Development of Teaching Methodology in the Field of Environmental Monitoring of Atmosphere

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Abstract The article substantiates the importance of conducting environmental monitoring of the surface layer of the atmosphere using specialized software-modeling systems. Information software is described for the tasks of monitoring and controlling the ecological status of urbanized areas (AISEEM system), which was developed by the authors. The features of the special course for training future specialists in the field of ecology and environmental protection using specialized software and modeling systems are considered.

Keywords Environmental monitoring · Teaching methodology · Atmosphere · Software

1 Introduction

Polluted air intensively affects not only humans and biota, but also the hydrosphere, soil and vegetation cover, the geological environment, buildings, structures and other man-made objects. Therefore, the protection of atmospheric air and the ozone layer

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is a priority environmental problem. This problem is given attention in all developed countries [1], in particular, the issue of air monitoring is important.

Monitoring in the field of atmospheric air protection in the modern sense can be considered as an information-analytical system, which is used for the purpose [2–4]:

- receipt, collection, storage, analysis of information on the state of atmospheric air and factors affecting its quality;
- assessment and analysis of information on the level of air pollution;
- predicting changes in pollution levels and real threats;
- development of scientifically based recommendations for making decisions on the protection of atmospheric air;
- operational information services to users at all levels;
- promoting the development of international cooperation in the field of atmospheric air protection, the rational use of natural resources and environmental safety;
- improving the quality of substantiation of environmental protection measures and the effectiveness of their application.

The priority environmental monitoring tasks of the environmental monitoring of the surface layer of the atmosphere (EMSLA) are considered [5–7]:

- long-term systematic observations of the surface layer of the atmosphere;
- analysis of the ecological state of atmospheric air and forecasting its changes;
- assessment of the levels and degree of danger of pollution to the environment and the life of the population;
- assessment of the composition and volume of emissions of pollutants;
- generalization of data on the level of pollution in a certain territory for a certain period of time;
- information and analytical support for decision-making on the protection of atmospheric air, the rational use of natural resources and environmental safety;
- information services of state authorities, local governments, as well as providing environmental information to the population of the country and international organizations.

The most important task of EMSLA is to provide information to determine strategies and to make decisions on managing the environmental safety of atmospheric air. The solution of this task will allow to determine the amount of damage suffered from pollution of the surface layer of the atmosphere, the level of morbidity of the population, to allow to select areas of promising development, to determine the state of pollution of certain areas of the city and the level of background pollution of the atmosphere [1, 8].

In modern conditions, the purposes of training future specialists in the field of ecology and environmental protection are:

1. the training of highly qualified professional ecologists capable of solving specialized tasks and practical problems in the field of ecology, environmental

protection and environmental management, that involves the application of theories and methods of sciences related to ecology, environmental protection and environmental management, characterized by interdisciplinary [9];
2. training highly qualified and professional ecologists who are able to solve scientific problems and questions to reduce the level of anthropogenic impact on the environment, develop effective environmental protection measures, and also solve practical problems in the field of ecology and environmental protection [10].

Also, the need to prepare future specialists in the field of ecology and environmental protection is the use of information and communication technologies (ICT) to help carry out modeling and forecasting man-made pressures on the environment, and therefore the ability to apply these technologies is important for further professional activity [11]. Considering the fact that ICTs are constantly being improved and new specialized systems are being developed for solving EMSLA tasks, it is important in training students to familiarize them with the latest developments, systems and software, and to develop the skills of future specialists in the field of ecology and environmental protection in further professional activities [12].

2 Main Part

Studies have shown that today the system of EMSLA of Ukraine is ineffective, has significant problems and disadvantages. The air quality monitoring network was established in the 1970s in accordance with the standards of the former USSR. The layout of the monitoring stations (posts) and their quantity, methods of sampling and analysis are implemented in accordance with the provision adopted in the USSR in 1989 [13, 14].

The existing network of stationary observations in modern conditions is no longer optimal for detecting and comparing background, average and maximum levels of air pollution. Such a position of the network of monitoring the state of atmospheric air of Ukraine does not make it possible to effectively solve the problems of EMSLA, and therefore needs to be significantly modernized in many aspects [15, 16].

Also the training of highly qualified specialists in the field of ecology and environmental protection is important to improve the efficiency of the EMSLA system. This, in turn, requires the development of new or improvement of existing programs for the training of such specialists using modern specialized software and modeling systems aimed at developing of practical skills and abilities to solve EMSLA problems. For this purpose, the special course “Methods and means of EMSLA” was developed, consisting of 4 modules:

- “Regulatory and legal support in the field of ecology and environmental protection”;
- “Environmental monitoring of the surface layer of the atmosphere”,
- “Methods and means of solving the problems of EMSLA”;

- "Information systems in the field of ecology and environmental protection".

The purpose of the special course is to train future specialists to develop their knowledge of regulatory support in the field of ecology and environmental protection, in particular, on EMSLA and develop their ability to solve EMSLA problems using special methods and tools, as well as the ability to use specialized software and modeling systems in the field of ecology and environmental protection in further professional activities [17].

The special course consists of lectures and practical classes, provides for consultations and independent extracurricular work of students on the study of additional and scientific literature [18].

There are 60 h for studying the discipline (16 h of lectures, 24 h of practical training, 20 h of independent work).

The main objectives of the special course are:

- to acquaint students with regulatory support in the field of ecology and environmental protection, in particular, about EMSLA;
- to teach to assess the current state of the EMSLA, the main and priority tasks of the EMSLA in different regions of Ukraine;
- to teach how to predict the state of the surface layer of the atmosphere using the methods of mathematical modeling;
- to acquaint students with the basic concepts and methods that are used in assessing the impact of man-made objects on the atmospheric air and to form the ability to use them;
- to form the skills for solving the problems of EMSLA using special methods and means;
- to form the ability to use specialized software and modeling systems in the field of ecology and environmental protection in future professional activities;
- to develop students' thinking and environmental literacy;
- to develop the skills of independent work.

During the *lecture course*, an outline of the main issues of regulatory support in the field of ecology and environmental protection, in particular about EMSLA, is provided.

During the *practical classes*, acquaintance with domestic and foreign modern specialized software-modeling systems is offered. The feasibility of using these systems is due to the fact that they significantly expand the possibilities of solving the problems of atmospheric air quality management.

To date, for solving the problems of EMPSA, domestic and foreign information-based software-modeling systems are used, for examples: the EOL-2000 environmental monitoring system [h], "Air" system, the ARM ECO, EkoGIS-Kiev, Ecotrans, EcoStat, "ERA-Air", "EPK ROSA", UPRZA "Ekolog", "Magistral-city 2.3", "GIS-Atmosphere", ZONE complex of operational analysis of the dosimetric situation KADO, "RADExpert", RODOS (European system), RECASS and NOSTRADAMUS (Russia), ARGOS (Denmark, Sweden), JSPEEDI (Japan), NARAC, MEPAS (USA), etc.

An important practical aspect in this course is the use by future specialists, developed by the authors, an information and software for the tasks of monitoring and controlling the ecological state of urbanized territories (AISEEM system), including a block of statistical analysis and preliminary assessment of technogenic loads on atmospheric air; block of mathematical modeling and forecasting of atmospheric pollution levels and risks for the population; block visualization and construction of environmental maps.

In Fig. 1 examples of the operation of some developed software modules of the AISEEM system are shown.

To date, information and software has been developed and implemented at the Office of Information and Analytical Support of the Ministry of Emergencies of Ukraine, the All-Ukrainian Research Institute of Civil Protection of the Population and Territories from Technological and Natural Emergencies, the State City Enterprise "Ivano-Frankivskteplokommunenergo", the Dnipropetrovsk Regional Center for Hydrometeorology, Department of the organization of civil protection measures of the State Emergency Service of Ukraine, a separate unit "Scientific and technical center" of the state enterprise "NAEC" "Energoatom".

Consider the main modules of the developed special course "Methods and means EMSLA".

The first module "Regulatory support in the field of ecology and environmental protection" envisages consideration of the following regulatory legal acts: Law of Ukraine "On Atmospheric Air Protection" (2007), Resolution of the Cabinet of Ministers of Ukraine "On Approval of the State Target Ecological Program for Environmental Monitoring natural environment" (2007), Directive No. 2008/50/EU of the European Parliament and of the Council "About atmospheric air quality and clean air for Europe", CORINAIR Inventory of atmospheric emissions in Europe; IPPC EMEP/EEA emission inventory guidebook 2013, Law of Ukraine "On Environmental Impact Assessment" (2017), National Plan for Reducing Emissions from Large Combustion Plants (2017), Draft Law on Strategic Environmental Assessment (No. 6106 of March 20, 2018), Regional publications of the World Health Organization and the like.

The *second module*, "Environmental monitoring of the atmospheric surface layer," highlights the role of environmental monitoring in environmental safety tasks, examines the theoretical foundations of the EMSLA and the main and priority tasks of the EMSLA in Ukraine. The tasks that need to be implemented to ensure the protection of the air basin of the city as a component of its environmental safety are determined. The methodology of assessing the territory of the city by the degree of air pollution and the direction of research by which monitoring in the field of atmospheric air protection in the modern sense can be implemented as an information-analytical system is considered. The stages of the process of managing atmospheric air quality indicators are distinguished. The main and priority tasks of the EMSLA are considered and it is determined that the most important task of the EMSLA is to provide operational information for determining strategies and making decisions on the prevention of air pollution. The basic requirements for the organization of the EMSLA network,

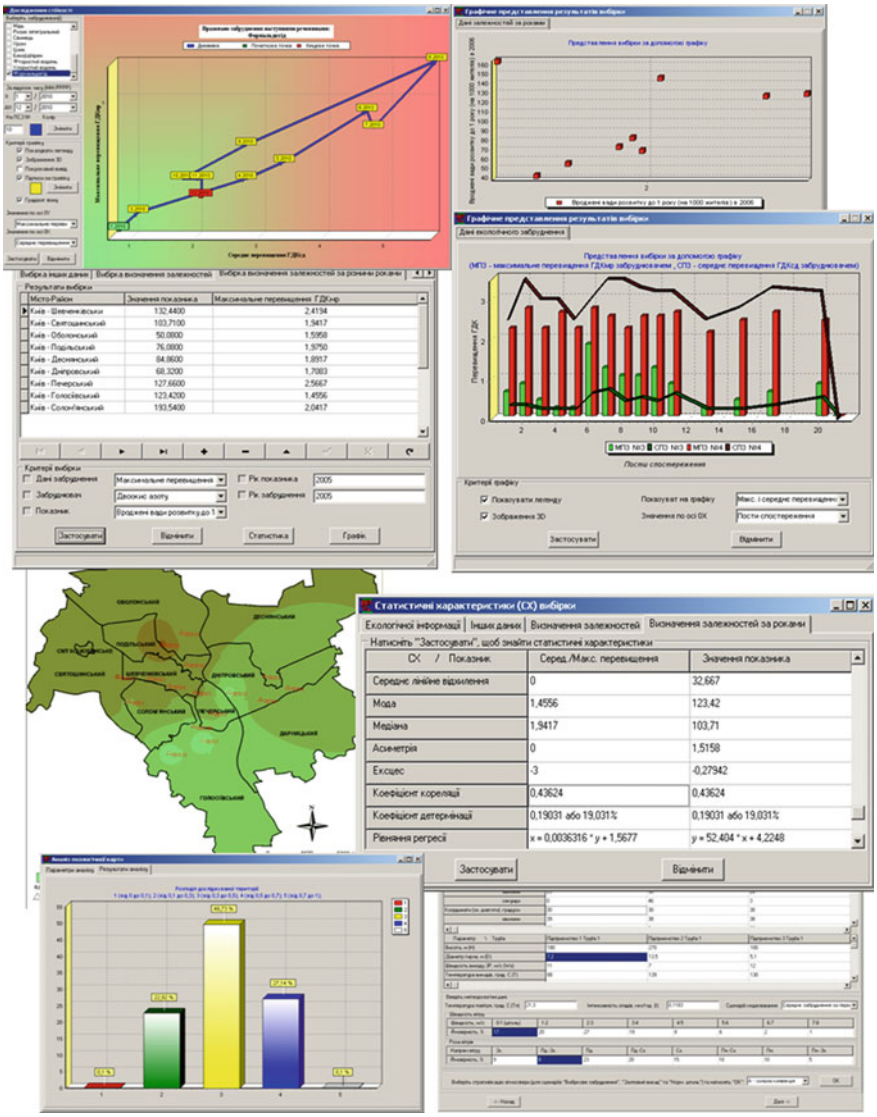

Fig. 1 Examples of some modules of the developed AISEEM system

sources of air pollution and the influence of meteorological factors on air pollution are considered. The current state of EMSLA in Ukraine is analyzed.

The *third module* "Methods and means of solving environmental monitoring problems of the atmospheric surface layer" covers the study of the main methods and tools for solving the problems of the EMSLA. Comparative assessments of the EMSLA capabilities and modeling methods used to solve the basic problems of ensuring

environmental safety of the atmosphere are given. Various approaches to the mathematical modeling of the distribution of impurities in the atmosphere are analyzed, their main advantages and disadvantages are determined. Methods are considered for predicting air pollution, based on the results of theoretical and experimental studies of the laws governing the propagation of impurities from their source. The models for assessing atmospheric air quality indicators (models of atmospheric air pollution and models of dispersion of impurities in the atmosphere) and conditional classification of models of atmospheric air pollution are considered. The concept of risk, domestic and foreign models for assessing environmental risks are considered.

The *fourth module* "Information systems in the field of ecology and environmental protection" describes the characteristics of the most famous domestic and foreign environmental information systems that solve the problems of quickly identifying current changes in the state of atmospheric air, predicting the spread of pollution in space, identifying places of increased concentration of harmful substances in order to make informed administrative decisions on sanitary-hygienic, design-technical and other measures to ensure environmental safety. Modern geographic information systems and the advantages of their use in the tasks of atmospheric air quality management are considered. The advantages of using modern computer-based environmental monitoring systems for air quality management tasks are examined: Government Information and Analytical System for Emergencies, EOL-2000 [h] Environmental Monitoring System, AISEEM Environmental and Energy Monitoring and Information Monitoring System, Air system, AWP ECO, EcoGIS-Kiev, Ecotrans, EcoStat, ERA-Air, EPK ROSA, URZA Ecolog, "Magistral-city 2.3", "GIS-atmosphere", ZONE complex of operational analysis of the dosimetric situation of KADO, geoinformation expert-modeling complex "RADExpert" and others. Systems and software systems using nuclear power plants are considered, namely: RODOS (pan-European system), RECASS and NOSTRADAMUS (Russia), ARGOS (Denmark, Sweden), JSPEEDI (Japan), NARAC and MEPAS (USA). The above described systems and software systems are compared according to certain criteria, and recommendations are given on the selection of these systems for the optimal solution of EMPS problems.

The developed information and software are aimed at solving many scientific and practical problems of the EMSLA. The main ones are [1, 19, 20]:

- collection, storage and processing of environmental monitoring data;
- sampling of environmental monitoring data, their graphic visualization and statistical analysis;
- construction and definition of urgent tasks of the EMSLA;
- determination of distributions of pollutant concentrations under various scenarios;
- calculation of environmental and technological risks;
- justification of the choice of coordinates for the rational placement of observation points of the network for monitoring the state of atmospheric air;
- study of the stability of territorial systems (study of the dynamics of risks during different periods of time);
- determination of the dependence of the effect of pollutants on other factors;

- visualization of various environmental data using graphs, charts, electronic maps, etc.

Review of the content of the main modules of the developed special course "Methods and means of EMSLA" was made in article [21].

Evaluation of students' learning outcomes is proposed to be carried out in the form of a test, as well as intermediate examinations, practical work, oral answers, educational research tasks. The main learning outcomes of the special course "Methods and means of EMSLA" using specialized software-modeling systems are presented in Table 1.

3 Conclusions

The current state of the EMSLA of Ukraine is characterized by significant shortcomings; it does not allow Ukraine to fully fulfill its obligations to international organizations in the field of air protection.

With the technical re-equipment and improvement of the regulatory and methodological support of the EMSLA system of Ukraine, it is important to train highly qualified specialists in the field of ecology and environmental protection. It provides for the passage of various special courses in this area.

The paper proposed the content and technology of training of one of these special courses, which was called "Methods and means of EMSLA".

An important practical aspect in this course is the use by future specialists of information and software for the tasks of monitoring and controlling the ecological state of urbanized territories (AISEEM system), developed by the authors. This will allow them to acquire knowledge and practical skills for solving problems of analysis, modeling, forecasting and visualization of monitoring data on the state of atmospheric air.

As a result of the study and on the basis of own experience of using specialized software-modeling systems for solving the problems of the EMSLA, the following conclusions can be drawn:

- it is important to familiarize students with regulatory support in the field of ecology and environmental protection, in particular, about EMSLA;
- it is important to acquaint students with the basic concepts and methods that are used in assessing the impact of man-made objects on the environment and to form the ability to apply them;
- it is important to teach students how to solve the problems of EMSLA with the use of special methods and means, as well as to develop the ability to use specialized program-modeling systems in the field of ecology and environmental protection in their future professional activities.

Table 1 The main learning outcomes of the special course "Methods and means of Emsla"

Knowledge	Skills	Attainments
Regulatory and legal framework in the field of ecology and environmental protection, basic terms, basic knowledge about the monitoring of atmospheric air	Orientation in regulatory support in the field of ecology and environmental protection	The use of regulatory support in professional activities
Concept and methods used in calculating air pollution	Evaluation of the state of the EMSLA, the main and priority tasks of the EMSLA in various regions of Ukraine	Systematization of the EMSLA tasks on the territory of Ukraine, calculation of air pollution indices
Approaches, methods and models for assessing the state of atmospheric air	Approaches, methods and models for determining the spatial distribution of pollutant concentrations	Classification, advantages and disadvantages of models of atmospheric air pollution and models of dispersion of impurities in the atmosphere
Environmental risks	Environmental risk assessment under man-made conditions	Risk assessment of chronic intoxication and instantaneous effects of toxic effects on the population, individual carcinogenic risk and hazard ratio of exposure of *i*-substance
Information systems EOL-2000 [h], AISEEM, Air, ARM ECO, EkOGIS-Kiev, Ecotrans, EcoStat, ERA-Air, EPK ROSA, UPRZA Ecolog, KADO, RADExpert, ARGOS, NARAC, MEPAS,JSPEEDI etc.	Software systems for modeling and forecasting the spread of pollution in space, identifying areas of elevated concentrations of harmful substances	The use of domestic and foreign information systems for assessing man-made pressures on the environment, skills in computer networks, the use of modern information technologies and software
Knowledge of general principles of modeling and predicting the state of the environment	Forecasting the state of the elements of the environment using mathematical modeling methods	Ability to choose and use methods of mathematical modeling and prediction of the state of the environment
Environmental information processing methods	Methods for processing environmental information, practical skills for obtaining and visualizing information about the current state of various environmental components	Assessment of the state of natural objects by the results of monitoring, collection, integration, processing, analysis and assessment of environmental information using ICT

Directions for further research should focus on the creation of specialized advanced training courses for decision makers in the management of environmental safety of technogenically loaded areas and the substantiation of relevant techniques.

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