Atmosphere monitoring system for practical training of students pursuing degrees in environmental sciences

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Abstract. **Issues related to preservation of the environment are among the most important global problems in the beginning of 21st century. These are central for the planet as a whole and also for each individual country, region and city. Solutions for said problems are discussed on various levels: legislative, judicial, economic and technical. Formation of professional ecological education is an essential task nowadays. In our teaching activities with students in the master's program "Ecology and Environment Preservation" at University of Mining and Geology „St. Ivan Rilski" we strive to ensure the necessary theoretical and practical competences of the future specialists – ecologists. In this paper, we present some major topics of the Atmosphere & Environment Course, as well as the system of practical training of students for field measurements.**

Keywords: ecology, atmospheric aerosol, ecological education, ecological monitoring.

I. Introduction

The task of any educational establishment is producing qualified specialists, taught to think and ready for further self-development. Educational process is a closed system including students, faculty, government organizations and possible future employers. This system should provide the best possible conditions for theoretical and practical training of students.

Issues related to preservation of the environment and mitigation of anthropogenic impact thereon have been especially focal in recent years. Therefore, it is particularly important that the students studying in the "Ecology and Environment Preservation" course receive not only the necessary theoretical basis of knowledge, but also acquire specific practical skills. They will be able to use these skills as specialists in the field of environmental protection.

II. Definitions, tasks and goals of ecology

Ecology – is a science studying the conditions of existence of live organisms and their correlations ad habitats. The term "ecology" (from Greek: oikos – home, logos – science) was first suggested by the German zoologist E. Hekkel.

Modern ecology combines in itself a number of fundamental sciences – biology, chemistry, physics, geography, sociology, geology, etc.

From scientific and practical point of view, ecology is divided into theoretical and applied science. Theoretical ecology deals with study of general order of life organization, and practical (applied) branch – with study of mechanisms causing destruction of biosphere by humans and search of methods for prevention of that process and for rational use of natural resources.

Impact on habitats is felt by organisms via so-called environmental factors, called ecological. Such factors include abiotic, biotic and anthropogenic. We shall discuss anthropogenic factors in more detail.

Anthropogenic factors are triggered by human activity causing impact on the environment (air pollution, water and soil contamination, soil erosion, decimation of forest and animal flora and fauna, etc.)

In view of the specifics of our course, we will discuss in more detail issues related to air pollution by aerosols.

Atmospheric air pollution should be perceived as any change of air composition and/or properties which might lead to negative impacts on human, animal or plant health.

There are two types of air pollution: innate– caused by natural processes (volcanic activity, weathering of rock formations, wind erosion of soils, smoke from wildfires, etc.); and anthropogenic – caused by human activity (power engineering, industry, transport, everyday activities, etc.).

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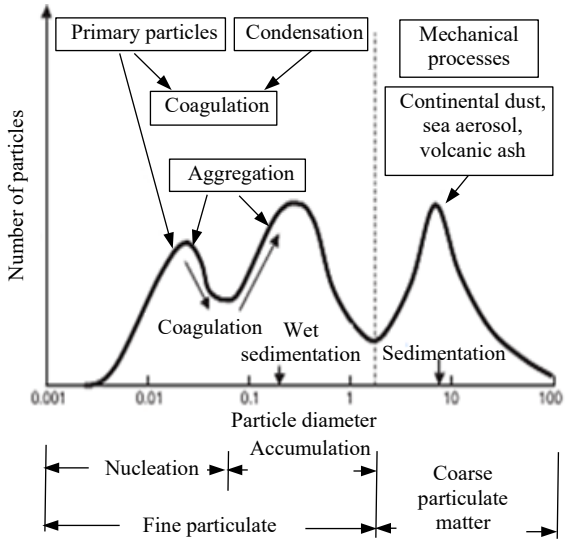

Fig. 1. Transformation processes of particles in atmosphere. Transition from fine particulate matter to coarse dispersed matter [1].

Depending on the scale of propagation these are: local, characterizing propagation of pollution in not very large areas (city, industrial zone, rural region); regional (scale of a country, island, peninsula, continent); global (affect the entire planet). According to the state of matter, harmful substances emitted to the atmosphere include: gas (sulphur, nitrogen and carbon oxides, hydrocarbons, etc.); liquid (acids, alkali, salt solutions, etc.); solid (dust of organic and inorganic origins, sooth, lead and its compounds, resinous substances, etc.)

A. Main characteristics of aerosol in atmosphere

Generally, aerosols are solid or liquid admixtures suspended in gas medium. Such gas medium, in the specific case, is the atmosphere.

Aerosol particle sizes range from few nanometers (new particles created by nucleation) to hundreds of microns (particles emitted from earth surface via wind erosion or from sea and ocean surfaces). Usually, size range includes five modes: nucleation mode – where particles first emerge from gas phase; Aitken mode - named after the Scottish meteorologist John Aitken; accumulation mode - where particle mass becomes bigger via coagulation and/or condensation of particles; coarse dispersed mode – for large particles; super coarse dispersed mode – for overly large particles. Experimental observations usually record up to three modes. Nucleation and Aitken modes are clearly visible on size distribution of aerosol particles (Fig. 1). Size distribution ranges from several nm to approximately 50 nm. Accumulation mode is observed on area distribution of particles.

B. Sources of atmospheric aerosol

Air pollution sources are the places where such pollutants are emitted to the atmosphere. Pollutants are two types – innate (natural) and anthropogenic (resulting from human activity). Table I present values of annual aerosol emissions of various sources. It can be seen that the sum of all aerosol emissions on the planet per annum is approximately 5,5 bill tons.

The main source of atmospheric aerosol is the underlying planet surface. Hence, it can be of continental origins (Fig. 2), sea aerosol, urban, rural, desert, etc.

TABLE I

Annual aerosol emissions	
Source	***Formation rate (10^6 t/yr)***
Natural	
Primary	
Sea salt	3000
Mineral dust	1500
Volcanic dust	300
Wildfires	100
Secondary	
Sulfates	40
Nitrates	30
Hydrocarbons	20
Anthropogenic	
Primary	200
Secondary	300
Total	5490

Main source of air pollution in cities is the automobile transport. Fig. 3 presents percentage content of different fractions in exhaust gases of diesel engines, it is seen that over 40% emissions constitute carbon and its compounds, and over 30% are unused fuel and oils.

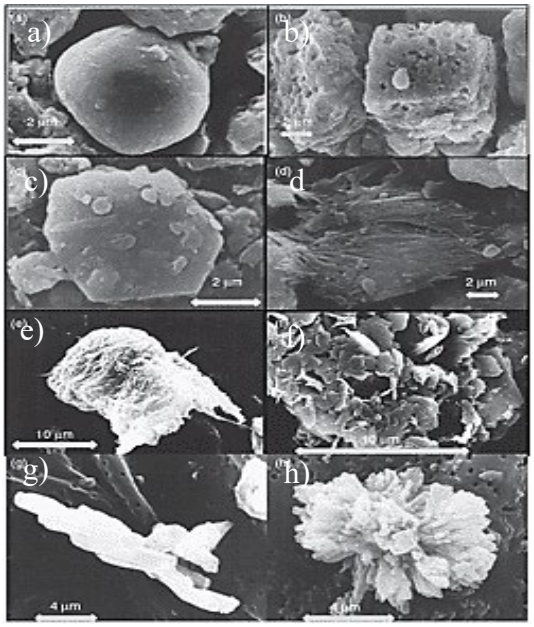

Fig. 2. Photos of particles of continental origins made by scanning electronic microscope: a – quartz; b – dolomite; c – kaolinite; d – paligorskit; e – smectite; f – ellit; g and h – gypsum [2].

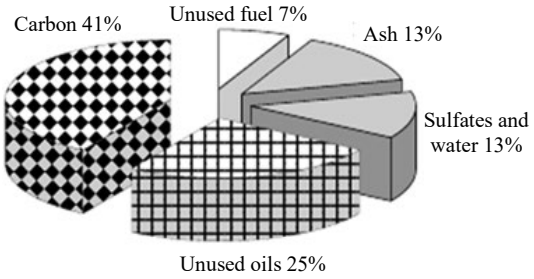

Fig. 3. Share of waste products in exhaust gases of a diesel engine [3].

C. Impact of aerosol admixtures on human health

Aerosol admixtures exert negative effect on human health depending on their concentration and chemical composition [4].

According to the definition of the World Health Organization, health is a positive state defining personality as a whole, e.g. a state of complete physical, metal and social well-being.

Fine particulate matter (FPM) affects mostly human respiratory system. Fig. 4 shows human respiratory system with its sections and the degree of penetration of aerosols of various diameters. The graph shows that the main share of the coarse dispersed matter (ca. 10 µm) is deposited in upper respiratory tract whilst mostly fine particles of diameters ca. 10 nm penetrate deep into the alveolae.

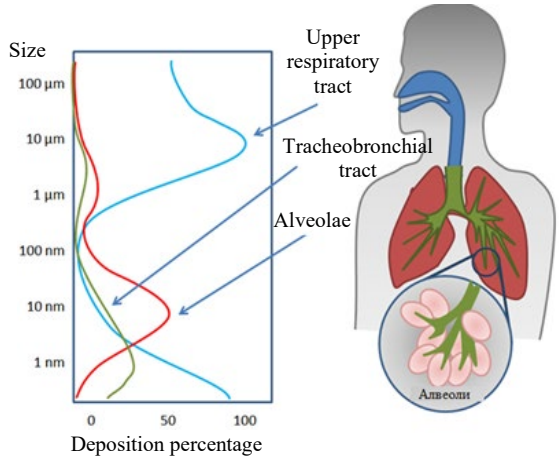

Fig. 4. Deposition percentage of aerosol particles in different sections of respiratory system during inhaling [5].

D. Ecological monitoring

One of the major activities for ecological control is the monitoring of the environment (from Latin „monitor"– observing, reminding) which is a system of observations, assessments and prognosis of state of the environment and the degree of pollution. The main principle of monitoring is continuous observation of the core parameters of the environment.

Advanced technologies make possible creation of efficient systems for ecological monitoring with high precision measurement, quick action, low inertia of sensors and capacity for recording large amounts of data [6].

In addition to scientific and research pursuits, said technologies (equipment and systems) should be used also for practical training of future specialists in the field of ecology. That is why we have developed such ecologic monitoring system and use it during laboratory and field experiments with students pursuing master's degree in "Ecology and Environment Preservation" at UMG „St. Ivan Rilski".

Major instruments in the system are portable laser particle counters PC200 (TROTEC, Germany) and a multifunctional meteorological station PCE-FWS 20-1 (Fig. 5).

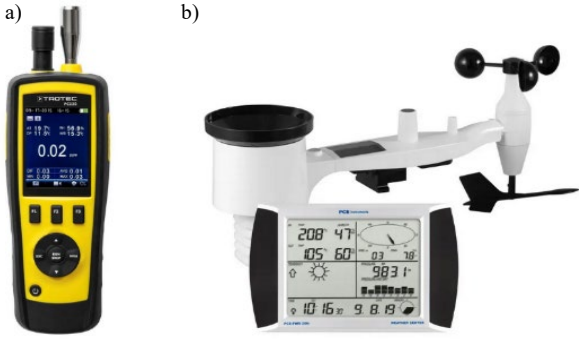

Fig. 5 Six-channel particle counter PC200 (a) and multifunctional meteorological station PCE-FWS 20-1 (b).

We use the multifunctional meteorological station for measuring wind direction and speed (with anemometer), outdoor temperature and relative air humidity (by integral thermos-hygrometer) and precipitation quantity (rain meter). Meteorological parameters are essential factor for the formation, propagation and distribution in space of fine particulate matter. Humidity influences aerosol size (especially of hygroscopic particles), and temperature and wind – generation and dispersion thereof.

There are different types of particle counters, however aerosol particle counters are used for measuring air pollution (both indoors and outdoors). They determine air quality by counting number of particles and measuring their size. The device is equipped with a small vacuum pump which draws in certain volume of air (predefined by the investigator). Particles contained in that volume pass through the ray of high energy light source – laser. Light is dissipated by the particles and registered by a photo detector. The principle of action of the particle counter is shown in Fig. 6.

The counter we use in the laboratory system is designed to work in six channels – recording particles with the following sizes: 0,3; 0,5; 1; 2,5; 5 and 10 µm. All measurements are displayed simultaneously on the device screen. There are visual (color scale) and audio signals when critical levels of FPM concentrations are reached. The device also records large amount of data in its internal memory and up to 16 GB on additional SD card.

Fig. 7 shows specific measurement made by students. Mass concentration of FPM 2,5 μm and wind direction and speed are presented.

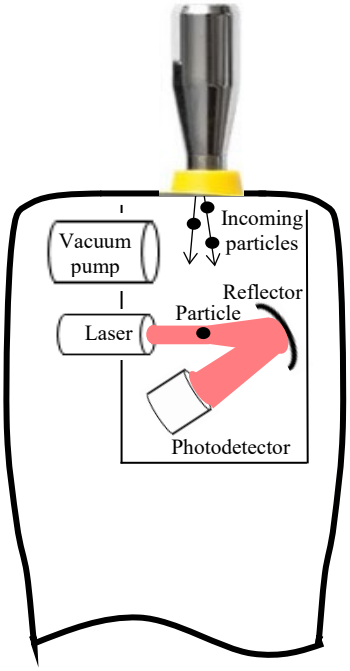

Fig. 6. Counter mode of work

The measurements were carried out in Borisov Garden in Sofia at distances of 0, 20, 50 and 100 m from Tsarigradsko Shosse Blvd. towards park interior. The purpose was to determine impact of park vegetation on the mass concentration of fine particulate matter of different sizes. Measurements were taken every thirty minutes during the first half of the day. Only hours with the highest (9:00 to 10:30) and lowest (12:00) values are shown on the graphs. The students concluded that concentration fell sharply between the boulevard and the 20th meter, and with further distance changes were already insignificant. There was no wind in the beginning of measurements. This and the peak vehicle traffic reflected in higher concentrations at 9:00 h. Later wind gusts 1-3 m/s appeared mostly slantwise from the park to the boulevard and despite intensifying traffic at times, concentrations fell.

This is a small part of the students' practical activity. They carry out similar measurements under different weather conditions for a given season and also during different seasons. The goal is to make the corresponding conclusions about the generation and distribution of atmospheric pollutants according to the relevant conditions.

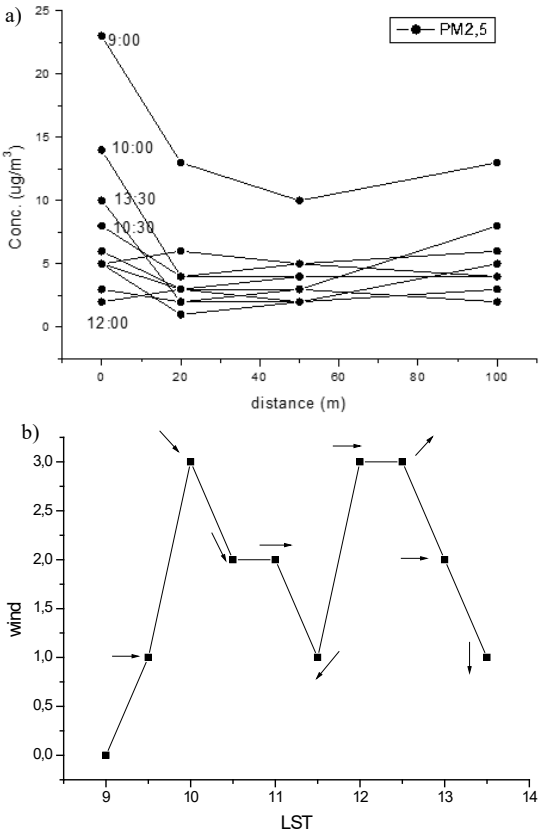

Fig. 7. FPM 2,5 μm mass concentration (a) and wind – direction and speed (according to local summer time (LST)) (b).

III. CONCLUSION

Traditional education is a conservation system that focuses predominantly on theoretical preparation of trainees. Dynamics of contemporary life and the problems it places before us requires introduction of new practices in the process of teaching and learning, to ensure not only theoretical but also good practical development of competences. We believe that an important part of such teaching is presenting to students advanced methods and equipment for work in their chosen field of future professional endeavors.

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