km2; Universal Combinatorial Impurity Index of the River (UCIIR). The parameters of given directions, taking into account the impact of the railway lines on water bodies, were developed according to the main points of the roadway and railway lines maintenance instruction [10], where maintenance conditions of subgrade, river outlets, strengthening and protective structures are characterized. Protective structures include surface waters retractors (flumes, gutterways, earth trenches); structures for subsoil water capturing and disposing (catchment, earth trenches, captures); strengthening structures (embankment walls, sea walls, wave absorbers and so on); protective structures (mudflow protection structures, landslide protection works, avalanche baffle works and so on).

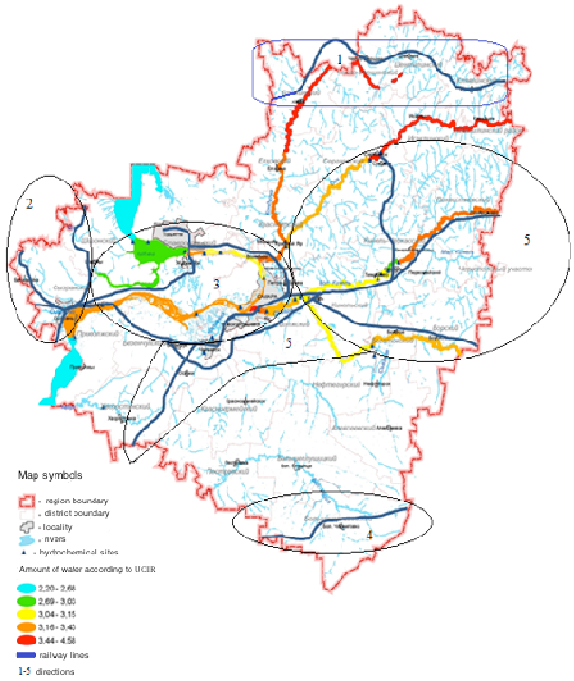

Figure 1. Railway lines direction along the Samara region and their proximity to water bodies.

Table I
Railway lines abd groups alond the samara region

№ Line	**The nearest branch OAO** «Russian Railway»	**Group of branch railway lines**
1 line	Gorkovskaya railway – branch OAO «Russian Railway»	Koshki-Klyavlino
2 line	Moscovskaya railway – branch OAO «Russian Railway»	Penza-Syzran
	Moscovskaya railway – branch OAO «Russian Railway»	Inza-Syzran
	Privolzskaya railway - Moscovskaya railway – branch OAO «Russian Railway»	Saratov-Syzran
	Gorkovskaya railway – branch OAO «Russian Railway»	Ulyanovsk-Syzran
3 line	Kuybischevskayarailway - Gorkovskaya railway – branch OAO «Russian Railway»	Syzran-Zigulesvkoye more
		Bezenchuk-Kinel
		Syzran-Samara
		Samara-Togliatti
		Timashevo-Surgut
4 line	Privolzskaya railway - Moscovskaya railway – branch OAO «Russian Railway»	Yug-N.Karmelik-Bolsheirgizskiy
5 line	Privolzskaya railway - Moscovskaya railway – branch OAO «Russian Railway»	Zvezda - Ishkovo
	Uzno-Uralskaya railway - branch OAO «Russian Railway»	Samara-Pohvistnevo
		Smishlyaevka -Borskoe

III. EXPERIMENTAL METHOD

Considered structures protect the roadbed of railways mainly focused on the influence of surface water masses, especially those located in the hilly and mountainous terrain.

It is necessary to talk about the impact of geographic location (hilly and mountainous terrain) railways choice of protective structures, which cause the interception, detention and / or redirection of surface wastewater.

Each form adjacent to or crossing the water body from the railroad tracks, and the transfer takes place flush contaminants located thereon, as well as with the right of way in the surface water body [6, 8, 14, 15].

Table II
Parameters of railway lines in Samara region

№ Line	**Group of branch railway lines**	**Section length, km**	**Crossing number pcs. on section length**	**Average crossing number on 1 km**	**The watercourse and tributaries length along railway, km**	**Catchment area, км^2**	**Traffic flow, mln. Tons**	**Universal combinatorial impurity index of the river**
1 line	Koshki-Klyavlino	198	235	0,84	137,5	2039,1	239,2	3,44 - 4,58
2 line	Penza-Syzran	25	30	0,83	35,36	1189,2	283,3	2,20 - 2,68
	Inza-Syzran	14	38	0,37	35,36	1189,2	283,3	2,20 - 2,68
	Saratov-Syzran	23	50	0,46	38,3	528,5	123,2	2,20 - 2,68
	Ulyanovsk-Syzran	85	225	0,38	55,25	1348,1	239,2	2,20 - 2,68
3 line	Syzran-Zigulesvkoye more	110	233	0,47	54,78	646,4	188,9	2,20 - 2,68
	Bezenchuk-Kinel	108	206	0,52	39,1	421,5	188,9	3,16 - 3,43
	Syzran-Samara	136	124	0,54	44,0	1130,8	188,9	3,44 - 4,56
	Samara-Togliatti	119	219	0,54	201,5	15773,9	188,9	3,44 - 4,58
	Timashevo-Surgut	84	157	0,54	-	1254,5	188,9	3,16 - 3,43
4 line	Yug-N.Karmelik-Bolsheirgizskiy	94	182	0,52	94,0	4051,4	123,2	2,20 - 2,68
5 line	Zvezda - Ishkovo	67	158	0,42	44,0	1130,8	123,2	2,20 - 2,68
	Samara-Pohvistnevo	163	236	0,69	74,1	1015,5	342,0	3,04 - 3,15; 3,16 - 3,43
	Smishlyaevka - Borskoe	100	180	0,56	174	6037,6	342,0	3,04 - 3,15
Average number		**1326**	**2271**	**0,549**				

The average crossing number for 1 km is 0.549 km, so, for every 500 m accounted for about one crossing railroad lines with a water body. Accordingly, runoff receives each 500 m in a water body with four sides, washing away polluted, which are on line and the adjacent territory, and they are transported into the reservoir and affect the quality of water composition indicators for water bodies [8.16, 17].

According to the presented table, for each selected direction was determined din of the storm-water drain and tributaries, which are designated catchment area for a single line. Selected areas can be divided into two main groups:

Within each of these groups the lines of the Samara region has a large number of (up to 20) gauging stations [1] conducting systematic monitoring of water pollution, are within each of these group lines in Samara region. For further analysis, we used the following parameters characterizing the water pollution: the concentration of suspended solids mg / l; oxidation, mg / l; sulphate concentration mg / l; copper concentration mg / l; manganese concentration mg / l.

It should be noted that the level and nature of pollution varies considerably from one to another gauging station within each of these five group lines. Therefore, the empirical mean number (characterizing

the average level of the relevant residues) and the empirical standard deviations (corresponding parameter characterizing variation within a given group of lines) were found for each of the contaminants in each of the lines the groups listed above.

The results are shown in Table 3. The average number of the corresponding parameter for the respective paths and the group and (after the sign ±) its standard deviation from the mean are given in each cell of this table.

The maximum allowable concentration is given in the last row of the table (MAC) of the respective pollution [5].

Table III
The pollutant groups and lines concentration.

Group line number	**Suspended material concentration mg/l**	**Oxidation mg/l**	**Sulphate concentration mg /**	**Copper concentration mg / l**	**Manganese concentration mg / l**
1	29±9	6,5±0,6	450±150	0,0040±0,0005	0,95±0,15
2	6±5	7,6±1,3	100±18	0,0027±0,0010	0,28±0,38
3	50±23	5,7±1,3	321±132	0,0126±0,0158	0,132±0,224
4	20±1	6,0±1,0	72±14	0,0025±0,0005	0,020±0,005
5	53±24	5,0±1,0	254±59	0,0094±0,0118	0,041±0,037
MAC solicitation	<7,25	5...10	<100	<0,0010	<0,010

Qualitative pollution level analysis corresponding to the standards for wastewater discharges into water bodies fisheries, is shown in Table 4.

In this table, sign "+" shows the cell, where pollution is mainly below the norm (the bulk of the sample corresponds to the standards), the sign "-" shows a cell in which the regulations repeatedly exceeded (that is, the bulk of the sample does not meet the standards) and sign «±» shows the cell in which the average pollution index number differs less from the than the standard deviation (obviously, in this case, an important part of the sample corresponds to the standards, and considerable - does not correspond).

Table IV
Qualitative pollution analysis

Group line number	**Suspended material concentration mg/l**	**Oxidation mg/l**	**Sulphate concentration mg /**	**Copper concentration mg / l**	**Manganese concentration mg / l**
1	-	+	-	-	-
2	±	+	±	-	-
3	-	±	-	±	-
4	-	±	+	-	-
5	-	±	-	-	±

Table 4 shows that the norm, unfortunately, is an important excess of maximum allowance pollutant concentration.

It should be noted that the level of the maximum allowance concentration in the range of different groups for various types of lines essentially impurities (sometimes many times) differ. Therefore, it is of interest groups the ranging group lines is interesting according to the degree of MAC, so asking the question of what kind of a railway groups are the most or least free from one or another type of pollution. The solution of this problem allows to find out:

- which exactly Kuibyshev Railway lines are firstly needed the environmental measures.

IV. RESULTS AND DISCUSSINGS

The results of these calculations (made under the assumption of corresponding distribution normality) are shown in Fig. 2 (a-d). In these figures, we can be seen the group railways are numbered in circles and arrows was a statistically important excess of the line pollution level one group over another (the arrow pointing from the group with a lower number of the parameter to a group with a large number of the parameter). Calculations were performed for the two levels of confidence - 68% (dotted arrows) and 95% (solid arrows). The necessity of using a relatively low confidence level of 68% is associated with a fairly high level of pollution parameters desperation within group railways. Thus, conclusions about the larger or lesser oxidation of water within different groups of

lines generally can be done only in this confidence level (assuming the correct conclusion on average two out of three). The conclusions reached at the confidence level of 95% (the correct conclusion in 19 cases out of 20), obviously, much more reliable. If the two groups of lines are not connected neither solid nor even the dotted line, it means that a statistically important difference between the groups for this type of pollution lines and almost no difference between the average accidental contamination.

The ranking group on the pollution line level is given in Table 5. In the column of the table groups of roads built by the level of contamination, from the top down, that is the most "polluted" the lines are in the upper row, and the most "pure" - at the bottom. In all cases, except the oxidation, the corresponding parameter number decreases from top to bottom. The presence (or absence) of the dividing line between the numbers of line groups implies the existence (or absence) of a statistically important (at least for a confidence level of 68%) the difference between the two. However it should be noted that the presence of groups in various lines one table cell 5 does not mean complete their identity and impossibility of their ranking within the cell. For example, between 3 and 5 groups of oxidation (second column of Table 5), indeed, there is no statistically important difference, as well as between groups 3 and 4; however, this difference is between 3 and 5 groups

This allows us to understand the ranking of tracks on the designated contamination, which allows to make more clearly conclusion about the most polluted railway line groups.

Table V
Ranking of line group on the pollution level

Suspended material concentration mg/l	**Oxidation mg/l**	**Sulphate concentration mg /**	**Copper concentration mg / l**	**Manganese concentration mg / l**
5 3	5 3 4 1	1	3 5 1	1
1		3 5		2 3 5
4		2	2 4	
2	2	4		4

According to the ranking given in Table 5 that the concentration suspended solids and oxidation ranging practically the same. We can understand that the second group of line, it ends in the line to Syzran; it does not make any important pollution in water bodies. A fifth and third are the most introduced by contamination to the make our environment more polluted. The most prosperous on the sulfates, copper and manganese concentration is fourth group of roads, the least happy is the first one. And the first line, located in the North, through which passes cargo tonnage mainly from the Urals and the Ural metallurgical company, importantly contaminated with metal salts.

The exposure level analysis of the transported cargo tonnage in five areas of several railways OAO "Russian Railways" and its comparison with the quality of water for at the universal combinatorial impurity index transit mass transfer of pollutants on water areas in Samara region.

Found communication, in consequence, the found similar things will allow to predict the maximum contamination of watercourse pollution from lines, with a choice of potentially dangerous line for the pollutants, for immediate repair or reconstruction of the protective drainage facilities.

V.CONCLUSION

It is necessary for the Kuibyshev railway (the branch of OAO Russian Railway (RR) in the Samara Region) to pay attention to the repair and reconstruction of RNTC principal objects: along spillways, small bridges and bridge crossing by railway line and water body crossings and give attention to the following (the “dirtiest” – ref. table 5) directions: the first, third, fifth, where a great number of crossings per one kilometre were identified and proved by UCIIR index.

It is advisable for the Kuibyshev railway (the branch of OAO Russian Railway (RR) in the Samara Region) to do urgent environmental action in order to prevent pollution from RNTC objects in water bodies i.e. to allocate petit combine purification plants (filter cartridges) for the surface runoff coming from the territory of railway bridges, bridge crossing, river outlets, strengthening and protective structures.

REFERENCES

[1] http://www.pogoda-sv.ru/nets/ [elektronny resurs - Gidrometeorologicheskie stantsii i posty - Samarskaya oblast] [electronic resource - Hydrometeorological stations and posts of the Samara Region].

[2] Teplykh S.Yu., Strelkov A.K. Characteristics of railroad natural-technogenic complexes. Procedia Engineering, V. 111, 2015, pp. 742-747.

[3] Strelkov A.K, Teplykh S.Yu, Bukhman N.S. Liquid filtration properties in gravel foundation of railroad tracks. Journal of Physics: Conference Series, 738(1), 2016, 012124.

[4] Bogomolov O.A. Ekonomika i ekologiya zheleznodorozhnogo transporta v sovremennyh REALIYAH [Economics and ecology of the raileay transportation in the modern world]. Internet-zhurnal Naukovedenie [Online magazine Science Studies], 1(6), 2011, pp.12-28.

[5] Gosudarstvenny doklad o sostoyanii okruzhayushchey sredy i prirodnyh resursov Samarskoy oblasti [State report on the state of the environment and natural resources of the Samara region], 2014, pp. 298.

[6] Strelkov A.K., Teplykh S.Yu., Gorshkalev P.A., Korenkova S.F., Sargsyan A.M. Opredelenie kontsentratsiy zagryazneniy v poverhnostnom stoke s zheleznodorozhnyh putey kosvennym metodom [Evaluation of pollutional load in the surface runoff coming from the railway lines using indirect method]. Vodosnabzhenie i sanitarnaya tekhnika [Water supply and sanitary engineering], 8, 2013, pp. 67-70.

[7] Strelkov A.K., Teplykh S.Yu., Gorshkalev P.A., Sargsyan A.M. Otsenka ekologicheskogo sostoyaniya tekhnicheskoy polosy otvoda [Assessment of ecological condition of strip of branch of railway tracks]. Put i putevoe hozyaystvo [Road and Track facilities], 3, 2014, pp. 31-34.

[8] Teplykh S.Yu., Sargsyan A.M. Vliyanie poverhnostnogo stoka s putey na vodnye obekty [The impact of surface runoff coming from railway lines on water bodies]. Put i putevoe hozyaystvo [Road and Track facilities], 5, 2012, pp. 27-29.

[9] Teplykh S.Yu., Sargsyan A.M. Zagryaznenie vodnyh obektov poverhnostnymi stokami s prilegayushchih putey zheleznodorozhnyh stantsiy [Pollution of the water bodies by the surface runoffs coming from the railway lines]. Vodoochistka [water cleaning], 2, 2012, pp. 31-32.

[10] TSP-544 Instruktsiya po soderzhaniyu zemlyanogo polotna zheleznodorozhnogo puti [Instruction on railway line roadway maintenance], M.,Transport, 2000, 100 p.

[11] Strelkov A.K, Teplykh S. Yu., Stepanov S.V., Sargsyan A.M. Monitoring pollution level in railroad right-of-way. Procedia Environmental Sciences, 32, 2016, pp. 147-154.

[12] Teplykh S.Yu., Sargsyan A.M. Evaluation and Prediction of Water Pollution by Surface Runoffs from Adjacent Ways of Railway Stations. IWA Regional Conference on Wastewater Purification and Reuse. 28th, 29th, And 30th of March, Heraklion, Crete, Greece, 2012, 67 p.

[13] Gorshkalev P.A., Teplykh S.Yu., Stok s zheleznodorozhnyh putey. Kompleksnaya sistema opredeleniya kachestvennyh i kolichestvennyh pokazateley (monografiya) [Surface runoff coming from the railway lines. The complex system of qualitative and quantitative indexes definition], LAP LAMBERT Academic Publishing GmbH & Co. KG, 2011, 148 p.

[14] Teplykh S.Yu., Sargsyan A.M. Rassmotrenie i prognoz zagryazneniy vodnyh obektov poverhnostnymi stokami s prilegayushchih putey zheleznodorozhnyh stantsiy [Pollution of the water bodies by the surface runoff coming from the railway lines]. IX Mezhdunarodnyy vodnyy forum. Mezhdunarodnaya nauchno-prakticheskaya konferentsiya «Voda I Dovkillya» Kiev [IX International Water Forum. International research-to-practice conference “Aqua Ukraine” Kiev], 2011, pp. 140-141.

[15] Strelkov A.K., Teplykh S.Yu., Gorshkalev P.A.. Izuchenie kachestvennyh harakteristik poverhnostnogo stoka s zheleznodorozhnyh putey [Studing quality characteristics of surface runoff coming from railways]. Urban construction and architecture, 1(9), 2013, pp.61-68.

[16] Strelkov A.K., Teplykh S.Yu., Gorshkalev P.A., Sargsyan A.M. Ekologicheskie aspekty vozdeystviya poverhnostnyh stochnyh vod s zheleznodorozhnyh stantsiy [Nature of oil pollutions oil from railways]. Urban construction and architecture, 4(13), 2013, pp.83-88.

[17] Strelkov A.K., Teplykh S.Yu., Gorshkalev P.A., Sargsyan A.M. Sovremennoe sostoyanie voprosa sbora i ochistki poverhnostnogo stoka s zheleznoy dorogi [Modern condition of the problem of collecting and purifying rail way surface drainage]. Science review, 4, 2014, pp. 123-129.

[18] Strelkov A.K., Teplykh S.Yu., Sargsyan A.M. Vliyanie obektov zheleznodorozhnogo transporta na gidrosferu [The impact of railway transportation objects on hydrosphere]. Geoekologiya zhilogo doma. geodinamicheski aktivnye razlomy i ih vozdeystvie na zdorove i zhiznedeyatelnost cheloveka. I Nauchno-prakticheskaya konferentsiya s mezhdunarodnym uchastiem [Geoecology of the living house. Geodynamic active faults and their impact on health and human activity. Research-to-practice conference with international participation], 2014, pp. 88-91.

[19] Strelkov A.K., Teplykh S.Yu., Gorshkalev P.A., Sargsyan A.M. Vzaimodeystvie obektov zheleznodorozhnogo transporta i ekosistemy [Interection between railway transportation and ecosystem]. Tekhnologii ochistki vody «TEKHNOVOD-2014»: materialy VIII Mezhdunarodnoy nauchno-prakticheskoy konferentsii; Krasnaya Polyana, g. Sochi [Water purification technologies “TEKHNOVOD-2014” Materials of VIII International research-to-practice conference; Krasnaya Polyana, city of Sochi] / Yuzhno-Rossiyskiy gosudarstvennyy politekhnicheskiy universitet (NPI) [South-Russian State Technical University (NPI)], 2014, pp.181-184.

[20] Teplykh S.Yu., Buhman N.S., Sargsyan A.M. Issledovanie polosy otvoda zheleznodorozhnyh putey na nalichie zagryazneniy [Study into the presence of pollution in the right-of-way railway zone]. Science review, 9, 2014, pp. 802-808.

[21] Strelkov A.K., Teplykh S.Yu.,.Buhman N.S., Sargsyan A.M. Analiz i harakteristika filtratsii poverhnostnogo stoka v ballastnoy prizme zheleznodorozhnogo puti [Analysis and specifications of filtration of surface runoff from railway track ballast section]. Vodosnabzhenie i sanitarnaya tekhnika: ezhemesyachnyy nauchno-tekhnicheskiy i proizvodstvennyy zhurnal [Water supply and sanitary engineering: scientific-technical monthly journal], 12, 2015, pp. 63-72.

[22] Strelkov A.K., Teplykh S.Yu. Metodologiya i metody otsenki zheleznodorozhnyh prirodno-tekhnogennyh kompleksov i struktur [Evaluation methodology and methods of railway natural-technogenic complexes and structures]. Mezhdunarodnyy vodny forum EKVATEK-2016. Konferentsiya «Sovershenstvovanie sistem vodopolzovaniya promyshlennyh predpriyatiy» [International water forum EKVATEK-2016. Conference entitled Water management Improvement at Industrial enterprises], 2016.

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Chemical and Biological Properties of the Lake Blue Clay

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Abstract. In this paper the chemical and biological properties of the lake blue clay are explored. A blue clay bed layer was found under the sapropel layer in the lake Plusons (area 4.8 km^2, Ludza countries, Latvia). It has been determined that the lake Plusons blue clay has a colloid composition, which contains Na, Mg, K, Ca, Fe, Cr, Mn, Co, Ni, Cu, Zn, Cd, Pb, Al, Ag, Ba. In samples Candida albicans, Pseudomona aeruginosa, Staphylococcus aureus and a total number of aerobic mezofile bacterium have been defined. In microbiological analyses the presence of Candida albicans, Pseudomona aeruginosa, Staphilacoccus aureus has not been stated. The number of mesophyll aerobic microorganisms is <1 CFU/0.1 g. Based on feasibility analysis Latgale lake blue clay has a high potential for its use in cosmetics and medicine.

Keywords: blue clay, chemical properties, biological properties.

I. INTRODUCTION

There are 2256 lakes in Latvia with a total area of 1001 km^2, which stands for 1.5% of the territory of Latvia. Sapropel is found in nearly all these lakes. The State Geology Office of Latvia states that there are more than 750 million m^3 of lake sapropel resources. A sufficient number of researches on sapropel in Latvia, its composition, qualities and possibilities of application, for instance, using sapropel in manufacturing solid soaps, manufacturing glues and composite materials, using sapropel as sorbent in heavy metal manufacturing and impact of sapropel humus substance on hydroponics [1] has been done. It has been proved that sapropel of the lakes of Latvia is not polluted with heavy metals.

A blue clay bed layer has been found under the sapropel layer in the lake Plusons (area 4.8 km^2 Ludza county [2]. There has been a research on the possible applications of the clay of Latvia [3, 4]. There is no any other data about the amount of blue clay bed in the lakes of Latvia due to the insufficient number of research works. Also, there are no scientific researches into blue clay composition, qualities and possibilities of its application. Lake blue clays are gained not from pits, but from freshwater waterbody depths, which are not influenced by anthropogenic pollution, that is why it is considered to be ecologically clean product, the research into which would open wide possibilities in usage of local product in cosmetology, medicine and other fields. The composition and qualities of lake blue clays and their usage possibilities in Europe are not sufficiently studied.

There are about 1000 lakes in Latgale region, in which the resources of blue clay have not been studied yet, therefore, carrying out the research and scientifically justifying the usage of blue clay as a local resource, will create a beneficial environment for manufacturing new high value-added products and services.

The aim of this research is to determine chemical and biological properties of Lake Plusons blue clay.

II. MATERIALS AND METHODS

Blue clay samples were inspected and collected from the lake Plusons. A blue clay bed layer has been found under the sapropel layer in the lake Plusons. Blue clay has been found in two places at depths of 4-12 m. Bed layer is estimated to be about 2 m thick. For gathering clays the device made after the sample collection analogue device ("Eijkelkamp" type) with working camera of 2 1 volume was used. Samples are placed into sterile, airtight plastic package and transported to the laboratory for analysis.

Research into organoleptic quality - odour is defined with sensory method, colour - visual method, consistency - sensory, visual method. The moisture of sediments was determined after drying at 105 ^{0}C.

Define in samples pH (LVS ISO 10390:2006), Ca, Na, K, Mg, Fe, Al, Mn, Zn, Co, Cr, Si, Cu, Ni, Zn, Cd, Pb, Hg. Metal concentrations were determined by use of flame atomic absorption spectroscopy (Perkin Elmer 503). The reliability and accuracy of the analytical results were checked using blank and references samples. Metal content data is provided for dry matter of sample. Two replicates were done for

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each sample. The mean values and standard deviation (SD) calculated.

In samples to define *Candida albicans* (LVS EN ISO 18416:2009), *Pseudomona aeruginosa* (LVS EN ISO22717:2009), *Staphylococcus aureus* (LVS EN ISO 22718:2009), total number of aerobic mezofile bacterium (LVS EN ISO 21149:2009).

III. RESULTS AND DISCUSSION

The chemical composition average values, standard deviation and organoleptic qualities of the Plusons lake blue clay and sapropel are presented in table I.

Table I
Analysis of chemical and organoleptic in the plusons lake blue clay samples and sapropel

Parameter	Unit	Result	SD	Sapropel	SD	MAC Belarus
Colour	-	grey	-	black-grey	-	-
Odour	-	sludge	-	weak, wet soil	-	-
Consistency	-	plastic, soft, smooth	-	plastic, soft, easily applied and adhesive	-	-
Moisture	%	80.16	0.67	90.53	0.43	-
Dry matter	%	19.84	0.67	9.47	0.43	-
pH	-	7.74	0.20	7.51	0.24	-
Na	mg/kg	135	14	70	3	-
Mg	mg/kg	4267	135	1053	114	-
K	mg/kg	53	7	169	28	-
Ca	mg/kg	328174	583	10805	303	-
Fe	mg/kg	6418	114	11550	116	-
Cr	mg/kg	2.57	0.04	3.78	0.01	-
Mn	mg/kg	959	38	369	15	-
Co	mg/kg	1.09	0.03	9.04	0.2	-
Ni	mg/kg	2.5	0.1	5.9	0.7	-
Cu	mg/kg	3.2	0.2	< 9	-	3
Zn	mg/kg	17.0	4.0	45.2	3.6	30
Cd	mg/kg	<0.1	-	0.6	0.1	1
Pb	mg/kg	4.8	0.2	2.2	0.1	5
Al	mg/kg	917	56	2780	102	-
Ag	mg/kg	<0.05	-	<0.1	-	-
Ba	mg/kg	422	24	359	20	-
C	%	7.01	0.79	25.41	8.4	-

MAC (*Maximum Allowable Concentration*)

It was determined that the lake Plusons blue clay has a colloid composition, grey colour, sludge odour, plastic, soft, smooth consistency which contains Na, Mg, K, Ca, Fe, Cr, Mn, Co, Ni, Cu, Zn, Cd, Pb, Al, Ag, Ba. Grey and blue colour indicates the presence of Fe (II) compounds [5]. Comparing the chemical composition of the blue clay and sapropel of Plusons lake shows that they are similar only in pH. pH of the Plusons lake blue clay is 7.74. French clays pH varied from 7.64 to 10.23 [6]. Clayey soils used traditionally for cosmetic purposes in South Africa the pH of the analysed samples ranged from 4.53 to 9.57 [7]. The pH of the clay soils used for cleansing can also influence their cleansing activity. According to [8, 9, 10] suitable skin cleansers must have pH near neutral or similar to that of the skin (4.5 to 5.5).

In comparison with sapropel there is significantly more Na, Mg, Al, Ca and Ba and less heavy metals such as Cd, Zn, Cu. EU directives forbid the presence of heavy metals in perfumery cosmetics, but there are no detailed requirements for sapropel and clay. Sanitary norms of Russia, Ukraine and Kazakhstan developed for health resorts and rehabilitation centres, determine that the concentration of heavy metals in therapeutic mud shall not exceed the local natural background soil concentrations that are characteristic of mud deposit region. Requirements for therapeutic mud properties and particularly sapropel type sediments have been developed only in Belarus. According to the requirements of Belarus, heavy metals in the lake Plusons blue clay do not exceed the permissible norms.

The most widely studied are French clays, which are obtained from quarries in the deepest layers of the lithosphere. In comparison with French green clays [24] the Plusona lake clay has a higher concentration of Ca and Mn, on average the same amount of Ba, but the content of other chemical elements is lower. There is significantly less Co, Ni, Cu, Zn, Pb, Cr element. Traditionally considered as toxic are As, Sb, Cd, Co, Cu, Pb, Ni, Zn, Hg, Se, Te, Tl, Ba, other less dangerous elements are Li, Rb, Sr, Cr, Mo, V, Zr[6]. Clays with high cation (Ca^{2+}, Mg^{2+}, Na^{+}, K^{+} and H^{+}) exchange capacity have been reported to ensure cleansing through absorption of toxins, bacteria and unwanted substances from the skin during topical application [6].

Clay control of contamination by microorganisms is also extremely important, given that they can be the origin of diseases or can damage the product when it

is stored. Results of the microbiological testing with Plusons lake blue clays show that the presence of *Candida albicans, Pseudomona aeruginosa, Staphilacoccus aureus* is not stated. The number of mesophyll aerobic microorganisms varied <1 to 3.6 X 10 CFU/0.1 g (Table II). It [11] must be mentioned that since clays can be contaminated during processing and storing by *Bacillus anthracis*, *Clostridium tetani* and *Clostridium welchii*, in this study the above mentioned microorganisms were not determined in the clay samples.

Table II
Microbiological tests results for Plusons lake blue clay samples

Parameter	Method	Result
Total number of aerobic mezofile bacterium	LVS EN ISO 21149 : 2009	<1 to 3.6 X 10 CFU/0.1 g (Tryptic soy agar)
Candida albicans	LVS EN ISO 18416: 2009	Has not been stated 0.1 g (Sabouraud dextrose agar)
Pseudomona aeruginosa	LVS EN ISO 22717:2009	Has not been stated 0.1 g (Cetrimid agar)
Staphylococcus aureus	LVS EN ISO 22718:2009	Has not been stated 0.1 g (Baird-Parker agar)

Both animals and people have used clay for therapeutic purposes since prehistoric time. There has already been proved the effectiveness of clay in cosmetology and in medicine [12, 13,14].

In pharmaceutical formulations, spas and beauty therapy, clay minerals are used for therapeutic purposes and their beneficial effect on human health. In pharmaceutical and clinical applications these minerals are used as active principles (gastrointestinal protectors, antacids antidiarrhoeaics, dermatological protectors, cosmetics) and excipients (inert bases, delivery systems, lubricants, emulsifiers) [15].

In SPA procedures and for maintaining skin health clay is used due to its sorption and calorific properties. In spas and beauty therapy clay minerals are used in geotherapy, pelotherapy and paramuds, to treat dermatological diseases, alleviate the pain of chronic rheumatic inflammations, arthritis, locomotor system diseases and injuries, moisturise the skin, and combat compact lipodystrophies and cellulite [15, 16]. The exchange of ions between the clay mixture and the skin can enable absorption of unwanted substances from the skin by the clay; hence ensuring skin cleansing action [7]. In dermatology clays are used in wound healing and in treatment of various irritations of the skin, different skin conditions, as well as they are recommended for inflammatory processes such as boils, acne, ulcers, etc. [17, 18]. In cosmetic industry clay is used in creams, lotions, body and face masks, shampoos, sunscreen products, toothpastes, powders, emulsions, bathroom salts, antiperspirants, lipsticks and eye shadows [19, 20, 6]. Clays are widely used in protective creams. Although such creams differ in composition according to the particular class of hazard against which protection is desired (dust, water, grease, sun, etc.). Clays are also used in sunscreen products, designed to provide sun protection by either scattering or absorbing radiant energy [19].

The usage of clay as UV filters is based on the layered structure of their particles and large specific surface and as a result, these particles effectively cover a certain area of skin and are able to absorb and reflect ultraviolet radiation [21]. Different types of clay minerals have different capacities to retain UV radiation. Comparing kaolinite, montmorillonite, illite and mixed-layer clay minerals, the lowest UV protection ability is in kaolinite, but the highest in clay minerals containing mainly illite clay minerals [21]. Clay mineral UV transmittance ability is affected by the parameters of clay mineral particles. Increasing the amount of clay in cream, UV transmittance decreases, thus increasing protection against UV radiation [21].

During the past 25 years, ~70% of newly discovered drugs introduced in the USA have been derived from natural products [22]. Vast application of French green clay in medicine has already been proved [14, 23]. A wide range and variety of minerals are used in the pharmaceutical industry as active ingredients. Such minerals may be administered either orally as antacids, gastrointestinal protectors, antidiarrhoeaics, osmotic oral laxatives, homeostatics, direct emetics, antianemics and mineral supplements, or parenterally as antianemics and homeostatics. They may also be used topically as antiseptics, disinfectants, dermatological protectors, anti-inflammatories, local anesthetics, keratolytic reducers and decongestive eye drops [19]. The absorptive properties of clay minerals are well documented for healing skin and gastrointestinal ailments. Sarkisyants *et al.* [24] studied the sorption characteristics of blue clay in relation to ions of heavy metals, the possibility of the introduction of this class of sorbents in bioprevention environmentally related chronic pathological processes were studied. Clay adheres to the gastric and intestinal mucous membrane and protect them and can absorb toxins, bacteria and even viruses. They do, however, have the disadvantage that they also eliminate enzymes and other necessary nutritive elements, which makes their prolonged use inadvisable [17, 25].

Clay therapeutic effects are divided by its colour, although scientific research on such categories is not available. Yellowish clay is used in some spas to

prevent bacterial infection on the skin; reddish clays are used for cleansing the skin, and bluish clays against the development of acnes. Similarly, greenish coloured clays are applied to reduce the amount of oil on the skin; and black clays for general body nourishment [26]. Similar information, but much more extended, can be found on cosmetic facial clay mask packages. There has also been the research on the use of nano-clays in medicine delivery systems[27].

Clay could provide an alternative treatment against numerous human bacterial infections. Clay has antibacterial properties. For example, the silver and quaternary ammonium surfactant-modified clays showed suitable inhibition properties over *E. coli* [28]. Three types of clays (white clay, gray clay and yellow clay) have an antibacterial effect against *Staphylococcus aureus* that was isolated from skin infection and have no effect against *Pseudomonas aeruginosa* that was isolated from patient with urinary tract infection. Pink mineral clay explained an antibacterial effect against *Pseudomonas aeruginosa*, and has low effect against *Staphylococcus aureus*. Results indicated that mineral clay provide an alternative treatment against numerous human bacterial infections [29].

French green clays have recently been shown to heal *Buruli ulcer*, a necrotic or 'flesh-eating' infection caused by *Mycobacterium ulcerans*. A clear distinction must be made between 'healing clays' and those we have identified as antibacterial clays. The highly adsorptive properties of many clays may contribute to healing a variety of ailments, although they are not antibacterial. The two French green clays used to treat *Buruli ulcer*, while similar in mineralogy, crystal size, and major element chemistry, have opposite effects on the bacterial populations tested [14]. Moreover, antimicrobial testing of the two clays on a broad-spectrum of bacterial pathogens showed that one clay promotes bacterial growth, while another kills bacteria or significantly inhibits bacterial growth [23]. One specific mineral demonstrated bactericidal activity against pathogenic *Escherichia coli*, extended-spectrum β-lactamase *E. coli*, *Salmonella enterica* serovar Typhimurium, *Pseudomonas aeruginosa* and *Mycobacterium marinum*, and a combined bacteriostatic/bactericidal effect against *Staphylococcus aureus*, penicillin-resistant *S. aureus*, methicillin-resistant *S. aureus* and *Mycobacterium smegmatis*, whereas another mineral with similar structure and bulk crystal chemistry, had no effect on or enhanced bacterial growth [30]. The reasons for the difference in antibacterial properties thus far show that the bactericidal mechanism is not physical (e.g., an attraction between clay and bacteria) but by a chemical transfer or reaction (pH and oxidation) [14]. The biological effects of clay minerals are influenced by their mineral composition and particle size [31]. Discovery that natural geological minerals harbour antibacterial properties should provide impetus for exploring terrestrial sources for the presence of novel therapeutic compounds. Combining the availability of natural bioactive resources with powerful combinatorial chemistry optimization methodologies could result in the development of new antibacterial agents to fight existing antibiotic-resistant infections and diseases for which there are no known therapeutic agents [30].

Clay in Latvia is very widespread as a mineral resource and the extracted quantity is one of the largest in northern Europe. Its application and studies are mainly related to construction materials and production of various ceramic materials [32]. The studies, which were carried out during the recent years on the expansion of application of the clay of Latvia and the creation of innovative products, are based on the application of new and improved ceramic materials in environmental technologies. [5] In the study [3] it was found that the majority of commercially available cosmetic clay masks in Latvia contain illite, which is the most common clay mineral in Latvia. In the field of geology clay is a size-based term for very fine-grained minerals with an estimated spherical diameter <2.0 μm and approximate density of 2.65 g/cm^3. This size fraction commonly contains discrete clay minerals (smectite, illite, kaolinite) [33]. French green clays are dominated by 1Md illite and Fe-smectite also in the mineralogical aspect [23]. Despite the fact that the clay is one of the most popular and easily available minerals in Latvia, only 3.2% of the clay-containing cosmetic products are produced in Latvia. Most of clay-containing cosmetic products (40.8%) available in Latvia are produced in France [3]. Illite containing Latvian clays with fraction under 63 μm before and after the treatment can be used as sorbents in purifying facial masks, because their adsorption of oleic acid and squalene is comparable with commercial illite and chlorite containing facial masks. Illite containing clay fractions, obtained from untreated clays, can be used as UV filters in sunscreens and other cosmetic products with low SPF factors. The studies of clays available in Latvia do not provide any evidence of their antibacterial properties, but it is possible to improve the antibacterial properties of clay containing products by adding silver doped hydroxilapatite [5].

Clay is applied and used not only in pharmacy and cosmetics. Clays and clay minerals are used as well in environmental technology. Clay minerals can be used for the removal of organic pollutants from a water or by a filter [34, 35]. In order to remedy environmental damages caused by polluted gases the clays and clay minerals can be used as adsorbents in natural form or after specific modification [36]. Aflatoxins are toxic compounds found in grains and other food crops infested by Aspergillus fungi. Aflatoxins are

recognized carcinogens for animals and humans. Clay additives have been used to pelletize and improve the flow characteristics of animal feeds. Reduced aflatoxicosis in animals is an extra benefit of clay additives. Clay additive use has also been examined for reducing human aflatoxicosis [37].

However, clay minerals can also have an adverse effect on human health when they are inhaled over a very long period. In the lung, clay minerals can cause diverse pathologies such as cancer, mesothelioma, or pneumoconiosis, but the toxicity of these minerals is generally related to the presence of quartz or asbestos from mining operations. The pathogenicity of fibrous clay minerals (sepiolite and palygorskite) is related to the geological conditions of formation [15]. The studies of Bertolino et al. [38] on Mineralogy and geochemistry of bottom sediments from water reservoirs in the vicinity of Córdoba, Argentina: environmental and health constraints reveal alarming concentrations of trace metals (U, W, As). Regarding potentially toxic trace elements such as As, Cd, Hg, Pb, Te, Tl, Sb and Se, [39] simulated digestive processes with 14 different herbalist's clays found on the Italian market and suggested for human internal use, and [40] carried out in vivo experiments on their mobility. The former observed that these trace elements are present in low concentrations after digestion, but pointed out that ingesting clays without knowledge of their composition may be dangerous. No information was available on the genotoxicity of clays or clay minerals [31].

In different places and different types of clay have different chemical, physical and biological composition; therefore its usage can be varied. The trace element contents in different clays are very variable [15, 41, 42]. Furthermore, the cosmetic ability of clays is not only influenced by their physicochemical properties. Other specific mineralogical and chemical properties also play vital roles in the cosmetic capabilities of clays [7]. Properties of Latvian illite clays for application in cosmetics depend on the amount of clay minerals, the presence of other non-clay minerals and particle size distribution [5]. Therefore, before the use of clay in the industry there has carefully been studied not only its chemical, physical and biological composition, but also specific mineralogical properties.

IV. CONCLUSION

Heavy metals in the lake Plusons blue clay do not exceed the permissible norms. The clay of the lake Plusons has high concentrations of Ca and Mn, which are valuable compnents for improving skin condition.

In microbiological analyses the presence of *Candida albicans, Pseudomona aeruginosa, Staphilacoccus aureus* has not been stated.

Based on the performed chemical and biological analysis Latgale lake blue clay has a high potential for its use in cosmetics and medicine.

It is recommended to carry out furthers studies to get an in-depth understanding of the blue clay application possibilities in cosmetics, medicine or any other field. It is necessary to explore the lake blue clay mineral and granulometric composition and its anti-bacterial properties.

REFERENCES

[1] Research of modification possibilities and properties of peat, sapropel and clays. Kūdras, sapropeļa, mālu īpašību un modifikācijas iespēju pētījumi. [Online]. Available: http://www.lu.lv/vpp/zemes-dzilu-resursu-izpete-jauni-produkti-un-tehnologijas-zeme/5-apaksprojekts/projekta-rezultati/sapropelis/ [Accessed: 28.02.2017.].

[2] Database contains information about all lakes in Latvia. [Online]. Available: https://www.ezeri.lv/database/2171/ [Accessed: 01.02.2017.].

[3] Vecstaudža J., Stunda-Zujeva A., Irbe Z., Bērziņa-Cimdiņa L. 2012. Composition of Commercial Cosmetic Clay and Suitability of Latvian clay for Cosmetic Puropses. *Material Science and Applied Chemistry* 26: 42-49.[Komerciālo kosmētisko mālu sastāvs un Latvijas mālu piemērotība lietojumam kosmētikā. *RTU zinātniskie raksti: Materiālzinātne un lietišķā ķīmija.* 26: 42.-49. lpp.].

[4] Segliņš V., Stinkule A., Stinkulis Ģ. Valuable minerals in Latvia. Derīgie izrakteņi Latvijā. – Rīga: LU Akadēmiskais apgāds, 2013. 53.-86. pp.

[5] Dušenkova I. "Development of preparation technology and investigation of properties of Latvian clays for application in cosmetic products," dissertation, Riga Technical University, Latvia, 2014. [„Latvijas mālu sagatavošanas tehnoloģijas izstrāde un īpašību pētījumi izmantošanai kosmētiskajos produktos," Promocijas darbs, Rīgas Tehniskā universitāte, Latvija, 2014.].

[6] Lopez-Galindo A., Viseras C., Cerezo P. 2007. Compositional, technical and safety specifications of clays to be used as pharmaceutical and cosmetic products. *Appl. Clay Sc*. 36(1-3): 51-63.

[7] Matike D.M.E., Ekosse G.I.E., Ngole M.V. 2011. Physico-chemical properties od clayley soils used traditionally for cosmetics in Eastern Cape, South Africa. *Int. J. Phys. Sci*. 6(33): 7557-7566.

[8] Ananthapadmanabhan KP., Moore DJ., Subramanyan MM., Meyer F. 2004. Cleansing without compromise: the impact of cleansers on the skin barrier and the technology of mild cleansing. *Dermat. Thera.* 17: 16-25.

[9] Gfatter R., Hackl P., Braun F. 1997. Effects of soap and detergents on skin surface pH, stratum corneum hydration and fat contents in infants. *Dermatology* 195: 258-262.

[10] Korting HC., Greiner K., Hubner K., Hamm G. 1991. Changes in skin pH and resident flora by washing with synthetic detergent preparations at pH 5.5 and 8.5. *Sci. Cosmet. Chemis.* 42: 142-158.

[11] Bubik J.S. 1992. Preparation of sterile talc for treatment of pleural effusion. *Am. J. Hosp. Pharm.* 49: 562–563.

[12] Ghiaci M., Aghaei H., Soleimanian S., Sedaghat S. 2009. Enzyme immobilization: 1. Modified bentonite as a new and efficient support for immobilization of Candida rugosa lipase. *Applied Clay Science* 43(3-4): 289-295.

[13] Ray E. Ferrell J. R. 2008. Medicinal clay and spiritual healing. *Clays and Clay Minerals* 56(6): 751–760.

[14] Lynda B. Williams, Shelley E. Haydel. 2010. Evaluation of the medicinal use of clay minerals as antibacterial agents. *Geol Rev.* 52 (7/8): 745–770.

[15] Carretero, M.I., Gomes, C.S.F., Tateo, F., 2006. Clays and human health. In: Bergaya, F., Theng, B.K.G., Lagaly, G. (Eds.), Handbook of Clay Science, Developments in Clay Science, vol. 1. Elsevier, Amsterdam, pp. 717–741.

[16] Abdel-Motelib A., Kader Z.A., Ragab Y.A., Mosalamy M. 2011. Suitability of a Miocene bentonite from North Western Desert of Egypt for pharmaceutical use. *Appl. Clay Sci.* 52(1-20): 140-144.
[17] Carretero M.I. 2002. Clay minerals and their beneficial effects upon human health. *Appl. Clay Sci.* 21: 155-163.
[18] Bergaya F., Theng B.K.G., Lagaly G. Clays, environment and health// Handbook of Clay Science. – Amsterdam: Elsevier Ltd., 2006. 623-717 p.
[19] Viseras C., Aguzzi C., Cerezo P., Lopez-Galindo A. 2007. Uses of clay minerals in semisolid health care and therapeutic products. *Appl. Clay Sci*. 36: 37-50.
[20] Carretero M.I., Pozo M. 2009. Clay and non-clay minerals in the pharmaceutical industry. Part I. Excipients and medical applications. *Appl. Clay Sci*. 46: 73-80.
[21] Hoang-Minh T., Le T.L., Kasbohm J., Gieré R. 2010. UV-protection characteristics of some clays. *Appl. Clay Sci.* 48: 349-357.
[22] Newman DJ., Cragg GM. Natural products as sources of new drugs over the last 25 years. 2007. *Nat Prod*. 70: 461–77.
[23] Lynda B. Williams, Shelley E. Haydel, Rossman F. Giese, Jr., Dennis D. Eberl. 2008. Chemical and mineralogical characteristics of french green clays used for healing. *Clays and Clay Minerals* 56(4): 437–452.
[24] Sarkisyants L.O. Skupnevskii S.V. Chopikashvili L.V. 2015. Examine the possibility of using the blue clay as a means of efferent therapy. *Modern problems of science and education* 1 (7): 1435-1438.
[25] Carretero M.I., Pozo M. 2010. Clay and non-clay minerals in the pharmaceutical and cosmetic industries. Part II. Active ingredients. *Appl. Clay Sci*. 47: 171-181.
[26] Ma'or Z, Henis Y, Alon Y, Orlov E, Sorensen KB, Oren A 2006. Antimicrobial properties of Dead Sea black mineral mud. *Derma*. 45(5): 504-511.
[27] Surech R., Borkar N.S., Sawant V.A., Shende V.S. 2010. Nanoclay drug delivery systems. *Pharm. Sci. Nanotechnol*. 3 (2): 901.-905.
[28] Parolo M.E., Fernandez L.G., Zajonkovsky, Sánchez M. P., Baschini M. Antibacterial activity of materials synthesized from clay minerals. Science against microbial pathogens: Communicating current research and technological advances. Spain: Formatex Research Center, 2011. 144.-151. p.
[29] Lafi S.A., Al-Dulaimy M.R. 2011. Antibacterial effect of some mineral clays in vitro. *Egypt. Acad. J. Biolog. Sci.* 3(1): 75-81.
[30] Haydel S., Remenih C., Williams L. 2008. Broad-spectrum in vitro antibacterial activities of clay minerals against antibiotic-susceptible and antibiotic-resistant bacterial pathogens. *The Journal of antimicrobial chemotherapy* 61 (2): 353–361.
[31] World Health Organization: Bentonite, kaolin and selected clay minerāls. Environmental Health. Criteria 231 [Online]. Available: http://www.inchem.org/documents/ehc/ehc/ehc231.htm [Accessed: 01.02.2017.].
[32] Segliņš, V., Sedmale G., Vircava I. 2011. Latvian mineral resources: summary of properties. *Scientific Journal of Riga Technical University Material Science and Applied Chemistry* 24: 116-135. [Latvijas minerālās izejvielas: īpašību apkopojums. 2011. *RTU zin. rakstu krāj. Materiālzinātne un lietišķā ķīmija,* 24. sējums, 116.–135. lpp.].
[33] Moore DM, Reynolds RC. X-ray diffraction and the identification and analysis of clay minerals. New York: Oxford University Press, 1997.
[34] Zadaka D., Mishael Y.G, Polubesova T., Serban C., Nir, S. 2007. Modified silicates and porous glass as adsorbents for removal of organic pollutants from water and comparison with activated carbons. *Applied Clay Science* 36: 174–181.
[35] Szabó E, Vajda K, Veréb G, Dombi A, Mogyorósi K, Ábrahám I, Májer M. 2011. Removal of organic pollutants in model water and thermal wastewater using clay minerals. *Environ Sci Health A Tox Hazard Subst Environ Eng.* 46(12):1346-56.
[36] Volzone C. 2007. Retention of pollutant gases: comparison between clay minerals and their modified products. *Applied Clay Science* 36, 191–196.
[37] Jaynes, W.F., Zartman, R.E., Hudnall, W.H. 2007. Aflatoxin B1 adsorption by clays from water and corn meal. *Applied Clay Science* 36: 197–205
[38] Bertolino S.R.A., Zimmermann U., Sattler F.J. 2007. Mineralogy and geochemistry of bottom sediments from water reservoirs in the vicinity of Córdoba, Argentina: environmental and health constraints. *Applied Clay Science* 36: 206–220.
[39] Tateo F., Summa V., Bonelli C.G., Bentivenga, G. 2001. Mineralogy and geochemistry of herbalist's clays for internal use: simulation of the digestive process. *Appl. Clay Sci*. 20: 97–109. In Lopez-Galindo A., Viseras C., Cerezo P. 2007. Compositional, technical and safety specifications of clays to be used as pharmaceutical and cosmetic products. *Appl. Clay Sc.* 36(1-3): 51-63.
[40] Mascolo N., Summa V., Tateo F. 2004. In vivo experimental data on the mobility of hazardous chemical elements from clays. *Appl.Clay Sci.* 25: 23–28. In Lopez-Galindo A., Viseras C., Cerezo P. (2007). Compositional, technical and safety specifications of clays to be used as pharmaceutical and cosmetic products. *Appl. Clay Sc.* 36(1-3): 51-63.
[41] Lopez-Galindo A., Viseras C., Cerezo P. 2007. Compositional, technical and safety specifications of clays to be used as pharmaceutical and cosmetic products. *Appl. Clay Sc.* 36(1-3): 51-63.
[42] Ahmet R. M., Angel F. 2001. Baseline studies of the clay minerals society source clays: chemical analyses of major elements. *Clays and Clay Minerals,* 49(5): 381-386.

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Impact of Laser on Microorganisms in the Digestate

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Abstract. At the biogas plant total of 40 digestate samples have been collected and investigated. The microbiological composition of digestate has been analysed before and after laser processing with wavelength λ 445 nm with power 2 - 4 W. Salmonella spp. has not been stated in any of the samples, Escherichia coli and Enterococcus spp. amount does not correspond Eiropean Union regulation R142/2011 requirements in any of the investigated samples; Staphylococcus aureus has been stated in 24 samples out of 40. By decreasing laser scanning speed and increasing power, the total number of microorganism colonies in digestate has decreased.

Keywords: laser, digestate, bacteria.

I. INTRODUCTION

The on-farm production of renewable energy from animal manures has rapidly expanded in central and northern Europe, with thousands of anaerobic reactors [1]. Nowadays there are several biogas plants in agricultural industry in Latvia. Anaerobic digestion converts waste material into two beneficial products, i.e. biogas and digestate. The remaining digestate contains high levels of macro and micro-nutrients and as such presents an environmentally sound alternative to mineral fertilisers. Digestate contains nutrients, which is in the form easily available to plants, with high nitrogen and phosphorus level, as well as from the agronomic point of view can easily diffuse, as it is similar to liquid stable manure [2], [3], [4].

However microorganisms, which are present in digestate, can cause microbial contamination of surface and water body contamination with different sources of digestate from biogas plants [5]. Clostridium spores can contaminate soils and crops when digestate is used as fertilizer, causing a conflictual cohabitation of biogas with traditional cheese productions [6]. Therefore the environmental benefits and risks of digestate still need to be defined. In order to fight bacterial infections and viruses high temperatures, disinfencants and ultraviolet light use usually used. Laser can be used as the source of ultraviolet light. Laser quality to annihilate microorganisms is widely used in clinical practice [7], [8]. During the past two decades laser radiation has been widely used as a principally new tool for studying biological structures and processes and as a factor for influencing them. The interaction of laser light with microorgnisms is a field, which has not been sufficiently well studied. As microorganisms play an important part in modern biotechnology, the investigations in this field are of a significant scientific and practical value.

The aim of this research is to define the influence of laser on total amount of microorganisms in digestate.

II. MATERIALS AND METHODS

A. Microbiological investigation

At the biogas plant which uses cattle manure, maize, food leftovers, animal bedding, biological litter connected with cattle breeding etc. as substrate for biogas production, total 40 digestate samples have been collected and investigated.

Samples were collected in sterile sample bags, using personal protection equipment immediately after the end of fermentation, before putting in storage reservoir. Each sample consists of 5 units (each unit corresponds to 500 ml). The samples were transported to the laboratory in thermobag, in which the temperature does not exceed +6 ^{0}C in order to prevent the reproduction of microorganisms. In the laboratory the total sample was created out of 5 units – using a sterile sample scoop, 100 ml of digestate were taken from each unit and mixed carefully.

For detection and enumeration of bacterial cultures standard Microbiology of food and animal feeding stuffs ISO methods, adapted in Latvia were used, namely: LVS EN ISO 6579:2003/A1:2007 Horizontal method for the detection of Salmonella spp. - Amendment 1: Annex D: Detection of *Salmonella spp.* in animal faeces and in environmental samples from the primary production stage; LVS EN ISO 6888-1 +A1:2007Horizontal

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method for the enumeration of coagulates-positive staphylococci (*Staphylococcus aureus* and other species) - Part 1: Technique using Baird-Parker agar medium; LVS ISO 16649-2:2007 Horizontal method for the enumeration of <beta>-glucuronidase-positive *Escherichia coli* - Part 2: Colony-count technique at 44 °C using 5-bromo-4- chloro-3-indolyl -<beta>-D-glucoronide. *Enterococcus spp*. ГОСТ 28566-90. Food products. Method for detection and determination of count Enterococci.

Before and after the processing with laser, the total amount of microorganisms in digestate samples was defined (colony forming units CFU/ ml). The method is based on LVS EN ISO 4833 – 1:2014 standard Microbiology of the food chain - Horizontal method for the enumeration of microorganisms - Part 1: Colony count at 30 degrees C by the pour plate technique (ISO 4833-1:2013).

B. Laser processing

15 g of digestate were poured in sterile, 75 mm in diameter Petri dish. Each sample was exposed to laser processing with invariable wavelength of λ 445 nm and variable power of 2 and 4 W, scanning speed - 20, 40, 60 and 80 mm/s (Fig. 1.). Laser systems parameters are given in Table I.

Table I
Laser systems embalaser A3 parameters

Laser type	Laser diode
Wavelength λ [nm]	445
Laser power P [W]	0 - 4
Cutting area [mm]	297 x 420
Scanning speed [mm/s]	1 - 150
Cooling type	No
Assisted gas	Air
Focal lens diameter [mm]	9
Focus distance [mm]	45 mm
Focal spot diameter [µm]	~200
Extra: https://www.laserglow.com/D4F	

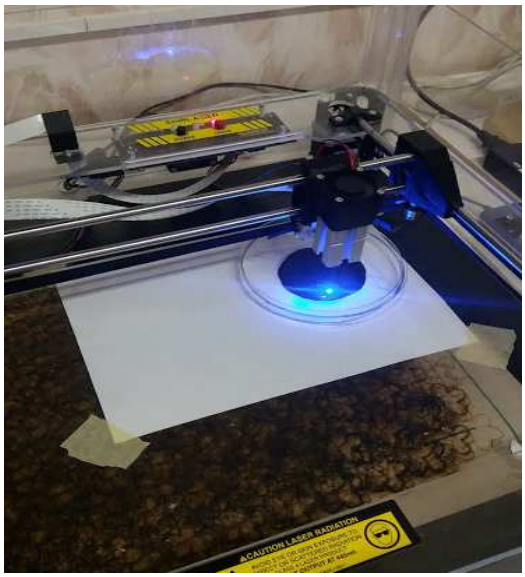

Figure 1. The laser processing of digestate samples

Samples were processed using the method of raster processing (a principle of sequential line scanning) (Fig. 2) with an option for variable interval *dy* = 100 µm. In given diameter (300 µm) of work spot, every line would overlap about 70%. Each sample was processed 3 times every time rotating the sample by 45^0.

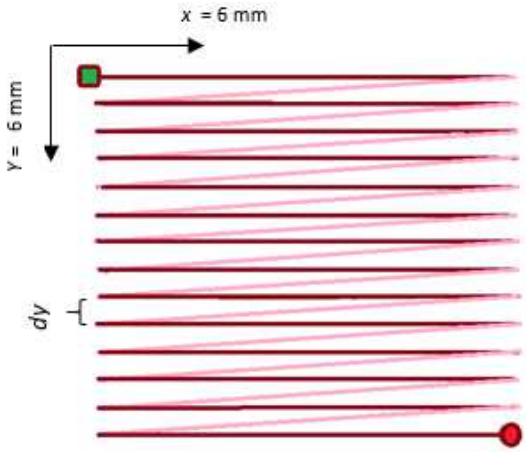

Figure 2. The principle of sequential line scanning

C. Theoretical aspects of the research

The studies were conducted with a diode laser with electromagnetic radiation in the visible part of the electromagnetic spectrum with wavelength λ = 445 nm (see Fig. 3).

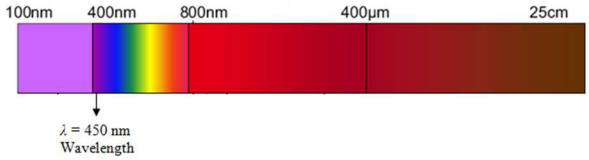

Figure 3. Electromagnetics spectrum.

Using the dependence (1) we can calculate the frequency of this electromagnetic radiation

$$\nu = c / \lambda = 6.74\times10^{14}\ \text{Hz} \qquad (1)$$

where c is the speed of light in vacuum - 3×10^8 m / s.

The energy of an electromagnetic radiation quantum fall on the specimen with colonies of bacteria is determined by the dependence

$$E = h\nu = 6.74\times10^{14}\times6.626\times10^{-34} = 1.017\times10^{-2}\ \text{J} \qquad (2)$$

where h is the Planck's constant, $h = 6.626\times10^{-34}$ J.s

The minimum diameter of the focal spot d_0 is defined by the expression (equation)

$$d_0 = M^2 \frac{4\lambda}{\pi}\frac{f}{D} \qquad (3)$$

where f is the focus distance, f = 45 mm.

For diode lasers a parametet M2 of quantifiy the beam quality is between 10 ÷ 20.

In our experiment the diameter is about 300 µm.

The power density q which is obtained in the area of the working spot on the sample is

$$q = P/S \quad (4)$$

where S is the area of the working spot,
P = 4W,

$$S = \pi r^2$$

d = 300 µm; r =150 µm

$$S = 3.14 \times (150\times10^{-6})^2 = 7.07 \times10^{-8}\ m^2$$

$$q = 4/7.07\times10^{-8} = 5.7 \times10^{8}\ W/m^2$$

At the fixed constant speed v – 80×10^{-3} m/s, the impact time of our experiment is set with the expression

$$t = d/v \text{ - duration of exposure} \quad (5)$$

where v – speed of processing; d - diameter of the focal spot.
d=300 µm= 300×10^{-6} m
v=80×10^{-3} m/s

$$t = 300\times10^{-6}/80\times10^{-3} = 3.8\times10^{-3}\ s = 3.8\ ms$$

v=20×10^{-3} m/s

$$t = 300\times10^{-6}/20\times10^{-3} = 15.0\times10^{-3}\ s = 15.0\ ms$$

The linear density of energy (LDE) during the process of interaction of laser radiation with the target is defined:

$$LDE = P/v = 4/80\times10^{-3}\ m/s = 50\ J/m = 0.05\ J/mm$$
$$LDE = P/v = 4/20\times10^{-3}\ m/s = 200\ J/m = 0.2\ J/mm$$

The interaction of laser radiation with the substance depends on three groups of factors associated with the laser source (power, wavelength, ect.), the optical and thermal properties of the target and the process parameters (speed, focus distance, step between lines, etc.).

III. RESULTS AND DISCUSSION

The microbiological standards for fermentation remains are defined by Eiropean Union regulation R142/2011 addition 5, section 3, paragraph 3 (EU regulation R142/2011), which controls the digestate microbiological pollution. Digestate representative samples, which were taken immediately after the transformation, have to correspond the following standards:

1. *Escherichia coli* amount does not exceed 5000 CFU/ml (one sample consists of 5 units, each of them is investigated as a separate sample);
2. *Enterococus spp*. amount does not exceed 5000 CFU/ml (one sample consists of 5 units, each of them is investigated as a separate sample);
3. *Salmonella spp*. 25 g has not been stated (one sample consists of 5 units, each of them is investigated as a separate sample);

Fermentation remains, which do not correspond particular requirements, are transformed once again, if Salmonella has been stated, they are liquidated according to the regulations of competent authority.

Digestate is not investigated to the presence of other pathogens, however, their presence is very probable.

In the following research *Salmonella spp*. has not been stated in any of the samples, *E. coli* and *Enterococcus spp.* amount does not correspond EU regulation R142/2011 requirements in any of the investigated samples; *Staphylococcus aureus* has been stated in 24 samples out of 40, EU regulation R142/2011 does not regulate the norm of the following microorganisms in digestate, however, *S. aureus* can cause threats to environment (See Table II).

Table II
Microbiological tests results for digestate samples

Parameter	Average CFU/ ml	SD
Salmonella spp.	25 g not stated	-
Enterococcus spp.	20 470	± 4114
Escherichia coli	14640000	±1680000
Staphyloccus aureus	165	± 35

Total number of bacterial colony in non-processed digestate at the dilution $1*10^{-14}$ and $1*10^{-15}$ has been shown in Table III.

Table III
The total number of microorganisms for digestate samples

Non-processed digestate dilution part	Colony forming units CFU/ ml	SD
$1*10^{-14}$	192	± 41
$1*10^{-15}$	82	± 29

The impact of laser on total number of digestate at the dilution $1*10^{-14}$ and$1*10^{-15}$ is shown in Figures 3, 4. In given scanning speed interval experimental data can be approximated using following equation

$$N = A \cdot v^B,$$

where N - number of microorganism colonies; A=const; B=const.

With the laser scanning speed 20 mm/s and power 4 W, the total number of microorganism colonies in digestate at the dilution $1*10^{-15}$ has decreased to 93 %, at dilution $1*10^{-14}$ - 90 %. By decreasing laser speed and increasing power, the total number of microorganism colonies has decreased.

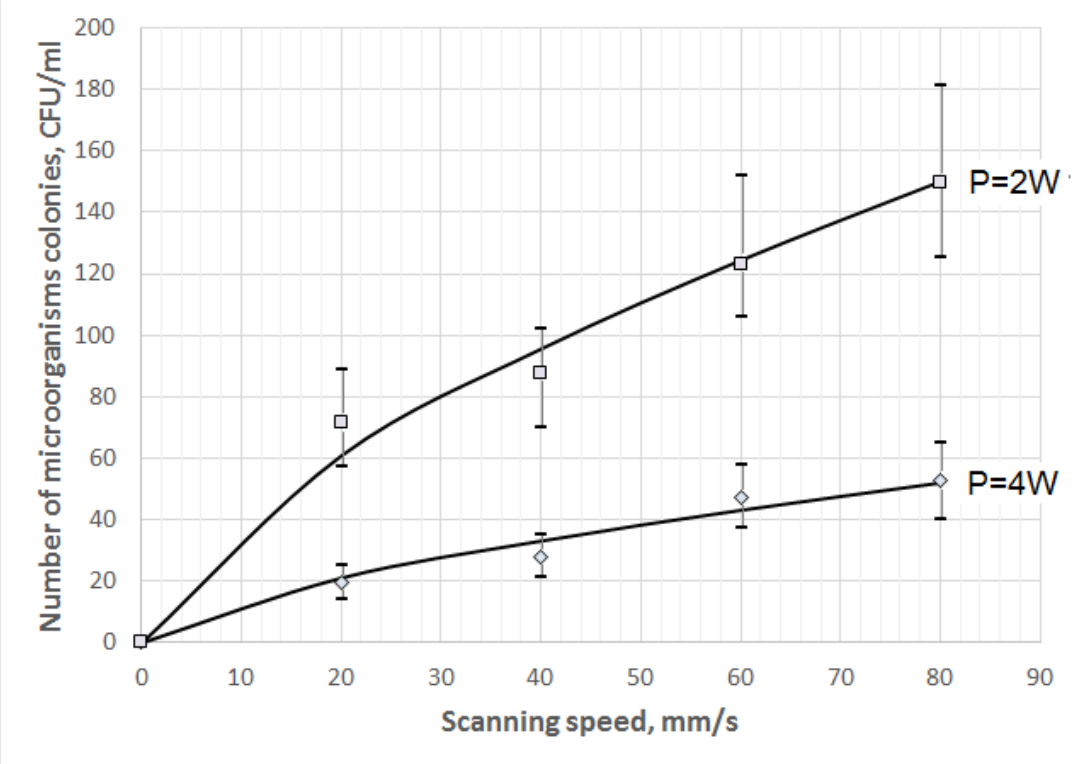

Figure 3. The total number of microorganism colonies (CFU/ml) after digestate processing with variable laser power and scanning speed (digestate dilution part 1*10-14). If P= 4 W, then A=3.0, B=0.65; if P= 2 W, then A=8.7, B=0.65

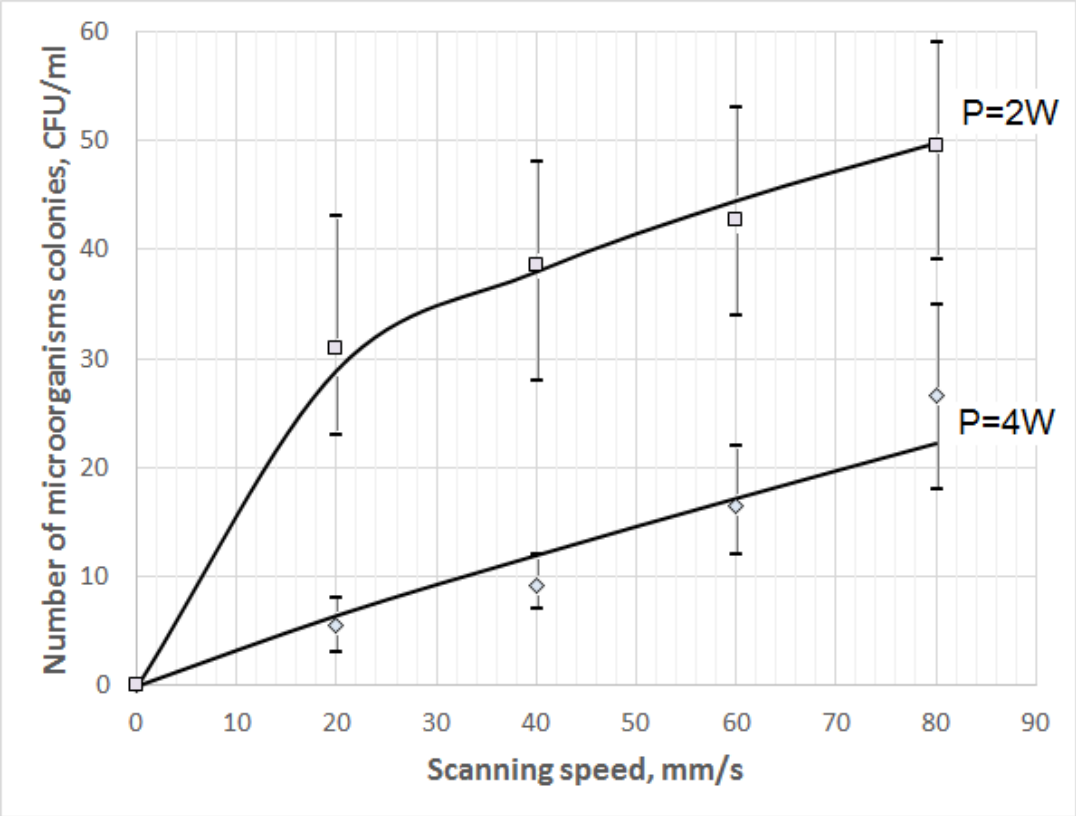

Figure 4. The total number of microorganism colonies (CFU/ml) after digestate processing with variable laser power and scanning speed (digestate dilution part $1*10^{-15}$). If P= 4 W, then A=0.45, B=0.89; if P= 2 W, then A=9.0, B=0.39

The bactericide impact of UV rays is based on photochemical reactions which result in irreversible damage of DNA. UV rays have an impact not only on DNA but also other cell structures, partly on RNA, cell membranes etcetera [9]. The strongest bactericidal qualities has the UV light with wavelength 250-265 nm [10] and 200−295 nm [9]. Laser with wavelenght 266 nm, impulse time 30 ps and frequency of 100 MHz provides power of about 300 kW. According to calculations, this much power is enough to destroy 90% of bacterial cells on in area of 1 ha, both on soil surface and lowest parts of atmosphere [11]. The UV sensitivity of different viruses and bacterial cells heavily differs [9]. The low-level laser radiation has an antibacterial effect on *Staphylococcus aureus, Escherichia coli, Klebsiella pneumoniae, Pseudomonas aeruginosa* (microorganisms – surgically infectious agents*)*. The most expressed bactericidal effect was registered in laser radiation of the green spectral range (λ=527 nm) [12]. *E. coli* bacteria inactivation by high-power laser irradiation is solely based on a thermal process [13].

IV. CONCLUSIONS

By decreasing laser scanning speed and increasing power, the total number of microorganism colonies has decreased. With the diode laser with electromagnetic radiation in the visible part of the electromagnetic spectrum and wavelength λ = 445 nm, laser speed 20 mm/s and power 4 W the total number of microorganism colonies in digestate decreased 90 - 93 %.

Further research intends to process the digestate with different types of lasers and different wavelengths. The impact of laser on microorganisms depending on the thickness of digestate layer and various types of microorganisms is to be researched as well.

REFERENCES

[1] Goberna M., Podmirseg S.M., Waldhuber S., Knapp B.A., García C., Insam H., "Pathogenic bacteria and mineral N in soils following the land spreading of biogas digestates and fresh manure," Applied Soil Ecology, vol. 49, pp. 18–25, 2011.

[2] Bioenergy, Association of New Zeland Inc. *The production and use of digestate as fertiliser.* Banz Technicalguide. 2013.

[3] Svensson K., Odlare M., Pell M. "The fertilizing effect of compost and biogas residues from source separated household waste," Agric. Sci., vol. 142, pp. 461–467, 2004.

[4] Gómez-Brandón M., Fernández-Delgado Juárez M., Zangerle M., Insam H. "Effects of digestate on soil chemical and microbiological properties: A comparative study with compost and vermicompost," Journal of Hazardous Materials, vol. 302, pp. 267–274, 2016.

[5] Studer I., Boeker C., Geist J. "Physicochemical and microbiological indicators," Ecological Indicators, vol. 77, pp. 314–322, 2017.

[6] Pulvirenti A., Ronga D., Zaghi M., Rita A., Mannella T., Pecchioni N. "Pelleting is a successful method to eliminate the presence of *Clostridium* spp. from the digestate of biogas plants", Biomass and Bioenergy," vol. 81, pp. 479–482, 2015.

[7] Migliorati E. K. J. Lasers and bacterial reduction: A comprehensive technique to treat chronic periodontitis. [Online]. Available: http://www.dentistryiq.com/articles/wdj/print/volume-2/issue-2/focus-on-perio/lasers-and-bacterial-reduction-a-comprehensive-technique-to-treat-chronic-periodontitis.html [Accessed: 01.02.2017.].

[8] Stepp H., Andersson-Engels S. "Editorial Therapeutic laser application and tissue interactions: Bringing light into clinical practice," Biophoton, vol. 3 (5–6), pp. 259–260, 2010.

[9] Lavrentjeva L.V., Avdeev S. M., Sosnin E. A., Velicevskaja K. J. "Analysis of excilamps UV radiation bactericide action on pure microorganism cultures," Tomsk State University Journal of Biology, vol. 2(3), pp. 18-27, 2008. Лаврентьева Л.В., Авдеев С.М., Соснин Э.А., Величевская К.Ю. 2008. Бактерицидное действие ультрафиолетового излучения эксимерных и эксплексных ламп на чистые культуры микроорганизмов. Вестник Томского государственного университета. Биология. 2(3): 18-27.

[10] Eglīte M., Aulika B., Avota M. *Environmental health.* 2008. Rīga Stradiņš University. *Vides veselība*. Rīgas Stradiņa universitāte. 2008. 696 lpp.

[11] Medvedev M., Gorbovskij S. "Destroying of pathogenic mycrobes using laser berams", Bulletin about atomic energy, vol. 8, pp. 43-45, 2003. Медведев М., Горбовский С. 2003. Уничтожение патогенных микробов с помощью лазерного излучения. Бюллетень по атомной энергии, 8: 43-45.

[12] Kasumyan A.S., Azoskova O.V. "Antibacterial effects of low-level laser radiationwith different wave length," Smolensk State Medical almanac, vol. 1 (1), pp. 31-33, 2015. Касумьян А.С., Азовскова О.В., Лелянов А.Д., Федосов Е.А. 2015. Антибактериальное действие низкоинтенсивного лазерного излучения с различной длиной волны. Смоленский медицинский альманах 1 (1): 31-33.

[13] Hibst R., Graser R., Udart M., Stock K. "Mechanism of high-power NIR laser bacteria inactivation," Journal of Biophotonics, vol. 3 (5-6), pp. 296–303, 2010.

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The Changes of Phosphorus and Potassium in Soil Under Different Lime Rates

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Abstract. The paper describes the influence of liming to phosphorus and potassium accumulation in soil. The research has been carried out at the Institute of Agronomy of Latvia University of Agriculture in the long-term subsurface drainage field established in Skrīveri in 1981. The experimental field was established with four rates of mineral fertilizers: without fertilizers (F0), N45P30K45 (F1); N90P60K90 (F2), N135P90K135 (F3) and four rates of lime: without liming (L0), 2.58 (L1), 5.70 (L2), 11.40 (L3) t ha^{-1} $CaCO_3$. Primary liming was done in 1981 (Estonian oil shale ashes), the maintenance liming was performed in 1994 (dolomitic limestone) and 2014 (BALTKALK).

After 35 years of trial similar soil parameters showed significantly different content of phosphorus and potassium related to the different rates of liming in all fertilizing levels. Without fertilizers, the liming provided the increase of phosphorus content in soil from 14 to 36 mg kg^{-1}, but the increase of potassium – from 55 to 72 mg kg^{-1}. On a low background of fertilizers (N45P30K45) the content of phosphorus and potassium under liming increased respectively from 20 to 32 mg kg^{-1} for phosphorus and 75 to 96 mg kg^{-1} for potassium. At the fertilizers level N90P60K90 the content of phosphorus and potassium increased respectively from 94 to 81 mg kg^{-1} for phosphorus and 115 to 165 mg kg^{-1} for potassium. At the fertilizers level N135P90K135 the content of phosphorus and potassium increased respectively from 174 to 203 mg kg^{-1} for phosphorus and 166 to 214 mg kg^{-1} for potassium.

Keywords: Liming, phosphorus, potassium, soil pH, long-term field experiment.

I. INTRODUCTION

Phosphorus and potassium are important macronutrients in plant life cycle. Phosphorus is aplant energy store and source in theform of adenosine diphosphate (ADP) and adenosine triphosphate(ATP) and can be found in proteins, enzymes and phospholipids. Potassium is associated with movement of water in plantand involved with enzyme activation within the plant which affects protein, starch and ATP production. However, plant available forms of thosemacronutrients in soil are limited and affected by many agrochemical factors.

Soil acidity is a parameter affecting the solubility and suitability of nutrients in soil. Factors affecting soil pH include organic matter decomposition, transformation into compounds available for plant nutrition. Nutrient intake changes depending on the soil pH [1].The concentrations of phosphorus had `U-shaped' relations with pH, with minima in the intermediate pH range (pH 6.0-7.0). Decreasing solubility with increasing pH from 5 to 7, most distinct for the oxoionic element P, would be caused by the formation of less soluble Ca phosphate and, respectively, with increasing Ca concentration and pH. The distinct increase in the concentrations of most of these elements above pH 7 is related to the simultaneous increase in the concentration of soluble organic C [2]. The results of other researches show that after soil liming, the plant available phosphorus content in soil increased. Regular application of lime in 10 years resulted in an increase of pH value as well as organic carbon, plant available phosphoruscontent [3]. The application of lime (3 and 12 t CaO ha^{-1}) increased the pH in average from 6.6 up to 7.0 and 7.2, but did not decrease extractable P below the level of untreated control [4] - [6]. An increase in the available phosphorus content in strongly acidic soil after liming was also recorded in other experiments [7] – [10]. Great effect on yield of winter triticale and N and P_2O_5 usage coefficients was done by combined application of NPK, lime and manure fertilizers [11], [6].The researches in Croatia show that soil pH increment by liming significantly increased phosphorus availability from 1.8 till 4.9 mg kg^{-1} per t ha^{-1} CaCO3 [8]. Regarding s12il available phosphorus considerably higher effects of carbocalk compared to dolomite treatment were found. Four years after carbocalk application, phosphorus content was increased for 12 mg 100 g^{-1} at the highest rate, while significant increase of soil available phosphorus (for 8.3 mg 100 g^{-1}) was determined at treatment with 18 t ha^{-1} dolomite [9]. Applying P fertilizer without soil testing may lead to P build up in soils, hence, increased P runoff potential [13]. Accumulation ofthe total P in the arable layer of soil had a tendency to decrease with increasing soil pH. The lowest amount ofthe total P was determined in soil with pH_{KCl} 6.7 [14].

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Liming without P fertilization increased plant P satisfactorily only in the high-P soil. P fertilising alone is a better practice than liming alone for improved plant growth conditions in acidic, low-P soils, unless there is relatively high P content in soil, in which case liming alone may be sufficient to increase P availability [10].

The application of lime believed to enhance soil health status through improving soil pH, base saturation, Ca and Mg. It reduces Al and Mn toxicity and increases both P uptake in high P fixing soil and plant rooting system [15].

Concentrations of potassium in soil solution decreased with rising pH [2]. The results of researches show that after 10 years soil liming, the plant available potassium content in soil decreased [3]. A laboratory experiment in India showed that nitrogen and potassium fertilizers treatments and liming initially decreased the water soluble and exchangeable K but increased the non-exchangeable K in soil. Water soluble K was significantly increased in limed soil throughout its incubation period, whereas it showed a decreasing trend in unlimed acid soil. Highest amount of exchangeable K was observed in acid soil after 90 days of incubation, whereas water soluble and non-exchangeable K were found to be highest in half and full limed soil respectively. Combined application of nitrogen and potassium fertilizer significantly increased the water soluble K [16].

Results of Austrian scientists estimatedthe increase of pH level in average from 6.6 up to 7.0 and 7.2 by application of lime (3 and 12 t CaO ha^{-1}) and there was no the decrease of extractable K below the level of untreated control observed. The extractable K in CaO treated soil remained still above the untreated control [5].

The researches in Croatia show that soil pH increment by liming significantly increased potassium availability from 1.3 till 1.5 mg kg^{-1} per t ha^{-1} $CaCO_3$ in soil and their transfer into aboveground plant organs [12]. Liming with carbocalk significantly decreased potassium availability at 45 t ha^{-1} and higher rates, whilst dolomite did not affected soil potassium content [9].

II. MATERIALS AND METHODS

Site and soil description.

The research was carried out at the Research Institute of Agronomy of Latvian University of Agriculture in the long-term subsurface drainage field experiment “Sidrabiņi”. Field experiment established in Skrīveri in 1981 under the guidance of professor Juris Štikāns. The paper presents the experimental data from the 1981–2014 periods. The long-term drainage field experiment was established on the uncultivated gleyic sod-podzolic*Hypostagnic EndogleyicAlbeluvisol* (*Hypereutric, stw-ng-AB(he)*) loam that had not been used in agriculture for 20 years before.

Experimental design.

The four rates of mineral fertilizers: F0 – without fertilizers, F1 – $N_{45}P_{30}K_{45}$, F2 – $N_{90}P_{60}K_{90}$ and F3 – $N_{135}P_{90}K_{135}$ calculated in form of P_2O_5 and K_2O were used together with four rates of liming: L0 – without liming, L1 – 2.58 t ha^{-1} $CaCO_3$, L2 – 5.70 and L3 – 11.40 t ha^{-1} $CaCO_3$ (slate ash with 80% neutralizing value) (Fig. 1). Primary liming was done in 1981 (Estonian oil shale ashes with 415.4 g kg^{-1}CaO, 44 g kg^{-1}MgO, 21 g kg^{-1} K_2O, 2.1 g kg^{-1} P_2O_5 and 76 g kg^{-1} SO_3), the maintenance liming was performed in 1994 (dolomitic limestone with 97.0% neutralizing ability, 188 g kg^{-1} Ca, 120 g kg^{-1} Mg, humidity content ≤0.2%, amount of particles smaller than 1 mm – 99.5%) and 2014 (BALTKALK with 97.6% neutralizing ability, 333 g kg^{-1} Ca, 6.9 g kg^{-1} Mg, humidity content 8–16%, amount of particles smaller than 1 mm – 88.8%). The total area (1.6 ha) of the experimental field was divided into 16 plots (15 × 50 m).

Agronomic practices.

Since 1994, a seven-year crop rotation was created: (1) winter triticale → (2) potato, → (3) spring wheat → (4) spring oilseed rape → (5) spring barley undersown with perennial grasses → (6) perennial grasses, 1st year of use, and → (7) perennial grasses, 2nd year of use. In the sowing year, mixtures of herb species were sown under barley. In the first rotations the components of mixtures were *Phleumpratense* and *Trifoliumpratense*, but in 2012 a mixture of *Trifoliumpratense*, *Festucapratensis*, *Phleumpratense* and *Festulolium* was made.

Traditional soil tillage was used including mouldboard ploughing (for winter crops – in the previous autumn, for spring crops – after harvest of previous crops), cultivation and rototilling before sowing. Mineral fertilizers were applied according to the anticipated rates of plant nutrient elements annually during the pre-sowing cultivation of soil. For winter crops the phosphorus as single superphosphate and potassium as potassium chloride were applied before the sowing in autumn and nitrogen in the form of ammonium nitrate was applied the next spring at the beginning of vegetation and at the tillering stage. During the growing season all the required common soil and crop management practices were applied – treatment with herbicides, fungicides and insecticides.

Experimental methods and assessments

The soil for agrochemical analyses was sampled from 0–20 cm depth annually after harvesting. Soil samples were taken in each plot using a 12 mm diameter steel auger, and the samples from each plot were mixed, dried and sieved. The content of phosphorus and potassium in soil was extracted from acid calcium lactate. Soil acidity (pH_{Cl}) was

determined according to the standard LVS ISO 10390:2006 Soil quality – Determination of pH.

Statistical analyses.

The obtained data mathematical processing was performed using analysis of variance (ANOVA).

Meteorological conditions.

The long-term experiment is located in the central part of Latvia (latitude N 56°38′, longitude E 25°08′). The annual precipitation amount is normally 670 mm. The annual air temperature is + 5.7ºC. The winter average air temperature is −4.3ºC. The duration of the growing season is 180–210 days.

III. RESULTS AND DISCUSSION

At the beginning of the experiment the soil was very strongly acid (pH_{KCl}4.7-4.9) with very low content of available phosphorus (10-20 mg P_2O_5 kg^{-1}) and low content of available potassium (40-60 mg K_2O kg^{-1}). Long-term application of mineral fertilizers to agricultural soils leads to accumulation of plant nutrients (phosphorus and potassium) in soil and depended on fertilizer rates [17] - [18].

The results show that the liming provided the increase of available phosphorus in soil (Fig.1 and Fig. 2).

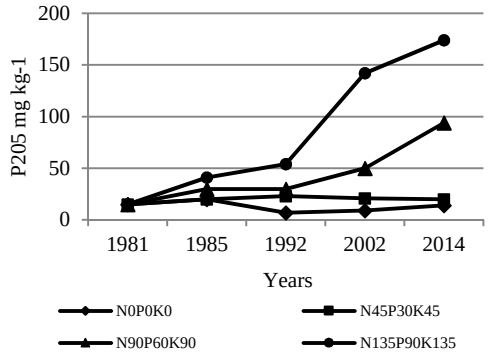

Fig.1. The changes of content of available phosphorus in soil without liming, 1981-2014

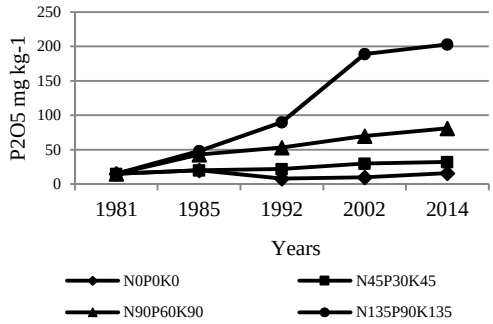

Fig. 2 The changes of content of available potassium with liming (11.40 t ha^{-1} $CaCO_3$).

In variant without fertilizers (L0) available potassium content did not change significantly during the experiment but the liming provided the increase of available phosphorus content in soil from 14 (L0) to 36 mg kg^{-1} (L3). In 2014 the content of available phosphorus characterized as very low.

At fertilizer rate F1, available P only started increasing 20 years after the establishment of experiment [18]. Liming provided the increase of available phosphorus content in soil from 20 (L0) to 41 mg kg^{-1} (L1). In 2014 the content of available phosphorus characterized as very low to low.

In variant with fertilizer rate F2, the available potassium increased slowly yet gradually [18]. The influence of liming on content of available phosphorus was significant. In 2014 the content of phosphorus in soil was 60 (L0) to 81 (L3) mg kg^{-1}. The level of available phosphorus corresponds to average.

In variant with fertilizer rate F3, the growth of available phosphorus was faster than in variants with lower fertilizers [18]. The influence of liming on content of available phosphorus was significant. In 2014 the content of phosphorus in soil varied from174 (L0) to 203 (L3) mg kg^{-1} depending on liming rate. The level of available phosphorus corresponds to high to very high.

The results of research show that the liming provided the increase of available potassium in soil (Fig. 3 and Fig. 4).

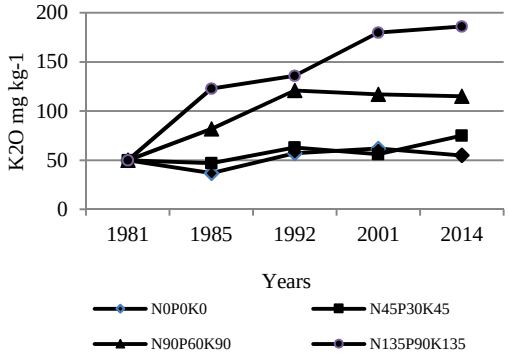

Fig. 3The changes of content of available potassium in soil without liming, 1981-2014

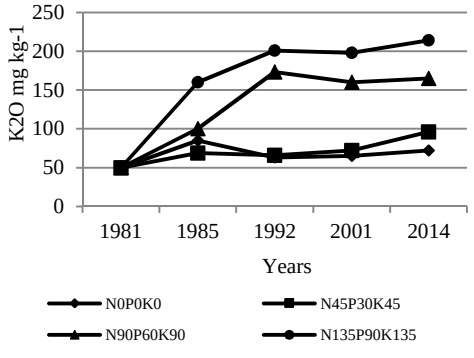

Fig. 4 The changes of content of available potassium in soil with liming (11.40 t ha^{-1} $CaCO_3$)

In variant without fertilizers (L0), the content of available potassium did not change significantly during the experiment [18] but the liming provided the increase of available potassium in soil from 55 (L0) to 72 mg kg^{-1} (L3). The content ofavailable

potassium after 32 years in all plots of experiment characterized as low.

On a low background of fertilizers (F1) available potassium started increasing only in 2002 [18]. The content of potassium under liming increased respectively from 75 (L0) to 96 (L3) mg kg^{-1} for potassium (in 2014).The content of available potassium characterized as low (L0, L1, L2) to medium (L3).

In variant with fertilizer rate F2, the available potassium enhanced rapidly and in 1992 stabilized, but during the last ten years the content of K started decreasing [18]. The content of potassium increased respectively from 115 (L0) to 165 (L3) mg kg^{-1} and in plots characterized as medium.

In variant with fertilizer rate F3, available potassium intensified very rapidly and reached a high level within five years. During the next period, the plant available potassium increased slightly but gradually [18]. The content of potassium increased from 186 (L0) to 214 (L3) mg kg^{-1} for potassium and characterized as high.

On the basis of these results it can be stated that liming enhances soil agrochemical properties - mostly acidic reaction provided the increase of availableplant macronutrients like phosphorus and potassium in fertilized and non-fertilized plots over 30 years period.

IV. CONCLUSIONS

The periodical liming provided the stable increase of available phosphorus and potassium in soil for long-term period.

The full and double of calculatedliming rate significantly influenced the availability of phosphorus and potassium in soil.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] A. McCauley, C. Jones and J. Jacobsen, *Soil pH and organic matter*, Nutrient Management Module, No. 8, 2009, p. 12.

[2] G. Tyler, T. Olsson. „Concentrations of 60 elements in the soil solution as related to the soil acidity", European Journal of Soil Science, vol. 52, pp. 151–165, 2001

[3] I. Jaskulska, D. Jaskulski and M. Kobierski, „Effect of liming on the change of some agrochemical soil properties in a long-term fertilization experiment", Plant, Soil and Environment, vol. 60 (4), pp. 146 – 150, 2014.

[4] J. Alves dos Santos, A. Ferreira da Fonseca, D. Zocco and I. Vieira, "Exchangeable cations and available phosphorus in soils with variable charge after application of special liming materials", African journal of Agricultural research, vol. 11 (30), pp. 2744 - 2760, 2016.

[5] S. Fischer, H.-J. Koch and K. Bürcky K. "Effect of liming central European loess soils on soil extractable phosphorus and potassium as determined by electro-ultrafiltration", Archives of Agronomy and Soil Science, vol. 61, Issue 6, pp. 725 - 736, 2015.

[6] E. M. Muindi, J. P. Mrema, E. Semu, P. W. Mtakwa, C. K. Gachene and M. K. Njogu. "Lime-Aluminium- Phosphorus Interactions in Acid Soils of the Kenya Highlands", American Journal of Experimental Agriculture, vol. 9 (4), pp. 1-10, 2015.

[7] M. Szymańska, M. Korc and J. Łabętowicz, "Effects of single liming of sandy soils not limed for more than 40 years in the light of results of long-term fertilizing experiment", Polish Journal of Soil Science, vol. 4, pp. 105–114, 2008

[8] N. Özenç and D.B. Özenç, "Interaction between available phosphorus and lime treatments on extremely acid pH soils of hazelnut orchards", ISHS Acta Horticulturae, vol.. 845, pp. 379 – 386, 2009.

[9] M. Rastija, V. Kovacevici, D. Rastija, P. Ragaly and L. Andric, *Liming impact on soil chemical properties, Agroecology and Organic Agriculture*::45. hrvatskii 5. Međunarodni simpozija gronoma, Veljače 15-19, 2010, Opatija, Hrvatska., pp. 124 - 127.

[10] V. Antoniadis, F. Hatzis, D. Bachtsevanidis and S. D. Koutroubas "Phosphorus Availability in Low-P and Acidic Soils as Affected by Liming and P Addition", Communications in Soil Science and Plant Analysis, vol. 46, Issue 10, pp. 1288-1298, 2015.

[11] M. Jelic, J. Milivojevic, V. Djekic, O. Nikolic, N. Deletic and M. Biberdzic, *The influence of liming and fertilization on yield and nitrogen and phosphorus use in winter triticale plants at pseudogley type soil*: *Proceedings of conference Research people and actual tasks on multidisciplinary sciences*, June 24 – 28, 2015, Lozenec, Bulgaria, pp.78-82.

[12] V. Kovacevic, M. Rastija, D. Rastija and R. Sudar, *Impacts of liming on grain yield, nutritional status and quality of wheat:, Proceedings of the 24th International Scientific-Expert-Conference of Agriculture and Food Industry*, September 25-28, Sarajevo, Bosnia and Herzegovina, 2013, pp. 331-335.

[13] H. Zhanga, J. L. Schroder, R. L. Davisc, J. J. Wangd, M. E. Paytonb, W. E. Thomasone, Y. Tangf and W. R. Rauna, "Phosphorus loss in runoff from long term continuous wheat fertility trials", Soil Science Society of America Journal, vol. 70, No. 1, pp. 163 - 171, 2005.

[14] I. Jokubauskaite, D. Karčauskiene, Š. Antanaitis, J. Mažvila, A. Šlepetiene, D. Končius, L. Pialaukaite-Motuziene, "The distribution of phosphorus forms and fractions in Retisolunder different soil liming management", Zemdirbyste-Agriculture, vol. 102, No. 3, pp. 251 – 256, 2015.

[15] N. Athanasea, R. Vickya, M .N. Jayneb and H. Sylvestre, "Soil acidification and lime quality: sources of soil acidity, its effects on plant nutrients, efficiency of lime and liming requirements", Agricultural Advances, vol. 2(9), pp. 259 - 269, 2013.

[16] R. Das and D. Saha, "Effect of liming on the changes of different forms of potassium in an acid soil treated with N and K fertilizers", Journal of the Indian chemical society, vol 91 (9), pp. 1619 - 1625, 2014.

[17] J. Vigovskis, A. Jermuss, A. Svarta and D. Sarkanbarde "The changes of soil acidity in long-term fertilizer eksperiments", Žemdirbystė = Agriculture, Vol.103 (2), pp. 129 - 134, 2016.

[18] J. Vigovskis, A. Jermuss, A. Svarta and Sarkanbarde, *The changes of nutrient content in soil in long-term fertilizer experiments: Materials of the 10th international Scientific and practical Conference: "Environment. Technology. Resources."*, June 18-20, 2015, Rezekne , Latvia, vol 2, pp. 329 – 332.

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Effectiveness of Rhizobial Strains on the Faba Bean Development and Yield in Soddy Podzolic Soils

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Abstract. In the frame of EU 7th Research Framework Programme of The European Union project EUROLEGUME (Enhancing of legumes growing in Europe through sustainable cropping for protein supplay for food and feed) two Rhizobium leguminosarium strains alone and in mixture were examinated to evaluate the influence on yield formation of faba bean (Vicia faba L.) 'Lielplatones'. The field experiment was carried out at the Institute of Agricultural Resources and Economics between 2014 -2016 in the organic cropping system field. The beans seeds were treated with rhizobia fungi by soaking in bacteria suspension for 30 minutes before sowing. A plant high was measured at the beginning of flowering (BBCH 61- 64), at the beginning of forming pods (BBCH 71- 75) and at the beginning of maturity (BBCH 81- 85).

The inoculation of plant seeds promotes a slight increase in the plant length. The highest yield was from seeds inoculated with strain R2. There were no significant differences between tested strains. The results of this investigation indicate that rhizobium inoculation is a recommendable management tool for faba beans generally but effectiveness of rhizobial strains strongly depending climate conditions. Seed treatment with Rhizobium contributed to an increase in the quantity of nitrogen in the soil.

Keywords: grain legumes, organic farming, soil, nitrogen.

I. INTRODUCTION

Grain legume crops play significant roles in the human diet and animal feed and the environment, but only the fraction of the species in this diverse group of plants is currently exploited in agriculture [3].

Faba bean (*Vicia faba* L.) is among the oldest crops in the world [14] with a long tradition of cultivation in the temperate zone of the northen hemisphere [5]. Because of comperatively good adaptivity to groving conditions [9,14] they are widely in different agroclimatical regions [12]. Due to their great resistance to low temperatures, they are, among leguminous plants, the best adapted to colder climates such as the Northern parts of Europe, and represent to the inhabitants of that region a source of energy, protein, folic acid, niacin, vitamin C, magnesium, potassium, iron and dietary fiber [6].

Faba beans are high- yield crop whose both– economic and ecologic role is very significant; they contain up to 35% of crude protein, approximately 50% of carbohydrate and no more than 15% of crude lipid [1,7,10,11]. Faba bean responds to and changes its environment by altering on-site soil fertility, microclimate, and co-habitats of wild flora and fauna [9] and is an excellent crops for cropping systems because of its unique ability to fix atmospheric nitrogen symbiotically which is heavy depends on sufficient populations of effective rhizobia [8]. The inoculation of the legume seed material with active nitrogen fixing bacteria strains before sowing has a significant role for the increase of the legume yield [1,13]. Inoculation can improve crop yields in cases where appropriate rhizobia are not present in the soil or the soil contains a significant proportion of non-nodulating or ineffective nitrogen-fixing strains. Inoculation of legume seeds with Rhizobium affects soil microbial community and processes, especially in the rhizosphere [13].

Although the global average grain yield of faba bean has almost doubled over the past 50 years, the total area sown to the crop has declined by 56% over the same period, owing to the cheap availabilty of fertilizers and competition with policy-baked cereal crops [8]. The new EU policy of agriculture promoted a sharp increase of spring field bean (*Vicia faba* L.) sowing area in Latvia. The total area under faba beans increased 19 times from 2010 to 2015- from 1.3 thou ha in 2010 to 25.9 thou in 2015 [11]. Taking into account that currant research trends in legumes are focused on new methodologies involving genetic and – omic studies, as well as new approaches to the genetic improvement of these species, inclyding the ralationships with their symbiotic rhizobia [5], the aim of this studies was to test new commercial Rhizobium inoculants effectivity for faba bean 'Lielplatones'.

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II. MATERIALS AND METHODS

Site and soil description. Three years experiments were performed in organically managed sodddy podzolic loamy sandy soils field at Institute of Agricultural Resourses and Economics (Priekuli, 57˚31'92"N, 25˚36'26"E) during 2014-2016. A measurement of soil pH and nutrient content was performed every year by the State Plant Protection Service of Latvia corresponding methodology traditionally adopted for agricultural experimental fields: for soil pH detection were used pH – potentiometrically in a 1M KCl suspension method, content of organic matter in soil- by Tyurin's method, in %, plant available phosphorus and potassium in soil by Egner-Riehm, nitrogen- by Kjeldahl method (standard LVS EN/IEC 17025:2005). The main soil agrochemical parameters are presented in Table 1.

Table 1.
Soil characteristics of experimental fields

Soil characteristic:	2014	2015	2016
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
N-NO3, mg kg^{-1} (0-20 cm)	2.1	6.1	2.7
N-NO3, mg kg^{-1} (20-40 cm)	3.8	3.3	3.5
N-NH4, mg kg^{-1} (0-20 cm)	2.2	2.4	1.9
N-NH4, mg kg^{-1} (20-40 cm)	0.6	0.7	1.4

In the trial area, the field crops have been cultivated according to the principles of organic farming since 2003. Faba beans were grown in six-field crop rotation: spring barley with clover as undersown-red clover-spring cereals-winter rye-potatoes-pulses. 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.

Field and crop management

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 before sowing in spring. Clover was cut and ploughed into the soil in the beginning of July. Straw and crop residues were not removed from the 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.

As the basic soil fertility management measure was green manure. 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.

Weather conditions

The weather conditions during research period are shown in Figure 1. They were different. Vegetation period's beginning in 2014 was fixed April 17th, 2015– 21st, but 2016– April 3rd. Respective local average precipitation is about 690 mm and generally there is a moisture natural surplus. The spring of 2016 differed among other springs with less precipitation in the beginning of vegetation. May was also extremely warm. Unexpectedly dry and warm was July 2014 that made negative influence on forming of pods.

As the coldest was 2015 with 12.7 ^{0}C as an average for six year period.

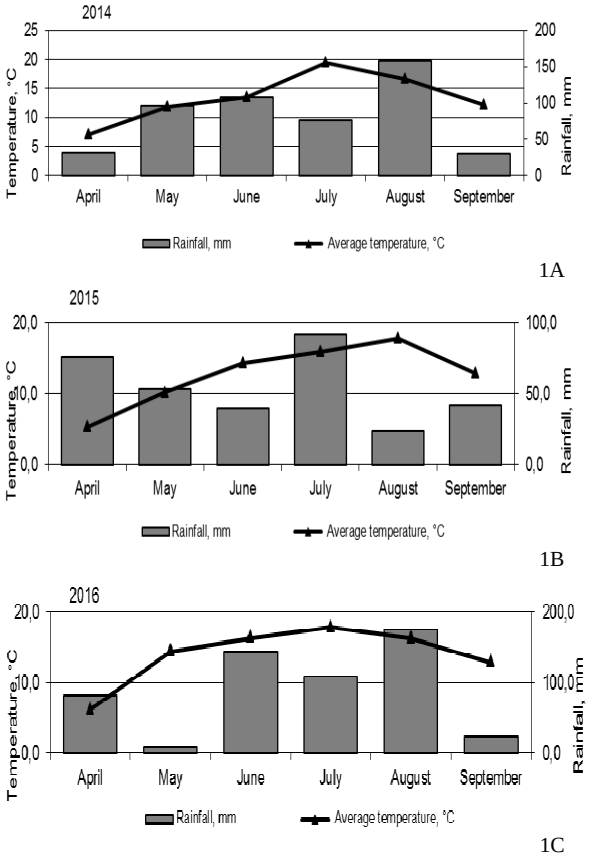

Fig.1. Monthly total precipitation and average air temperature during 2014 - 2016 (1A- 2014, 1B- 2015, 1C- 2016).

Innoculation, measuring and soil sampling

Three *Rhizobium leguminosarum* strains– RI, R2, R3 (mixture of R1 and R2) were obtained from the Rhizobium collection of the Latvia University of Agriculture of Institute of Soil and Plant Science. The inoculants were mixed with moistened bean's seeds by soaking in bacteria suspension for 30 minutes before sowing. Control seeds weren't inoculated with Rh. l*eguminosarum* strains. A 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).

The soil samples were taken from points randomly selected points of each treatment from the 0–20 cm and 20–40 cm soil layer using an auger with a 1 cm diameter. The composite sample was carefully

mixed. To avoid contamination of soil samples, the preventive measures accordingly to the guide were taken. Soil samples had been kept in cold until they were analysed in the laboratory.

III. RESULTS AND DISCUSSION

Effectiveness on the plant development

The inoculation of plant seeds promotes a slight increase in the plant length only in 2014 when in the period till the beginning of flowering was more precipitation than other two experimental years (Fig.2). In this year plants reached the greatest length-112-115 cm, which is typical for variety 'Lielplatones'. Plant height in 2015 was 90-95 cm, but in 2016– 55–62 cm only. The obtained data indicate significant negative impact of humidity deficit at the beginning of faba bean development, as it was fixed in May 2016 when rained down 9.8 mm only. There were no differences found between the tested *Rhizobium* strains.

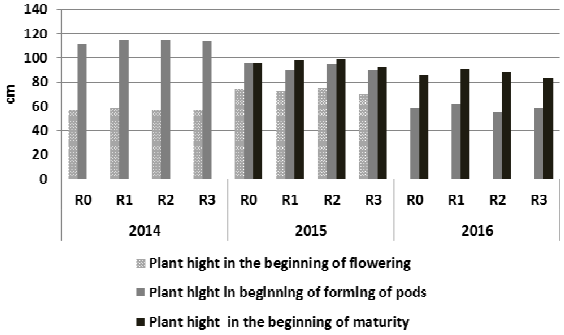

Fig. 2. Plant height at different *Vicia faba* L. development stages depending Rhizobium strain

Figure 3 shows that, depending on the year inoculation with *Rhizobium* influencing the forming of pods. Strain R2 reflected higher positive impact on the forming of pods per plant in 2014 and 2016 but strain R1 in 2015. Low (in 2015) or negative effect (2014 and 2016) fixed after inoculation with R3. The largest number (8.8) of pods per plant on average in all variants was formed in 2016, when the plants as compared to the other two years were the shortest. Because accordingly Bishop et al [2] it is difficult to reliably identify key stages of reproductive development in field conditions, to explain effects requires long term experiments.

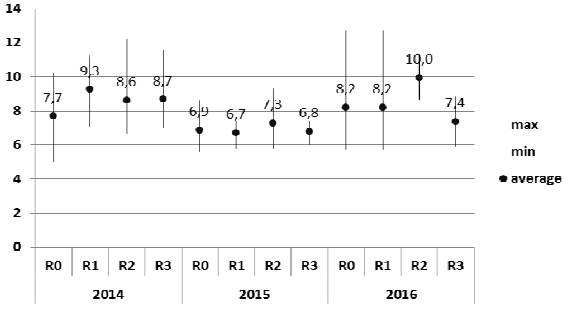

Fig. 3. Amont of pods per plant of *Vicia faba* L 'Lielplatones' depending Rhizobium strain

Effectiveness on the yield

Despite the fact that most of pods were formed in 2016, on average the highest faba bean yield (in average 3.2 t ha^{-1} for all variants) was obtained in the season of 2015 (Fig. 4). Results show that the crucial role played climatic conditions in July and August; in

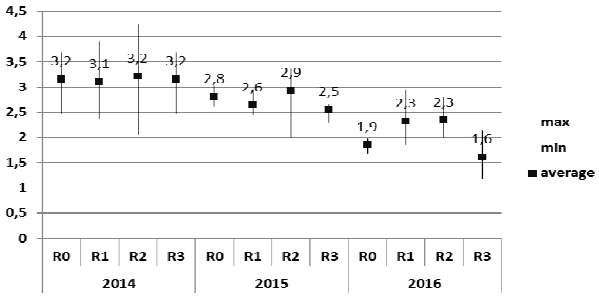

Fig. 4. The yield of *Vicia faba* L 'Lielplatones' depending *Rhizobium* strain

2015 when was obtained higher yield, July was characterized by moderate monthly temperature (15.9^{0}C) and rainfall (91.5 mm), followed by relatively dry and warm August. In the other two years in those months was a drastic deviation compared to long term average data.

In contrast to other author's [14] data inoculation with Rhizobium did not affect the yield formation; there was no significant influence of inoculation with *Rhizobium* on the yield of *Vicia faba* L 'Lielplatones' fixed.

Effectiveness on N content in soil

As affirmed by several researchers [4] also in our experiments inoculation with *Rhizobium* contributed to the increase of nitrogen in the soil both, 0–20 cm and 20–40 cm layer (Fig 5–7). For all examined strains inoculations positive effects most apparent was in 2014. Inoculation positive effects most apparent was using strain R2.

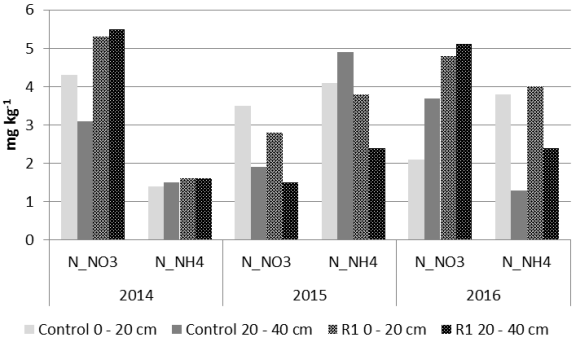

Fig. 5. Effect of R 1on soil nitrogen content

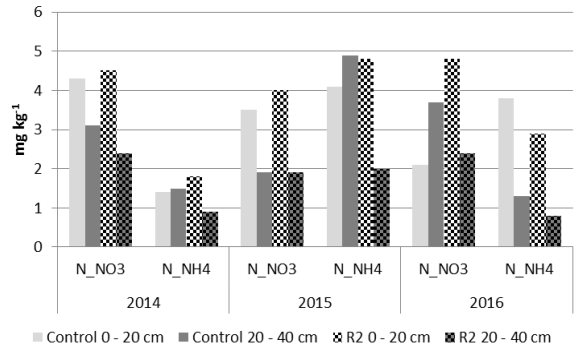

Fig. 6. Effect of R 2on soil nitrogen content

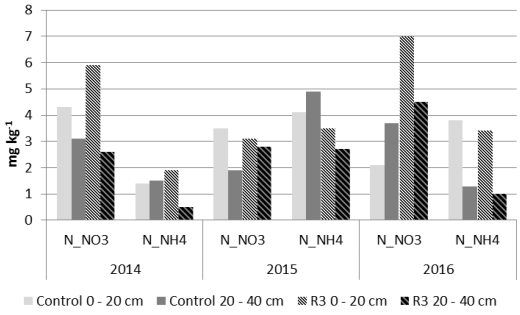

Fig. 7. Effect of R 3 on soil nitrogen content

IV. CONCLUSION

The results of this investigation indicate that rhizobium inoculation is a recommendable management tool for faba beans generally but effectiveness of rhizobial strains strongly depending climate conditions.

Neither strain R1 and R2, nor mixture of them did not provide a significant yield increase for faba bean 'Lielplatones'.

Faba bean 'Lielplatones' seed treatment with *Rhizobium leguminosarium* contributed to an increase in the quantity of nitrogen in the soil.

V. ACKNOWLEDGMENTS

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REFERENCES

[1] Ansevica, A., Alsina, I., Steinberga, V. The evaluation of rhizobium leguminosarum strains effectiveness in field beans (*Vicia faba* L.) at different soil microbiological activity. Agricultural Sciences (crop sciences, animal sciences). 2008, pp.71-75.

[2] Bishop, J. G. Potts, J.G., Jones, H.E. HEAT STRESS Susceptibility of Faba Bean (Vicia faba L.) to Heat Stress During Floral Development and Anthesis. Journal of Agronomy and Crop Science, 2, Version of Record online: 21 MAR 2016.

[3] Cernay, C., Pelzer, E., Makowski, D. A global experimental dataset for assessing grain legume production. Sci. Data 3, 2016, 160084.

[4] Denton, M., Pearce, D., Peoples, M. Nitrogen contributions from faba bean (Vicia faba L.) reliant on soil rhizobia or inoculation. Plant & Soil. 2013, Vol. 365, Issue 1/2, pp. 363-374.

[5] Due, G., Aleksic, J.M., Mikic, A., Paull, J., Redden, R.J., Sass, O., Stoddard, F.L.,Vandenberg, A., Vishnyakova, M., Torres, A.M. Grain legumes, De Ron, A.M (ed.). Handbook of Plant Breeding 10, Springler Science+Business Media New Yourk, 2015, pp. 141-178.

[6] Giménez, M., González, R. J., Wagner, J., Torres, R., Lobo, M. O., Samman, N. C. Effect of extrusion conditions on physicochemical and sensorial properties of corn-broad beans (*Vicia faba*) spaghetti type pasta. Food Chemistry. 136 (2), 538-545.

[7] Hawthorne, W. Pulses nutritional value and their role in the feed industry. Edition 2, Pulse Australia Pty Ltd, 2006.

[8] Jensen, E.S., Peoples, M.B., Hauggaard-Nielsen. H. Faba bean in cropping systems. Field Crops Research 115 (3), pp. 203-216.

[9] Kopke, U., Nemecek, T. Ecological services of faba bean. Field Crops Research, 115, 2010, pp. 217–233.

[10] Macarulla, M. T., Medina, C., De Diego, M. A., Chavarri, M., Zulet, A. M., Martınez, J. A., Noel- Suberville, C., Higueret, P., & Portillo, M. P., Effects of the whole seed and a protein isolate of faba bean (Vicia faba) on the cholesterol metabolism of hyper-holesterolaemic rats. British Journal of Nutrition, 85 (5), 2001, pp 607-621.

[11] Proskina, L., Cerina, S., Zeverte-Rivza, S.2016. Faba beans as an alternative protein source for broiler chicken feed. Proceedings of the 2016 International Conference "ECONOMIC SCIENCE FOR RURAL DEVELOPMENT', 41, Jelgava, LLU ESAF, 21-22 April 2016, pp 265-272.

[12] Salem, S. Alghamdi, 2009. Chemical Composition of Faba Bean (*Vicia faba* L.) Genotypes under Various Water Regimes. Pakistan Journal of Nutrition, 8: 477-482.

[13] Siczek, A., Lipiec, J. Impact of Faba Bean-Seed Rhizobial Inoculation on Microbial Activity in the Rhizosphere Soil during Growing Season. *Int. J. Mol. Sci.* 2016, *17*, 784

[14] Singh, A.K., Bharati, R.C., Manibhuskan, N.C., Pedpati, A. An assesment of faba bean (Vicia faba L.) currant status and future prospect. African Journal of Agricultural Research, 8, 2013, pp. 6634-6641.

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Promoting social entrepreneurship product

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Abstract. The object of the research are the social entrepreneurs and its business development. The aim of the research is to discuss existing marketing strategies applied to social entrepreneurship and to offer possible ways of their improvement. The research is relevant and consistent with the increasing role of social entrepreneurship taking the full power throe the fast changing political, economic, socio cultural and technological circumstances of the 21st century. While marketing the social entrepreneurship, the focus on marketing strategies must be revised. The research methodology includes both traditional and modern elements of marketing, such as marketing mix, strategies, customer segmentation and targeting, pricing altogether with the main elements of social entrepreneurship, such as social and economic aspects.

The results present thet in standard marketing strategies, the strategy for social entrepreneurs should include segmentation of the customers and consumers by taking into consideration standard criteria (such as geographical, demographical, psychographic and behavior segmentation) but also implementing own criteria most adequate for the products they are currently interested to produce. It is important which factors are significant enough to take decisions of expansion, harvest or liquidation of products.

Keywords: marketing mix, marketing strategy, social entrepreneurship, social sustainability.

I. INTRODUCTION

Every type of business consists of following market participants: suppliers, intermediaries, companies, competitors and customers. Social entrepreneurship, as an object of the research, is also a part of the modern business environment with the one exception – customers of the product or service produced by such companies are not often the consumers or targeted customers of the related goods. In many cases the decision maker is that paying part, such as the government, a foundation, an individual sponsor or a funder. The ultimate consumer in many cases gets an access to services at no cost or at discounted prices through the payer. This additional customer profile makes an issue of this research as in the case of social entrepreneurship the focus on marketing strategy should be slightly different from traditional businesses.

The aim of the research is to discuss existing marketing strategies applied to social entrepreneurship and to offer possible ways of their improvement. **The research is relevant and consistent** with the increasing role of social entrepreneurship taking the full power throe the fast changing political, economic, socio cultural and technological circumstances of the 21st century.

While marketing the social entrepreneurship**, the focus on marketing strategies** must be revised. For social entrepreneurs sometimes main benefit is not a profit but grow of positive reputation. This can be achieved throe dissemination of marketing strategies, devoted to enhance the image through public recognition. The same can be stated both for customers of socially related goods and for the final consumers. The goods they buy may mean to them not only profitable deal and cost optimization but also can increase their intangible sense of social outcome.

II. MATERIALS AND METHODS

The research methodology includes both traditional and modern elements of marketing, such as marketing mix, strategies, customer segmentation and targeting, pricing altogether with the main elements of social entrepreneurship, such as social and economic aspects. **Works of various authors related to the research field were analyzed, such as Ph. Kotler (Principles of Marketing) [8], J. Dees (Entreprising nonprofits…) [3], J. Boschee (Strategic Marketing…) [2] and others[5,7,9].** Tools of the research include observation, experiment, analysis of the specific literature and statistical methods, interviews with participants of social entrepreneurship. Ethics of the research must take into consideration specific groups of the targeted consumers that often represent different minorities, people with disabilities, low income population and taking into attention rapidly changing political situation in European Union – refugee groups.

While discussing a role of marketing in the social entrepreneurship an additional element should

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be stated among the main elements of marketing mix – and this is a social impact. The social mission, its goals and objectives should be analyzed altogether with product, its price, distribution place and necessary promotion. When evaluating special target group for social business following questions should be stated and discussed by decision makers:

1. Most segments of the final consumers should be stated.
2. Which of them are reached and served in a most effective way with the most limited resources?
3. How is it possible to attract more of prospective consumer segments? Which customers should be involved then?
4. Is the cost consistent with the social outcome?
5. Are there certain ways to decrease the cost without reducing the impact provided?

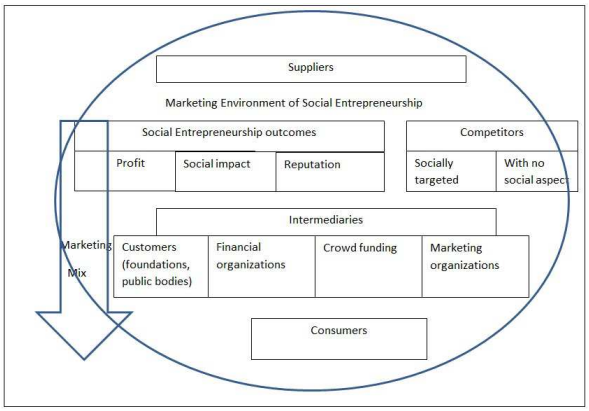

Fig.1 Marketing environment of social entrepreneurship

On a figure 1 there is marketing environment of social entrepreneurship analyzed. Unlike the tradition entrepreneurs, social entrepreneurs should take care not only about their profit maximization. Social impact and increase of positive brand or company`s image reputation must also be taken into attention. As a company, it meets on a market with competitors who could have better market proposition or have/ have not been socially targeted. In this case there also should be different strategies applied. Sometimes socially targeted competitors have the same intention with the company and their interests intersect or match. In this case competitor may become a partner or even intermediary on a way to a related targeted auditorium. For example a company that produces food with the purpose to disseminate for a special social group (as homeless people) and sponsored by a public body or a foundation may join with food disseminators on wheels that serve the same or similar groups of people. In this case resources spent on promotion and distribution elements of marketing mix will be decreased and total cost of the product will become lower as well.

However the situation when socially related entrepreneur meets with a competitor who doesn't have a social relation is quite opposite from the previously stated. In this case the development of a situation often goes with more pessimistic prognosis for market growth possibilities for a social entrepreneur. As an example there can be mentioned price comparison experiment that was hold between rugs sellers in Latvia. "Lude" [1] is a company very closely related to the social entrepreneurship as it uses recycled textile materials to produce rugs. Although the design is developed by professional designers, these rugs are made by the group of senior people. The intention of the business is not only to sell textile rugs and get profit but also to increase social impact by improving both financial and social status of the elderly people. The production of "Lude" could be easily found in Latvia, mostly in shops related to the Latvian crafts and design and also at online stores, such as etsy.com [4]. The price on a textile rug sized 70 x 120 cm can vary but starts with 90 EUR. Comparing the price with similar on quality (recycled textile) and size (70 x 140 cm) rug, offered for a sale by a competitor with no social relation, such as "Jyusk" , there is a price starting from 19.99 EUR.

Formally it looks as there is no much sense in purchasing "Lude" rugs as its price is 4.5 times higher than offered by the competitor. However there is an importance of the third aspect – reputation of the social entrepreneurship seen very clearly. When people purchase "Lude" rugs they understand perfectly the reason they are ready to overpay for. The sense of social responsibility they get. This is an additional aspect to marketing mix, intangible outcome that should be emphasized and underlined by marketing tools.

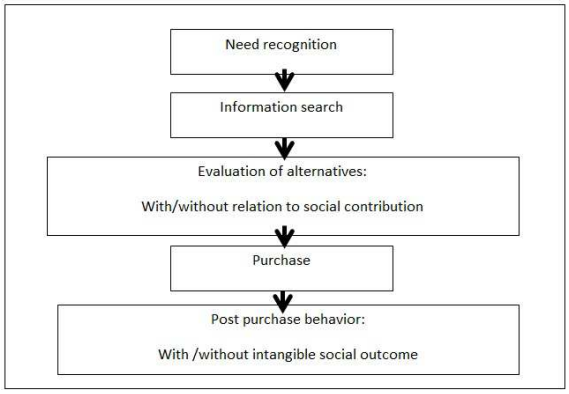

Fig. 2 Buyer behavior process in case of socially related goods purchase

Intangible outcome customers and consumers get when purchasing goods or services from social entrepreneurs. This outcome should be positioned as an additional element of customer's response to the marketing mix. Social impact from marketing mix meets intangible outcome, the sense that customers get while buying socially related products. In this

case the buyer behavior process could be described as stated on a figure 2.

III. RESULTS AND DISCUSSION

As being mentors of social entrepreneurs for past 2 years in the frames of the NEW D(o)or initiative, the authors were participating in various meetings, interviews and lectures with the project participants – social entrepreneurs from Latvia, Ukraine, Lithuania and Russian Federation [10]. During these meetings several important factors were obtained:

1. Negative attitude to marketing from the side of social entrepreneurs. Mostly related to weak knowledge of the subject and interpreting marketing as a tool of profit maximization for companies with ignorance of needs of a society at large.
2. Main marketing strategies were learned firstly during the meetings with mentors and invited lecturers. Before that the achievements of social entrepreneurs – project participants were made mostly thanks to their inborn sense of market behavior.
3. Fear of rejection. This is equal to the described by Ira Kalb, the marketer who also delivered a course of marketing lectures to the social entrepreneurs in USA: "Those that tend to be more intelligent and socially-conscious (the ones who gravitate to social entrepreneurship) tend to be more sensitive to rejection - a natural part of the sales process. The fear of rejection is often given as a reason why so many shun marketing/sales" [7].

During the meetings with the social entrepreneurs it should be explained that this stated perception of marketing they have is wrong. According to the definition of marketing given by the marketing guru, Ph. Kotler: "Satisfying needs and wants through an exchange process" [8]. It is clear money and profit maximization are not mentioned among the main objects and goals in the theories of modern marketing. Quite opposite – the concept of marketing was born as a need of a new response while old market concepts – the production, the product and the selling concept showed their imperfection in attempts to get new customers and to achieve the market share growth. Then was offered modern marketing approach – first sense the needs of current and potential customers and then give an adequate response with the product that will satisfy their needs. Needs satisfaction – this approach is more than consistent with the orientation of social entrepreneurship which aim is to increase social impact exactly buy satisfying those targeted segments that due to different reasons remained unsatisfied by traditional businesses before.

While marketing their social offers, social entrepreneurs may often meet following problems:

1. Incentives of third party payers (intermediaries or customers) do not align with the social mission or the interests of the consumers. For example, a public health organization may be pressured to lower payments for drug rehabilitation services to a point lower than practical. In this case, organizations compete to be the lowest cost provider, which may compromise social impact.
2. Paying customers cannot accurately assess quality of programs or services. Measuring social value is difficult. As a result, customers lack adequate information to gauge the quality of social goods and services. Social value is not determined by customer demand or a lack thereof.
3. Social benefits created by social ventures often exceed consumer value. The total societal benefits surpass what they directly provide to the individuals they serve. This would be seen in programs that prevent youth from committing crimes that generally have a high cost to society or reducing the incidence of spreading diseases among the healthy population. Alternatively, high consumer demand does not necessarily indicate high social value. Homeless shelters serving alcoholic beverages may demonstrate high demand, but this demand is not a sign that these shelters would be superior. [3]

Going back to marketing strategies that should be offered to social entrepreneurs there can be mentioned special strategic matrix, developed especially for the social entrepreneurs by the scientist Jerr Boschee [2]. It is stated that making strategic marketing decisions, however, is more difficult for a social entrepreneur than it is for either a traditional nonprofit or a commercial business, both of which are primarily concerned with a single bottom line. A traditional nonprofit will continue offering products and services that have a significant social impact even if they lose money; commercial enterprises will not. Social entrepreneurs, on the other hand, are equally concerned both with social impact and income, and that means they must simultaneously analyze the social impact and financial viability of each product and service - and only then they are ready make decisions about which ones to expand, nurture, harvest or kill.

Table 1
The Strategic Marketing Matrix for Social Entrepreneurs [2]

	Positive financial returns	Negative financial returns
Significant social impact	Expand	Nurture
Minimal social impact	Harvest	Kill

The matrix, given at the table 1 is simple and easy way for social decision makers to think about the intersection of social impact and financial returns. It can be expanded to measure the consistence of the degree of social need being addressed and the anticipated financial results. Next matrix could be used when more detailed analysis is needed. It measures the relationship between the degree of

social need being addressed and the anticipated financial results:

Table 2
The Expansion of the Strategic Marketing Matrix for Social Entrepreneurs, adapted from [2]

Potential level of reachable profit/ losses Volume of social need	Significant	Modest	Modest losses	Significant losses
Critical	Expand	Expand	Nurture	Kill
Sizeable	Expand	Expand	Nurture	Kill
Minimal	Harvest	Harvest	Kill	Kill
No social need	Kill	Kill	Kill	Kill

To use this expanded matrix analysis a social entrepreneur first has to make following steps:

1. To divide a market into all possible segments and to answer a question of each of the selected segments.
2. How many people of the segment are ready or are able to pay for this product and how strong is their need?
3. Are there any intermediaries or customers, as public bodies, available to cover these expenses to that related segment?
4. How all elements of marketing mix can be used or updated to make differentiation and positioning of the product to the related segment?
5. Environmental forces – how significant their role is? Are these factors playing positive or negative role? Are they helpful or damaging? How is possible to use the opportunities and decrease the role of the threats?
6. Who are you main competitors? Are they also representatives of the social entrepreneurship or do they represent traditional field of a business? How is possible to evaluate the threats from them?
7. In money equivalent – how is it possible to measure the market?
8. Are there any other opportunities for your product`s grow within this segment?
9. What is a current position of you product in this market? It there market grow, is it constant or declining? Which trends is possible to predict right now?
10. What is the fixed and variable cost? What is the perspective for profit or losses? A preliminary calculation should be provided.

The same as in standard marketing strategies, the strategy for social entrepreneurs should include segmentation of the customers and consumers by taking into consideration standard criteria (such as geographical, demographical, psychographic and behavior segmentation) but also implementing own criteria most adequate for the products they are currently interested to produce providing also a social impact. For example, a company that produce necessary equipment for the sportsmen of Paralympic games can disseminate a table of different levels of these sportsmen disabilities. According to the level of disability each of them needs own equipment.

Next, following strategies should be applied to each group of products dedicated to each special segment:

1. Products with social impact able to bring potentially large profit should be expanded and require most of the resources.
2. Programs with a large social impact but not yet achieved financial stability should de additionally nurtured.
3. If the company plans to continue to support its socially sustainable products with good financial profit but with low social impact – this should be revised or harvested.
4. Products, both low with their social impact and profit should be taken away from a market or "killed".

Last but not least step that should be taken into attention when developing a marketing strategy for a social entrepreneurship should be how to measure which factors are significant enough to take decisions of expansion, harvest or liquidation of products. Following factors then should be taken into attention:

1. Significant success factors. Obviously the business must be profitable, the team should be strong and trustful, price should differ in a better side from competitors. There is also possible to mention delivery speed, sales volume, purchase convenience, reputation, amount of intermediaries, power of suppliers and much more.
2. Environment forces, both internal, micro and macro should be properly analyzed. Some of them, such as internal and micro is possible to control, some are so large that it is only possible to be informed about their existence. However in any case the entrepreneur should be forewarned.
3. Competitors and their power. As was shown already, some of the competitors may rely to the same field of the social entrepreneurs. Some of them can play on the same field but with no belonging to the social entrepreneurship. It was proved in case with textile rugs experiment that those entrepreneurs not related to social impact sometimes can offer better price offer to a customer as they don't have to include expenses on social aspects in their self-cost of a product. Despite the fact the total contribution to a society at large provided by social entrepreneurs is more significant, customers still can choice a product with no social component in a short run perspective.

Altogether all these three factors could be analyzed together in a matrix. Significant factors, that might bring a success and environmental forces with lower or higher level of impact to a product and to the development of social entrepreneurial business at large should be measured by an entrepreneur or even by his team or by invited experts, such as mentors,

business angels etc. Each of the factors should have its own weight; the total should be equal to 100 per cent. Then each of competitor`s products altogether with the product of a social entrepreneur must be ranked. Total ranking should be considered depending on a amount of the research participants, for example, if there are five participants (the social entrepreneur and his four competitors), the total ranking must be five. Each of the participants will get multiplied result of ranking and the weight percentage.

IV. RESULTS

As an example there is given analysis of already well known social entrepreneurial company "LUDE" which main area of business is handmade manufacture by senior women of textile rugs, made from recycled or second hand materials. These products are compared to the other offered at the same market field such as etsy.com [Etsy.com, 2015], an online network for buy and sell of home made crafts.

Table 3
Competitive Analysis for Social Entrepreneurs on Example of Textile Rugs

		The Charkha, India		ADRugs, Latvia		Lude, Latvia	
Factors	Weight	Rank	Score	Rank	Score	Rank	Score
S.S.F.1	20,00%	2	0,4	3	0,6	1	0,2
S.S.F. 2	20,00%	2	0,4	1	0,2	3	0,6
S.S.F. 3	15,00%	1	0,15	3	0,45	2	0,3
S.S.F. 4	20,00%	1	0,2	3	0,6	2	0,4
E.F.1	20,00%	3	0,6	2	0,4	1	0,2
E.F.2	5,00%	2	0,1	1	0,05	3	0,15
Total	100%		1,85		2,3		1,85

Significant success factor 1: social impact

Competitor 1, The Charkha, India. These rugs are made from recycled materials (former Indian sari dress), so there is a social impact. This is stated in the description of the product, so customers understand the social outcome they gain at a purchase.

Competitor 2. ADRugs. These rugs are made from recycled materials (as described on a website), so there is a social impact.

Lude – these rugs are made from recycled materials or second hand dress by elderly people, so there is double social impact. This is stated in the description of the product, so customers understand the social outcome they gain at a purchase [1].

Significant success factor 2: price

Competitor 1, The Charkha. Prices for rugs can vary depending on a size, but starts from 63.89 EUR

Competitor 2, ADRugs. Price can vary, but starts from 32.85 EUR.

Lude: Prices for rugs can vary depending on a size, but starts from 80 EUR. (which is cheaper comparing to the prices listed on their own site, from 90 EUR). It is clear, that in a question of price Lude has the weakest position and this should be seriously revised.

Significant success factor 3: price assortment

Competitor 1, The Charkha. There are 53 different items available for sale.

Competitor 2, ADRugs. There are only 5 items on site.

Lude: 37 items are available for sale at etsy.com

Other significant success factors that might be taken into consideration:

Significant success factor 4: promotion and positive reputation

Feedbacks and positive reviews (for example, The Charkha has 56 reviews and got favorite mark by 101 people, Lude has only 1 review and got favorite mark by 7 persons, however ADRugs has no reviews and only 2 favorites).

Environmental forces should be also taken into attention. E.F.1: for example, both ADRugs and Lude are located in Latvia, so it is easier to deliver within one country. Environmental forces, such as political implications, delay with delivery etc. may destroy logistics process for The Charkha, located in India). Lude gets better ranking due to more positive feedbacks from customers who already had received the rugs.

E.F.2 : demographical situation. Lude gets better ranking because it gives paid work and offer additional social activities to the group of population which is constantly growing in Latvia – the senior people. This group is traditionally suffering from low income and current prognosis on demographical situation of the country predict that this part of population will continue growing. ADRugs gets the lowest ranking as there is no mention about their team structure and The Charkha is giving work to poor women of India who traditionally suffer from unemployment and negative attitude from other parts of the society.

Let's look at the business model as an example of social entrepreneurship company "Lude" [Lude, 2015] a. In this case, the business model is the business concept underlying the practice [5]. It includes four basic components: costumer interface (1) a core strategy, (2) strategic resources (3) , the value net (4) (network of social support on the basis of common values).

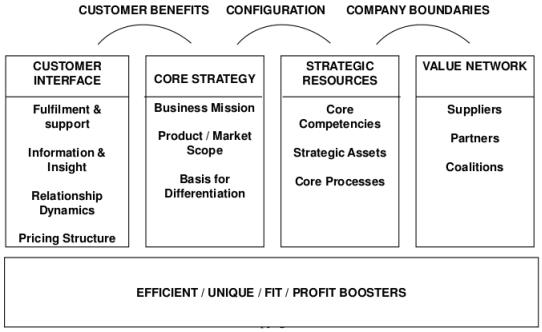

Fig. 3 Component of business model

Table 3.
Overview of the components of business models of social entrepreneurship

Costumer interface Customer interface has four elements: fulfillment and support, information and insight, relationship dynamics, and pricing structure.	The production of "Lude" could be easily found in Latvia. The price of the products is high. Buyers pay for social responsibility.
Core strategy includes business mission, product/market scope, and basis for differentiation. Controlled items or zone preemptive influence within the value network	Company "Lude" uses recycled textile materials to produce rugs
Strategic resources include core competencies, strategic assets, and core processes. Requirements for strategic resources included in the business model	- Investment - Human resources - Risk Management
Value net. Integration of target groups	- A large proportion of workers is also an owner - Strong business relations (suppliers - customers) within group

The authors of this paper agree with the conclusions Schoen and Mair [9]:

1) To fulfill its mission, and timely resolution of problems of the successful organization of social entrepreneurship is to create a social network's value at an early stage of its development.

2) The successful organization of social entrepreneurship carefully take into account their resource needs and in line with the strategy of developing the resource, which should be integrated into the business model at a very early stage of development of the organization.

3) The successful organization of social entrepreneurship integrates its target group in the social network's value at an early stage of development of the organization.

These aspects need to be considered during the formation of a marketing strategy for social enterprise.

To summarize it is possible to say despite the fact The Charkha and Lude have market offerings filled with social impact, still the company with the lowest share of social sustainability offers the cheapest price and fast delivery. However if positive feedbacks of customers are very important especially for those concerned about social outcome to get. So, it is obvious that Lude is on a right way of development, however they have to revise their price policy.

V. CONCLUSION

While marketing the social entrepreneurship, the focus on marketing strategies must be revised. For social entrepreneurs sometimes main benefit is not a profit but grow of positive reputation. This can be achieved throe dissemination of marketing strategies.

In the social entrepreneurship an additional element should be stated among the main elements of marketing mix – and this is a social impact. Intangible outcome customers and consumers get when purchasing goods or services from social entrepreneurs. This outcome should be positioned as an additional element of customer's response to the marketing mix. Social impact from marketing mix meets intangible outcome, the sense that customers get while buying socially related products.

It is stated that making strategic marketing decisions, however, is more difficult for a social entrepreneur than it is for either a traditional nonprofit or a commercial business, both of which are primarily concerned with a single bottom line. A traditional nonprofit will continue offering products and services that have a significant social impact even if they lose money; commercial enterprises will not. Social entrepreneurs, on the other hand, are equally concerned both with social impact and income, and that means they must simultaneously analyze the social impact and financial viability of each product and service - and only then they are ready make decisions about which ones to expand, nurture, harvest or kill.

The same as in standard marketing strategies, the strategy for social entrepreneurs should include segmentation of the customers and consumers by taking into consideration standard criteria (such as geographical, demographical, psychographic and behavior segmentation) but also implementing own criteria most adequate for the products they are currently interested to produce providing also a social impact.

To measure which factors are significant enough to take decisions of expansion, harvest or liquidation of products, following then should be taken into attention: significant success factors; environment forces; competitors and their power.

VI. ACKNOWLEDGMENTS

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REFERENCES

[1] About Lude. Textile rugs. Link: http://www.lude.lv/?section=about (accessed 17.01.2017)
[2] Boschee J. Strategic Marketing for Social Entrepreneurs. Social Enterprise Reporter, 20015.
[3] Dees, J.G., Emerson, J., & Economy, P. Enterprising Nonprofits: A Toolkit for Social Entrepreneurs. Toronto: John Wiley & Sons, 2001.
[4] Etsy.com https://www.etsy.com/ru/search/handmade?q=textile+rug&ship_to=LV (accessed 17.01.2017)
[5] Hamel, G. Leading the revolution. Harvard Business School Press, Boston, 2000
[6] Jysk product sortment. Link: http://www.jysk.lv/paklajs-acre.html (accessed 17.01.2017)
[7] Kalb Ira. Marketing: the missing ingredient in social entrepreneurship. Huff Post Business newspaper, 04.01.2015.

[8] Kotler Philip, Armstrong Gary. Principles of Marketing. 14th Edition. Pearson Prentice Hall, 2007.

[9] Mair, J., Schoen, O. Social Entrepreneurial Business Models: An Exploratory Study. ESE Business School, University of Navarra, WP №610 October 2005.

[10] New D(o)or, social initiative. Link: http://www.newdoor.lv (accessed on 17.01.2017)

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GIS-modeling of Lake Onego Shoreline in the Holocene and Late Pleistocene

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Abstract. The application of GIS software for reconstruction of Lake Onego shoreline in the Holocene and the Late Pleistocene presented. Reconstruction was originated from the ideas of the Lake Onego depression deglaciation model proposed by I. Demidov [1] and the data of E. Deviatova [2] concerning Lake Onego depression isostatic uplift in the Holocene. ArcGIS software was used to perform GIS-modelling which was based on the original digital elevation model of the lakebed and its watershed. Twelve digital paleogeographic maps were developed as a result. Paleogeographic maps were verified by hand-drawn images of I. Demidov and E. Deviatova and by matching the lake shoreline and the position of archeological sites. Maps are available on-line in the electronic form [3]. The surface area of the Lake was determined at different stages of its development. The quantitative data obtained in this study is valuable for estimation of the lake volumes and the rates of discharge in the past.

Keywords: GIS-modeling, Holocene, Lake Onego, Late Pleistocene.

I. INTRODUCTION

Geographic information system (GIS) is valuable tool for reconstructing natural circumstances of the past. Together with digital elevation models (DEM) and paleolimnological and paleoclimatic research data GIS software enables to reconstruct major landforms in a high quality level [4; 5; 6]. Nevertheless, until now these methods were not applied to assess the process of Lake Onego development.

Lake Onego is the second largest lake in Europe with a surface area approximately ten thousand square kilometers. The Lake is located on the border between crystalline rocks of the Fennoscandian Shield and sedimentary rocks of the East European Platform. The lake depression was covered with glacial streams or proglacial lakes during the Pleistocene Scandinavian glaciations [7].

Currently there are several models of the Lake development in the Late Pleistocene and the Holocene [8; 9; 10; 11; 1]. These models give various estimation of glacioisostatic uplift of the lake shores, lake dimensions and water levels. A contemporary model of I. Demidov [1; 10] was accepted as a basic model of the lake depression deglaciation. It includes six main stages of the lake depression development in the Late Pleistocene.

Geologist E. Deviatova in collaboration with archeologists V. Filatova, N. Lobanova, U. Savateev and A. Shuravlev [2; 12; 13; 14] carried out extensive paleogeography studies of Lake Onego shoreline position in the Holocene period. The general evolution patterns of lake, relief, vegetation and climate with their connection with human settling activities were considered. The studies were conducted on several key locations where well-known archeological sites were densely situated.

Glacioisostatic uplift data, published by I. Demidov [1; 11] and E. Deviatova [2; 12; 14] were assimilated to develop the model of Lake Onego development in the Holocene and the Late Pleistocene by GIS-software.

II. MATERIALS AND METHODS

The studied area lies in North-West part of Russian Federation and covers 570 km from North to South and 502 km from West to East (Fig.1).

The DEM developed by J. Ferranti [15] with spatial resolution three arc seconds was used as a source of watershed elevation data. This is the first freeware global elevation model with spatial resolution less than 100 m with coverage of the studied region. It is based on ASTER GDEM, USGS STRM DEM and topographic maps data. The DEM was converted to UTM WGS 84 zone 36N projection (EPSG: 32636), and the same projection was used for other mapping features.

The DEM of lake depression was developed by using GIS *Surfer* software and was based on depth measurements, obtained from navigation charts of Lake Onego and the Svir River [16]. The lake depression DEM was led to sea level (SL) and combined with watershed elevation DEM. Thus, the

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present-day DEM of lake watershed and its depression was obtained.

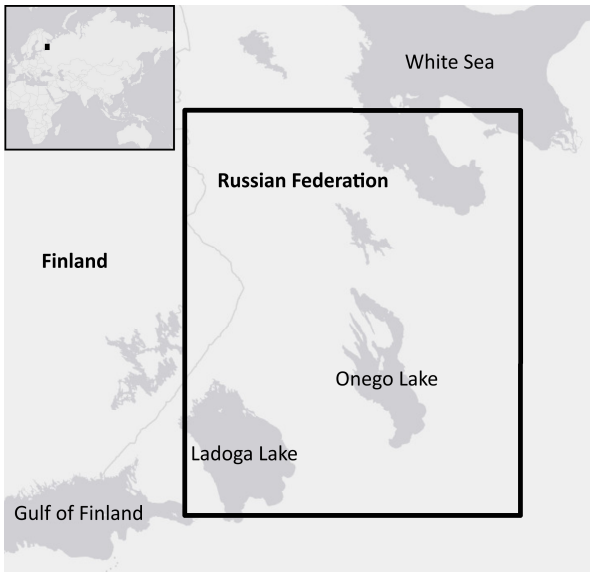

Fig. 1. Studied region location

The Earth's crust was flexed in the studied region because of considerable pressure going out from overlaid glacial shields. Later, when glacial shields were melting the area begun to suffer the compensational glacioisostatic uplift, which increased seismic activity and migration of the lake shoreline position. The highest uplift took place at the North shore of the lake because of considerably stronger glacial shield cover. Thus, the tilt of lake depression was around 30 m per 100 km of length 13 300 yrs BP, 12 300 yrs BP — 26 m, and 11 000 yrs BP it was 18 m [1]. By this reason, the Earth's crust uplift must be taken into account during the shoreline reconstructions.

The glacioisostatic uplift raster was defined to transform the present-day DEM to the paleo-DEM. The glacioisostatic uplift data of [2; 12; 14] and [17] was used for the Holocen period and the data [1; 11] was used for the Late Pleistocene period. The present day water level (33 m SL) was subtracted from glacioisostatic uplift elevation mark (SL) of each data point in relevant period. As a result, the glacioisostatic uplift raster was calculated by means of 3D interpolation with a first order polynomial. The *Surfer* software was used for this purpose. Although the dynamic of Earth's crust galcioisostatic uplift 14 500-12 300 yrs BP was weak, the tilt of depression 13 300 yrs BP was accounted for entire the Late Pleistocene. To take into account the lake level change in other stages in the Late Pleistocene the water level was corrected by its difference between 13 300 yrs BP and the target stage. In the Holocene, glacioisostatic uplift of the Earth's crust had the main influence on the water level variation. Thus, glacioisostatic uplift rasters were calculated for minimum and maximum levels of every target periods.

On the next stage, the glacioisostatic uplift raster was subtracted from present-day DEM (Fig. 2) and the paleolake shoreline was established as a $(33 \pm \Delta h)$ m contour line. Where the Δh value is an average cumulative vertical error, occurred during DEM interpolation, elevation measurements, glacioisostatic uplift determination and raster interpolation. Average DEM error was calculated by using mean-square deviation between DEM values and topographic map elevation marks. Raster interpolation error was estimated as mean-square deviation between elevation marks and interpolated values at the same positions. Other errors were obtained from primary data sources, where they were mentioned. The map algebra and geo referenced calculations were implemented with the *ArcGIS 10.2.2* with *Spatial Analysis* package.

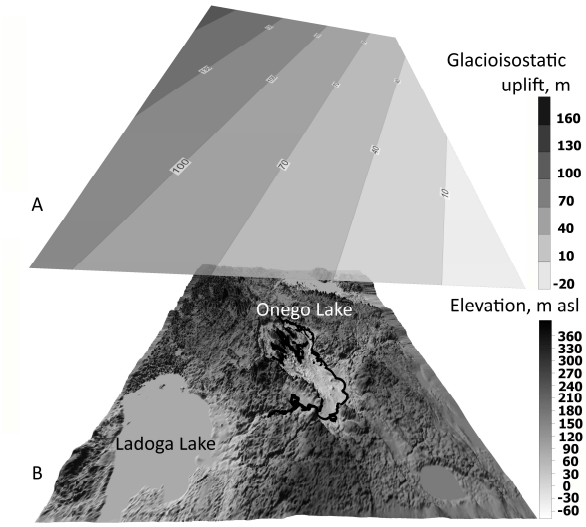

Fig. 2. Glacioisostatic uplift raster (A) and present day DEM (B).

Paleogeographic maps were verified in two ways. The first one was implemented by comparison of maps with hand-drawn images of I. Demidov [1; 7] and E. Deviatova [2; 12; 13; 14]. Shoreline contours and island sizes were compared. The second way of verification was carried out by matching the lake shoreline with a position of archeological sites.

Mutual position of the shoreline for each reconstructed period and archeological sites dated in this period were considered in connection to each other. The proximity of the fresh water sources was required for human settling during the Stone Age and the Early Metal periods with hunting and fishing-based economies. Considering this, we may suppose that archeological sites had to be situated on the shore, not far from the reconstructed shoreline. For this purpose, the data of 130 archeological sites position with carbon dating was used.

III. RESULTS AND DISCUSSION

DEM vertical error

The heights of the developed DEM were observed to be in average 1.65 m lower, than elevation marks of the geodetic control net. The standard deviation was 5.89 m. Confident interval lies in a range from -1.1 to -2.2 m with α=0.05.

Interpolation error

Determination coefficients for polynomials interpolated vary significantly from 0.18 to 0.99, and were 0.76 in average. The lowest coefficients (0.18, 0.34) were observed for the latest climatic period (SA) where values of glacioisistatic uplift were nearly the same as the mean DEM error. In any case, low values of determination coefficients were balanced by consideration of interpolation errors, which were varied from ± 0.7 m for SA up to ± 2.5 m for DR.

Paleogeographycal verification

The paleoreconstructions are available online [3].

Paleogeographic maps were verified by hand-drawn images of I. Demidov and E. Deviatova. Compared with hand drawings of I. Demidov, our maps were detailed considerably and had strict geographic reference. On the contrary, in comparison with E. Deviatova reconstructions, our maps roughed the fine relief forms. The main reason for this was a higher vertical error of DEM used. Even so the common shoreline configuration and dimensions of large islands conforms to sketches and descriptions of E. Deviatova. Considering this, the reconstruction presented a new data about shoreline position on the unstudied area, which covers most part of the lake shoreline.

Archeological verification

Substantially in all the cases, where archeological sites had strict GPS reference and dating, they were situated on the shore or within a range of water level fluctuation. In a few cases, archeological sites were positioned on the lake surface, but not far than 50 m from lowest shoreline. That was due to the horizontal DEM error, because this type of error was not taken into account during vertical error estimation. Horizontal DEM error was assumed as a ½ of DEM mesh size and lies around 45 m [18].

Morphometry of lake

We used the developed paleogeographic maps to calculate the morphometric characteristics of Lake Onego in the Past (Table).

In the 14 500 yrs BP the area of the lake was the smallest, due to considerable glacial shield cover over the lake depression. Later, when the glacial shield melted, the water surface increased up to historical maximum in 13 300 yrs BP (Fig.3). In 13 200 yrs BP the lake acquired a new threshold for runoff to the White Sea basin, and the lake level dropped considerably. At 12 400 yrs BP the ice-dammed lake attained another runoff threshold across the northern part of the Onego-Ladoga water divide and the lake level dropped again.

Table
Surface area of Lake Onego in the Holocene and the Late Pleistocene. Confident interval with α =0.05

Yrs BP (Climatic period)	Area, km^2
14 500 (BL)	2711 ± 64
14 000 (DR_2)	14785 ± 684
13 300 (AL)	32 328 ± 1484
13 200 (AL-DR_3)	24 879 ± 1078
12 400 (DR_3)	22 590 ± 1169
12 300 (DR_3)	21 484 ± 1149
12 300-10 300 (DR_3)	17 728 ± 1040
10 300-9300 (PB)	15 562 ± 1213
9300-8000 BO)	13 018 ± 1231
8000-4700 (AT)	11 195 ± 1157
4700-2500 (SB)	10 634 ± 764
2500-800 (SA)	9598 ± 273

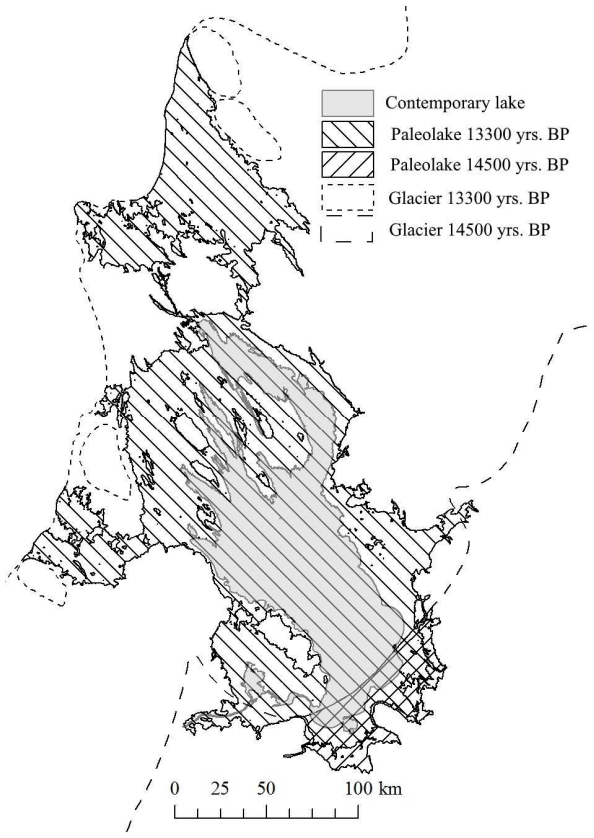

Fig. 3. The smallest and the largest stages of Lake Onego development.

At the end of the Younger Dryas 12 400-12 300 yrs BP, when the drainage pathway via the Svir River to Lake Ladoga was reopened, another regression happened. By that time, the lake had already lost its connection to the glacier, which had retreated westwards. Later the glacioisostatic uplift activities play the main role in lake shoreline formation. The area of the lake surface was reduced during the following climatic periods.

IV. CONCLUSION

GIS-based reconstructions of Lake Onego development in the Holoceneand the Late Pleistocene were presented in the article. Reconstructions were originated from the ideas of the Lake Onego depression deglaciation model proposed by I. Demidov and the data of E. Deviatova concerning Lake Onego depression isostatic uplift in the Holocene. GIS-modeling was performed using *ArcGIS* software on the base of original digital elevation model of the lakebed and its watershed. The reconstructions for all periods were unified, had spatial resolution 90 m and a strict geographic conjunction. Twelve digital paleogeographic maps were developed as a result. The produced maps are available on-line. Paleogeographic maps were verified by using hand-drawing images of I. Demidovand E. Deviatova and by matching lake shoreline with a position of archeological sites.

The Holocene period reconstructions based on I. Demidov data have been found to be more precise than previous hand drawn images. Our reconstructions of the Late Pleistocene period based on data E. Deviatova were likely to rough the fine relief forms. Nevertheless, they have been produced in a global scale for the whole lake surface, which was not conducted earlier.

Based on our reconstructions the area of the lake surface was determined at different stages of its development. The quantitative data obtained in this study is valuable for estimation of the lake volumes and the rates of discharge in the past. Awareness of the lake's shoreline position allows determining areas, where human settling was possible, and increases our chances of discovering new archaeological sites.

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REFERENCES

[1] I. N. Demidov, "On a maximum stage in the evolution of periglacial Lake Onega, variations in its water level and glacioisostatic shore uplift of the shore in the Late Glacial Period" in *Geology and mineral resources of Karelia*, 2006, vol. 9, pp. 171-182 (in Russian).

[2] E. I. Deviatova, *The natural environment and its changes during the Holocene (the northern and central coast of Lake Onega)*. Petrozavodsk, 1986, 108 p (in Russian).

[3] D. Subetto, M. Zobkov , M. Potakhin , A. Tarasov, *Lake Onego Development GIS-reconstruction in the Late-Glacial Period*, January 2017. [Online]. http://www.arcgis.com/apps/MapJournal/index.html?appid=47d76ba2004e463d96eba1d8a1825fe1. [Accessed February 15, 2017], (in Russian).

[4] M. Jakobsson, S. Björck, G. Alm, T. Andrén, G. Lindeberg, N.-O. Svensson, "Reconstructing the Younger Dryas ice dammed lake in the Baltic Basin: bathymetry, area and volume" in *Global and Planetary Change*, 2007, vol. 57, pp. 355-370.

[5] J. Vassiljev, L. Saarse, "Timing of the Baltic Ice Lake in the eastern Baltic" in *Bulletin of the Geological Society of Finland*, 2013, vol. 85, pp. 9-18.

[6] H.-L. Habicht, A. Rosentau, A. Joeleht, A. Heinsalu, A. Kriiska, M. Kohv, T. Hang, R. Aunap, "GIS-based multiproxy coastline reconstruction of the eastern Gulf of Riga, Baltic Sea, during the Stone Age" in *Bores*, 2017, vol. 43(1), pp. 83-99.

[7] *Lake Onego. Atlas* / N. N. Filatov (eds.), Petrozavodsk, 2010, 151 p. (in Russian).

[8] G. S. Biske, G. T. Lak, A. D. Lukashov et al., *Structure and history of the Onega Lake depression.* Petrozavodsk, 1971, 74 p, (in Russian).

[9] D. D. Kvasov, "The origin of Lake Onego depression" in *Paleolimnology of Lake Onego*. Leningrad, 1976, pp. 7-40 (in Russian).

[10] M. Saarnisto, T. Gronlund, I. Ekman, "Lateglacial of Lake Onega — contribution to the history of the eastern Baltic basin" in *Quaternary International*, 1995, vol. 27, pp. 111-120.

[11] I. N. Demidov, "Degradation of the Late Valdai Glaciation in the basin of Lake Onega" in *Geology and mineral resources of Karelia*, 2005, vol. 8, pp. 134-142 (in Russian).

[12] E. I. Deviatova, "Paleogeography of Sheltozero settlements" in *Archeological sites of Onego Lake basin*. Petrozavodsk, 1984, pp. 25-47(in Russian).

[13] E. I. Deviatova, "Paleogeography and human settlement of Karelia" in *Ancient Karelian settlements*. Petrozavodsk, 1988, pp. 7-18 (in Russian)

[14] E. I. Deviatova, N. V. Lobanova, V. F. Filatova, *Paleogeography of Archeological Monuments at Pindushi*. Petrozavodsk, 1987, 60 p. (in Russian).

[15] J. Ferranti, Digital elevation data, January 2017. [Online]. Available: http://www.viewfinderpanoramas.org/. [Accessed February 15, 2017].

[16] *Lake Onego and River Svir. Navigation charts*, Moscow, 1988 (in Russian).

[17] G. A. Elina, A. D. Lukashov, T. K. Yurkovskaya, *Late glacial and Holocene palaeovegetation and palaeogeography of the Eastern Fennoscandia.* Petrozavodsk, 2000, 240 p. (in Russian).

[18] E. Rodriguez, C. S. Morris, J. E. Belz, "A Global Assessment of the SRTM Performance" in *Photogrammetric Engineering and Remote Sensing*, 2006, vol. 72(3), pp. 249-260.

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