MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
National Aviation University

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ENVIRONMENTAL MONITORING

Lecture Course

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UDC
BBC

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Курс «Моніторинг довкілля» знайомить студентів з основами екологічного моніторингу за допомогою лекцій, лабораторних вправ та самостійного вивчення. Досліджуються теми від загальних уявлень про систему, ієрархічні рівні та нормативно-правове забезпечення здійснення моніторингу довкілля до контролю якості компонентів навколишнього середовища.

Для студентів вищих навчальних закладів, що навчаються англійською мовою за освітньо-професійною програмою «Екологія та охорона навколишнього середовища».

Dudar T. V.

Environmental Monitoring: Lecture Course / Compiler
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The course “Environmental Monitoring” introduces students to the basics of monitoring of environmental components through lectures, laboratory exercises, and self-study. Topics ranging from the concept and general ideas about the system, hierarchical levels and regulatory support for environmental monitoring to quality control of the environmental components are explored.

It is intended for students specializing in Ecology and Environmental Protection doing their courses in English.

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PREFACE

When we heal the earth, we heal ourselves

David Orr

This Lecture Course complies with the new syllabus of "Environmental Monitoring" for students specializing in "Ecology and Environmental Protection", and also contains a lot of useful materials for students doing the courses in "Environmental Education", "Natural Resource Management" and many others. This is the author's approach to expound the Environmental Monitoring for the students of the above academic field in the framework of Education in English Program. The author followed the traditional syllabi and basic methodological concepts used in the Ukrainian universities which are still different from the corresponding syllabi widely used in other countries. The first part of the Lecture Course provides theoretical basics of environmental monitoring as a science, hierarchical levels and national regulatory support for the implementation of environmental monitoring.

The second part emphasizes on the quality control of environmental components, basically on the new approach to the issues of air and water quality control. In the frame of courses mentioned above it is highlighted how humans impact and are impacted by worsening the environment quality and how the situation has to be controlled and improved. For example, when discussing the question of air quality control, we note how air quality monitoring posts have to be located, how the data have to be analyzed, presented and assessed. Even contemporary anthropogenic climate change becomes relevant in the course of geology because we discuss the effects of changes in the precipitation regime on landslide pattern. The author hopes that the Lecture Course will be useful for all students studying Environmental Monitoring as a part of Environmental Sciences, as well as for PhD students and young professionals for presenting their research in English.

The lectures course on "Environmental Monitoring" highlights the system approach to methodological basics of the environment conditions comprehensive assessment and the factors influencing them. Monitoring is carried out in order to study and forecast changes in the environment and develop scientifically sound recommendations for management decisions on environmental safety, prevention of accidents and disasters, protection of the population and territories in case of emergencies of natural and man-made origin, preservation of natural components quality, and solving problems of natural resource management.

Part 1
GENERAL IDEAS ABOUT THE SYSTEM, HIERARCHICAL LEVELS AND REGULATORY SUPPORT FOR THE IMPLEMENTATION OF ENVIRONMENTAL MONITORING

1.1. The concept of environmental monitoring and the main stages of its development

The Concept of Environmental Monitoring 4.
Brief history of Environmental Monitoring.

1.1.1. The Concept of Environmental Monitoring

The need to study anthropogenic changes against the background of natural changes has led to the creation of a system of regular observations of changes in the environment.

At the same time, all processes occurring in the atmosphere, surface and groundwater of land, seas and oceans, as well as in geological environment, are also need to be observed and monitored.

Systematic observations in space and time of one or more elements of natural environment for a specific purpose and according to a pre-designed program is called ***"environmental monitoring"*** (hereinafter — EM).

The word "monitoring" comes from the Latin "monitor", which means "monitor (control). The term "monitoring" has entered the scientific community in English-language literature, where its meaning is defined as "control observations".

Monitoring differs from the usual control in that it is not carried out once, but involves the implementation of continuous systematic monitoring for a certain period of time.

In the modern interpretation, the term EM was first introduced at the UN Stockholm Conference on Environment (1972), as a generalizing concept for the definition of systematic observations of one or a group of components of the environment. In Ukraine, the general provisions defining the concept of environmental monitoring are enshrined in law. Environmental monitoring is a comprehensive systematic observation, collection, analysis and assessment of information about the state of the

environment and factors influencing it, forecasting changes and developing scientifically sound recommendations for decisions making on compliance environmental safety, preservation of the natural environment and natural resource management.

From the standpoint of public administration, the EM is a tool for assessing the state of the environment, as well as preparing data for making adequate management decisions and further informing government, public and international organizations.

EM plays an important role in the environmental policy of all countries. It is a source of information for society about the state of the environment and trends in its development.

Depending on the purpose, *routine, crisis and background* monitoring of the environment is carried out.

Routine environmental monitoring (Routine EM) is a continuous observation carried out in a comprehensive network for optimal according to the number and location of monitoring posts for long-term programs. It allows us to make appropriate management decisions on the basis of analysis, assessment, and forecasting of the state of the environment.

Crisis environmental monitoring (Crisis EM) is an intensive observation carried out under special programs to control natural objects and sources of man-made impact, located in areas of environmental tension, in areas of accidents and dangerous natural phenomena, in order to ensure appropriate responding to environmental emergencies, analyzing and assessing risks to the population and the environment, predicting possible negative consequences and making decisions on their elimination.

Background environmental monitoring (Background EM) is a long-term comprehensive study carried out:

• in specially designated nature protection zones (for example, natural and biosphere reserves) in order to study the patterns of their development and assess and forecast changes in the state of ecosystems;

• in areas remote from industrial and economic activity to determine the average (background) level of environmental pollution of certain areas under conditions of anthropogenic pressure;

• for scientific rationale of construction and reconstruction projects and optimization of their functioning.

1.1.2. Brief History of Environmental Monitoring

In the world history of environmental monitoring, viewed from the standpoint of accumulation of knowledge about the processes and phenomena occurring on the Earth planet and in some regions, as well as the formation of a system of observations of these processes at the interstate level, there can be considered five basic periods:

1 — ancient times;

2 — the first half of the first millennium (AD);

3 — the second half of the first millennium AD to the XVI century;

4 — from the XVI century to the beginning of the XIX century;

5 — from the beginning of the XIX century up to date.

The history of observations dates back to ancient times, when vague notions of climate change and global floods first arose. The first examples of observations about natural environment are known from the history of ancient civilizations, which arose and developed several millennia BC within the territories that usually occupied the fertile valleys of large rivers: the Nile — in North Africa; Tigris and Euphrates — in Mesopotamia; Indus and Ganges — in India; Yellow River — in China; Amu Darya, Syr Darya, Murgabu — in Central Asia.

Legends and descriptions that have come down to our times, as well as archaeological research, highlight the amazing data about the outstanding hydraulic structures (canals and dams), created on the basis of observations to combat floods and to provide favorable conditions for agriculture by irrigation lands in dry periods.

Take, for example, the inhabitants of the Nile Valley. The perfect knowledge of the ancient Egyptians, who lived in the III–IV millennium BC, is still surprising. By mastering this river, the Egyptians reached a high level of hydraulic engineering. They were able to build a complex network of irrigation canals and ensure their proper operation. The construction of the first flood defenses on the Nile is associated with the name of Pharaoh Menes (IV millennium BC). During his reign, large-scale irrigation systems were established to protect water resources — protect the valley from excess water in the event of high floods and irrigate land at low water levels. Trying to explain the causes of the Nile floods, it was the ancient Egyptians who created the first monitoring network – a series of devices for monitoring the high levels of the Nile River (the famous “Nilometers”). These devices do not differ in

principle from modern rail water meter posts, which are widely used for hydrological monitoring around the world. A number of observations preserved on these nilometers cover a period of more than 1,400 years. These data are an invaluable contribution to the science of pre-environmental monitoring.

Further data on the observations development can be found in the works of the eminent ancient historian Herodotus and the eminent physician of the time Hippocrates (V century BC). Herodotus chose Egypt as the place of his observations. Repetitive Nile floods have prompted the eminent naturalist to study climate, geology, and geophysics. These studies, along with hypothetical judgments, also include some ideas that are still unquestionable.

From ancient times the dependence between living organisms and human life on the processes that take place in the environment were noticed. Sophocles (496–405 BC) noted the possibility of the transition of diseases from field crops to animals and uterine infants. It was described in his famous work "King Oedipus".

From the testimony of the Greek historian Thucydides (born about 460 BC) there is evidence of volcanic activity in the Aeolian Islands in 427 BC. The flooding of the islands of Euboea, Orobia and Atalanta, soil fluctuations and the destruction of some buildings in Athens, the intensification of epidemic diseases during this period were connected with theses nature phenomena.

From the second half of the first millennium AD until the sixteenth century there was a decline in all natural sciences on the European continent. This was the period of scholasticism — the era of religious-idealist philosophy of the feudal system, when science recognized only church dogmas and was a "servant of the church" and the ruling elite.

In the history of geographical science and geology of the seventeenth century became a transitional era to new research and discoveries — a period when scientific thought freed itself from the influences of insufficient knowledge of antiquity and scholastic ideas of the Middle Ages. During this time, numerous observations of natural phenomena intensified, which marked the beginning of the establishment of the laws of geophysics and meteorology and their mathematical generalization.

In the middle of the XVII century by decree of Tsar Alexei Mikhailovich daily visual observations of the weather, much of which

survived to our time, began. Researchers of that time surveyed and described the vast expanses of Siberia and the Far East up to Sakhalin, the Kuril Islands and the Bering Strait. The world received a lot of generalized geographical data not only on the general characteristics of Siberia and the Far East, but also on meteorological conditions in these harsh areas, hydrological and ice regimes of Siberian rivers, Arctic seas, climate in different regions of Russia and its impact on human life.

Archaeological research by academician B. Rybakov showed that the ancient Slavic tribes inhabited the Middle Dnieper and Bug rivers, had an idea of weather and climate change, the impact of natural disasters on crops, took measures to protect their housing from lightning strikes, etc. When in the early ninth century the ancient state of Kievan Rus was formed, the Slavs, thanks to numerous military campaigns in Byzantium, became acquainted with the natural features of the Black Sea, the Balkans, the conditions of navigation in the Black and Azov Seas. An analysis of the chronicles shows that the information about extreme natural phenomena was usually based on the observations of either the chronicler himself or obtained from people who visited other lands. And what is especially important, in the summer letters recorded not only the year but also the exact date, day and month of the event. A comparison of the exact dates of such events recorded in the Kyiv Chronicles highlighted the course of climate change in Eastern Europe.

At the beginning of the XIX century there were many proposals for the creation of a service for regular hydrometeorological observations. In 1873 the International Meteorological Committee was established at the Vienna Meteorological Congress. In 1879 Heinrich von Wild was elected as a president of the International Meteorological Committee, which he headed for 17 years, at the First International Congress in Riga. In 1884, Academician M. Rykachev developed a special program for the organization of meteorological observations. The provisions of this program regulated the actions of station operators who were to monitor and test devices compared to devices of the Geophysical Observatory (the Meteorological Center of that tine). The unification of meteorological networks and further development of meteorological observations service, the service of weather forecasts, and the development of climate research are connected with the name of M. Rykachev. It was he who laid the foundations of the aerological service, which was developed only after almost forty years.

According to archival data, the first instrumental meteorological observations on the territory of Ukraine started in Kyiv in 1771. The Unified National Meteorological Service of Ukraine (Ukrmet) was established by the Decree of the Council of People's Commissars of Ukraine on November 19, 1921.

After gaining independence, in 1991, the State Committee of Ukraine for Hydrometeorology was established. Since 1992 under the auspices of the National Academy of Sciences and the Ministry of Ecology and Natural Resources the development and implementation of a unified national system of environmental monitoring "Ukraine" began. The legal basis of this system was the Law of Ukraine "On Environmental Protection", adopted in 1991 (Article 22). In 1993, the Cabinet of Ministers of Ukraine approved the "Regulations on National Environmental Monitoring".

The Hydrometeorological Service of Ukraine provides public authorities and administrations of all levels, local governments, enterprises, institutions, organizations of all sectors and the population with information on the state and projected changes in natural conditions, annual and long-term meteorological, agrometeorological, hydrological river and sea forecasts, and warnings about dangerous and natural hydrometeorological phenomena and processes. Each year the organizations of the Hydrometeorological Service of Ukraine compile and deliver to consumers about 275 thousand forecasts and warnings. Personnel potential of Hydrometeorological Service Ukraine has about 5.5 thousand highly qualified specialists who provide solutions to the mentioned above issues.

Terminology to chapter 1.1:
environmental monitoring — моніторинг довкілля;
regular observations — регулярні спостереження;
state of the environment — стан довкілля;
risk assessment — оцінка ризику;
routine monitoring — загальний моніторинг;
crisis monitoring — кризовий моніторинг;
background monitoring — фоновий моніторинг;
monitoring post — пост спостережень (*за станом довкілля*);
monitoring network — мережа спостережень (*за станом довкілля*).

Answer the questions

1. What is environmental monitoring the study of?
2. What do we call routine monitoring?
3. What do we call crisis monitoring?
4. What do we call background monitoring?
5. What are the basic periods of EM development?
6. What is a Nilometer?
7. What is considered as a beginning of the EM in Ukraine?
8. When was the Law of Ukraine "On Environmental Protection adopted"?
9. What is the Hydrometeorological Service of Ukraine about?
10. What data does the Hydrometeorological Service of Ukraine provide?

1.2. Environmental Observations Management

> Sources and factors of anthropogenic impact on the environment from aviation industries.
> Monitoring as a system of observation of anthropogenic factors impact on the environment.

1.2.1. Sources and factors of anthropogenic impact on the environment from aviation industries

Let us consider the sources and factors of anthropogenic impact on the example of aviation transport. The composition of environmental pollution in air transport processes is extremely diverse. The main sources of environmental pollution among aviation industries are airports and the equipment connected with them.

Ground sources of pollution can be divided into those located inside the airport (or aircraft repair plant), and those located outside the airport (or aircraft repair plant). The latter include, first of all, thermal power plants that run on different types of local fuel, so the nature of pollution is determined by the type of fuel, methods of combustion and ways to dispose of emissions.

The main harmful substances contained in the flue gases of thermal power plants include *sulfur dioxide SO_2, carbon monoxide CO, nitrogen oxides NO_x, solid carbon particles (soot)*.

Vapors of oil products, solvents, paints, alkalis, acids, aerosols of aqueous solutions of caustic, carbonate and phosphate sodium, sulfur

dioxide, nitrogen oxides, carbon monoxide enter the air from the production facilities of the airport or aircraft plant.

Warehouses for fuels and lubricants pollute the air at the airport with aviation fuel, lubricants and special fluids.

The vapors of aviation fuel enter the atmosphere: when they are pushed out of tanks in the process of filling them with fuel, in the process of "low respiration" of tanks, as well as evaporation of spilled fuel through leaks etc.

The environment is significantly affected by aviation ground equipment, which includes special technical ground equipment for aircraft maintenance, air transportation and maintenance of airfields. Special vehicles pollute the air mainly with carbon oxides *CO, C_xH_y hydrocarbons, nitrogen oxides NO_x*.

The production activities of aviation industries cause pollution of soils and water bodies with industrial and domestic wastewater containing various mechanical, physical and chemical impurities.

Soil pollution also occurs due to the deposition of pollutants from the air basin on the soil surface, which enters the atmosphere with the exhaust gases of aircraft, ground aircraft and boiler houses.

Sources of industrial wastewater at airports are aircraft maintenance facilities (aviation technical bases, ancillary production, etc.), as well as buildings of ancillary facilities (warehouses, technical depots, fire depots, boilers, etc.).

The wastewater from the production sites of airports contains *benzene, acetone, petroleum products, acids, alkalis, various dissolved compounds of metals — aluminum, copper, beryllium, chromium,* etc., as well as other pollutants.

Surface runoff from airports is characterized by the presence of mineral suspensions, petroleum products, dissolved organic mixtures and substances containing nitrogen.

Oil and oil products cause special damage to water reservoirs. Oil pollution of wastewater causes various and profound changes in the composition of aquatic biocenoses and even in the entire fauna and flora of water bodies.

This is due to the physical and chemical properties of oil itself, which is extremely diverse in composition and can release into the water different substances.

1.2.2. Monitoring as a system of observation of anthropogenic factors impact on the environment

At the present stage of human development, the protection and management of the environment is an urgent problem required knowledge and combined efforts of many educational subjects (ecology, biology, physics, chemistry, mathematics, computer science, metrology, hydrology, climatology, soil science, etc.), a range of scientific, methodological and practical approaches. Environmental monitoring (EM) as a branch of environmental science is also based on general environmental Environmental Monitoring laws and interacts with natural, geological, geographical and technical sciences (Fig. 1.1)

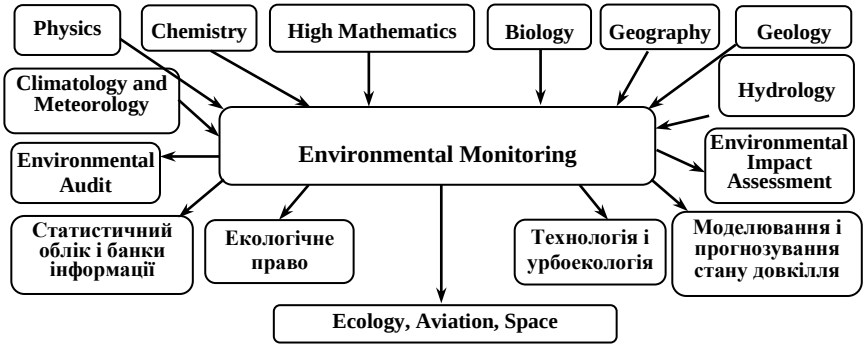


Fig. 1.1. Relationship of the subject "Environmental Monitoring" with other subjects from the Bachelor Curriculum

The main principles of environmental monitoring are *complexity* (provides a coordinated program of different activities), *synchronicity* of all observation systems, *consistency of observation* of both — the state of the environment and man-made effects, as well as *consistency of terms* of carrying out observations with typical hydrometeorological situations.

The *object of environmental monitoring* research is considered multicomponent complex natural and anthropogenic dynamic systems of different levels (global, regional, local) and their individual components that function in time and space.

Methods of observations and methodological support for their implementation, mathematical models and forecasting and modeling systems, regulatory framework and organizational mechanisms for the

creation and operation of monitoring systems can be considered as *the subject of environmental monitoring* research.

The environmental monitoring management is an extremely complex multifaceted task. “The subsystems observation” (control), “assessment of the actual situation”, “forecast” and “management” can be considered as separate components of the monitoring system. *Control* is a set of observations (data acquisition), which allows us to assess the actual state of the environment at the time of observations. *Forecast* is a scientifically sound prediction of the emergence and development of processes that can change the state of the environment. *Management* is a set of measures that help eliminate or reduce negative impacts on the environment.

Terminology to chapter 1.2:
aviation industry — авіапідприємства;
atmosphere — атмосфера;
biosphere — біосфера;
water bodies — водні об’єкти;
pollution — забруднення;
object of environmental monitoring — об’єкт моніторингу;
subject of environmental monitoring — предмет моніторингу.

Answer the questions

1. *Name the sources of environmental pollution in aviation industry.*
2. *What are the atmosphere pollution?*
3. *What are the sources of ground and water bodies pollution?*
4. *What is the relationship of environmental monitoring with other subjects?*
5. *What is the object of environmental monitoring research?*
6. *What is the subject of environmental monitoring research?*

1.3. Monitoring as a system for assessing and forecasting the future state of the environment

Environmental monitoring uses a variety of methods to obtain *primary and secondary* information. To obtain primary information, *direct observations* are used at appropriate monitoring stations, posts, sampling points etc. (stationary, mobile, remote ones). Secondary information is accumulated during the *processing of data* obtained as a result of primary information. Geographic information systems (GIS)

have been developed and are in operation to process and generalize computer databases, combined with certain analytical tools for working with spatial information. The obtained data give an idea of the state of the environment and the main processes that take place in it, as of the current time. These data make it possible to predict the development of the environment, predict critical situations of natural and man-made nature in the future and take measures to avoid them.

Atmospheric air monitoring is performed by stationary and mobile observation posts. Monitoring of water bodies and soils is carried out in stationary and mobile laboratories. The state of water and soil is also monitored by biological and radiometric methods. Based on the monitoring results, recommendations for reducing the level of environmental pollution and a forecast for the future are developed.

Reliable methods of analysis are needed to obtain *objective information* about the state and pollution of various objects in the environment (air, water, soil, etc.). The effectiveness of any method is assessed by a set of indicators such as selectivity and accuracy of determination, reproducibility of the results, sensitivity of determination, the limits of detection of the element and the expressiveness of the analysis. In addition, the methods should provide analysis in a wide range of concentrations of elements (including trace). This should be taken into account when choosing monitoring methods and means (Table 1.1).

To carry out environmental monitoring, it is necessary to select the most characteristic species in the ecosystem and its features, to study the nature of responses of biosphere elements to anthropogenic impact through *field and laboratory experiments, mathematical modeling and analysis of field observations*. Field observations make it possible to identify the main trends in ecosystem change under the influence of anthropogenic factors, to find relationships between different factors of action and biological reactions.

Experimental studies are conducted by studying and analyzing the combination of the effects of various anthropogenic factors on complex biological systems. With the help of such an experiment it is possible to simulate real situations with a changed state of the environment, which are possible in the future, to identify individual factors that cause different changes, such as, for example, eutrophication of water bodies due to nitrogen and phosphorus compounds.

Table 1.1

Stages of environmental monitoring

№	Stage	Type of works	Technology	Content
1	Primary monitoring	System of primary environmental observations. Information and analytical monitoring. Certification of objects of potentially hazardous objects	Current control system (including in real-time) of the most important indicators of the environment state in manual semi-automatic and automatic modes. Automated transmission of primary information. Computer databases processing of problem-oriented information and its analysis	System of observations, collection and transmission of primary information. Obtaining and accumulating structured primary information. Replenishment of integrated databases. Analysis of operational and all available information on the current state of the environment
2	Predictive Monitoring	Modeling and forecasting of environmental condition. Specialized field research	Methods of mathematical modeling and forecasting of changes in environment state in time and space. Technical and technological measures to prevent emergencies and reduce losses	Assessing the environment state, forecasting its changes, and determining the sustainability of geoecosystems. Recommendations for decision-making on prevention of negative changes in the environment state, and compliance with environmental safety requirements

End table 1.1

№	Stage	Type of works	Technology	Content
2	Predictive Monitoring	Modeling and forecasting of environmental condition. Specialized field research	Models and forecasts of risks and consequences of emergencies. GIS technologies for creating a comprehensive parametric model of geoecological processes	Modeling and forecasting the consequences of emergencies on pollution of different natural environments and different levels of environmental hazards. Creation of a permanent model of the territory for environmental safety management
3	Socio-Economic Environmental Monitoring	Application of mixed models of risk assessment for the population residence taking into account environmental and medical data. Implementing measures to reduce the impact hazardous factors and monitor their effectiveness	Analysis and forecasting system for managing the development of socio-economic and environmental processes at the local and regional levels. Strategy of environmentally safe development of the territories economic activity within zones of influence of potentially hazardous objects taking into account indicators of health of the population and a condition of biosphere	Information and analytical complex of modeling and forecasting and multifactor socio-environmental and economic models of the system "potentially hazardous object of the region – environment" Creation of permanent model of the territory for optimization of environmental and economic situation, reduction of environmental risk for the population residence and management of social and environmental safety

Mathematical modeling allows to establish the relationship between the action of factors and the reaction of biota in complex ecosystems, as well as to investigate the sensitivity of the ecosystem to a factor, to predict the future state of the ecosystem.

The *environmental monitoring entities* in different countries are *Ministries and Agencies*, which are entrusted by state regulations with the implementation of functions for monitoring environmental objects.

The process of observation, evaluation and using the information obtained as a result of monitoring should be considered as *a sequence of interrelated actions* — from the identification of information needs to the application of the information product.

Consistent implementation of the *entire monitoring cycle* should be determined and planned taking into account the information needs and specifics of the current environmental situation under consideration.

Financing of works on the implementation of environmental monitoring is carried out in accordance with the procedure for financing of natural protective measures at the expense of funds provided in the national and local budgets of countries in accordance with the National Laws.

Reimbursement of a certain part of the costs of creating, improving and ensuring the functioning of the components of the monitoring system may be provided by innovation funds within the funds provided for environmental measures, funds of international organizations involved in international environmental programs, international grants, and other sources of funding.

Monitoring the impact of destabilizing factors for the environment requires the coordinated efforts of different *monitoring entities*, both within a single country and within neighboring countries. The main purpose of such environmental monitoring is to identify extreme values of parameters for each environment component to determine the load limit. This is the only purpose of determining the impact of technogenesis on changes in environmental conditions, which involves the development of a general strategy for assessing the status, control, protection and management of the environment in general. The *monitoring system* is the only way to minimize various miscalculations in the management of processes that take place in the environment, which lead to both irreversible processes in it and to economic damage, dangerous effects on ecosystems and health.

Terminology to chapter 1.3:
risk assessment — оцінка ризику;
predictive monitoring — прогнозний моніторинг;
sequence of interrelated actions — послідовність;
взаємопов'язаних дій;
entire monitoring cycle — повний цикл моніторингу;
impact on the environment — вплив на навколишнє середовище;
direct observations — безпосередні спостереження;
data processing — обробка даних;
monitoring entities — суб'єкти моніторингу.

Answer the questions

1. What is it meant under primary environmental monitoring?
2. What is it meant under secondary environmental monitoring?
3. What are the stages of environmental monitoring?
4. What methods are used to carry out predictive monitoring?
5. What is the potentially hazardous object? Give an example.
6. What are the ways of monitoring financing?

1.4. Classification of Environmental Monitoring Types

Environmental Monitoring Classification by Yu. Israel.
Environmental Monitoring Classification by Scale of Impact.
Other Environmental Monitoring Types.

1.4.1. Environmental Monitoring Classification by Yu. Israel

Depending on the environmental monitoring objectives and tasks, methods of observation and available equipment for their implementation, there are different types of environmental monitoring classification created by various authors. Each classification has its own specific features depending on the principles chosen by the author of its construction.

Classification of environmental monitoring depending on the principle approach was proposed by environmental monitoring founder in the former USSR Yu. Israel (Table 1.2).

Table 1.2

Classification of environmental monitoring by Yu. Israel

Classification Approach	Monitoring Type
Universal Systems	Global monitoring, including background and paleomonitoring. National monitoring. International (e.g. monitoring of trans boundary air pollution)
Approach on Biosphere Components	Geophysical monitoring. Biological monitoring, including genetic one, etc.
Approach on Different Environment	Monitoring of anthropogenic impacts (including pollution and reaction on it) in the atmosphere, hydrosphere, pedosphere, cryosphere, biota.
Factors and Sources of Impact	Monitoring of pollution sources. Ingredient monitoring (for example, certain pollutants, radioactive substances, noise)
Severity and Globality of the Problem	Ocean Monitoring. Monitoring of Ozonosphere
Methods of Observation	Monitoring of physical, chemical and biological indicators. Satellite-based monitoring (remote methods)
System Approach	Medico-biological (health) monitoring. Climate monitoring. Options: bioecological, geoecological, biosphere monitoring, etc.

The classification by observation methods is ancillary and indicates the available opportunities for observation rather than the specified nature of monitoring. There are observations on chemical, physical and biological indicators, for example, for water bodies — on hydrogeological indicators. Monitoring of chemical parameters is sometimes called chemical monitoring.

During the monitoring, there may be special interests that go beyond those described above. A special place is occupied by background monitoring, the purpose of which is to obtain a standard of the environment state and its changes under conditions of minimal anthropogenic impact. Background monitoring data are needed to analyze the results of all types of monitoring.

1.4.2. Environmental Monitoring Classification by Scale of Impact

The classification by scale of impact is illustrated by Fig. 1.2. The lower hierarchical level is the level of detailed environmental monitoring, implemented within the territories of individual enterprises, factories, economic complexes, deposits, etc. This level is also called object monitoring (*об'єктовий моніторинг*). Detailed (object) environmental monitoring systems are the most important link in higher-level systems. Combining them into a larger network (for example, within a city, district) forms a local-level monitoring system (Fig. 1.2).

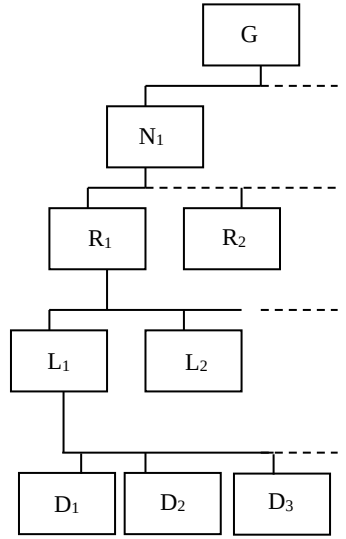
Monitoring level	Structural Scheme	Notes
Global		Intergovernmental EM system
National		National EM system
Regional		Oblast EM system
Local		City, district EM system
Detail (object)		EM of plant, industrial enterprise or ore deposit

Fig. 1.2. Block diagram and ratio of environmental monitoring systems of different levels (according to V. Korolev, 1995)

Local systems, in turn, are grouped into larger ones — regional environmental monitoring systems that cover the territory of a region, oblast or several oblasts. Regional monitoring is designed to assess the changes in areas of integrated anthropogenic development.

Regional environmental monitoring systems are integrated within one state into a single national monitoring network and form the national level of the monitoring system. National level of environmental monitoring systems are a necessary prerequisite for compliance with environmental legislation, systematic control over the state of all components of the environment, ensuring efficient and environmentally friendly engineering and economic activities.

The national concept of monitoring is being developed by creating a single national integrated environmental monitoring system, working on a single methodological unified approach, rather than simply summarizing the different monitoring systems of its individual components – groundwater, soil, rocks and more.

National networks of EM form an intergovernmental monitoring system — a higher, global level of EM system.

As regions of interests for monitoring research can be considered:

– individual locations and zones, the sizes of which do not exceed tens of kilometers (local monitoring);

– local sources of potential hazard, such as areas near radioactive waste disposal sites, chemical plants (impact monitoring);

– areas up to thousands of square kilometers (regional monitoring);

– global processes and phenomena in the Earth's biosphere and ecosphere (global monitoring).

1.4.3. Other Environmental Monitoring Types

Monitoring aimed at identifying past changes in the environment is called historical or *paleomonitoring*. Some features (annual tree rings, annual layers in glaciers, etc.) are studied in case of paleomonitoring. It is possible to reproduce the conditions of the past in which these features were formed.

Bioecological monitoring provides monitoring of the environmental in terms of its impact on human health, as the ultimate goal of monitoring is to protect people from adverse factors. In addition, human health is the most complex indicator of the environmental state. The main objective of bioecological monitoring is the scientific substantiation of the connection between the environmental state and the human health. Significant assistance to bioecological monitoring can be provided by sanitary-epidemiological and veterinary services, service

for plant protection, hydrobiological control. Proper location and sufficient density of monitoring posts, as well as effective management of receiving, processing and transmitting information are of great importance. The network of bioecological monitoring posts should be located in places of the population concentration. Observations of radionuclides, harmful gases and heavy metals can also be carried out.

Geoecological monitoring makes it possible to predict natural changes in the environment and phenomena that worsen the living conditions. Geoecological monitoring is based on geophysical, geo- and biochemical and biological methods — on the data of maximum permissible concentrations of pollutants, on the ability of the natural environment to self-remediation, etc.

Geophysical monitoring is a system of observations of the abiotic part of the biosphere (climate, relief, temperature and solar radiation); *physical monitoring* — observation of the physical parameters of the biosphere (solar radiation, pollution); *biological monitoring* — observation of the biotic component of the biosphere and its response to anthropogenic actions, as well as deviations of biota from normal natural state at different levels (molecular, cellular, at the level of organisms, populations, groups).

Terminology to chapter 1.4:
impact — вплив (*на навколишнє середовище*);
global monitoring — глобальний моніторинг;
national monitoring — державний моніторинг;
regional monitoring — регіональний моніторинг;
local monitoring — локальний моніторинг;
detail monitoring — об'єктовий моніторинг;
classification approach — принцип класифікації;
severity and globality — гострота і глобальність проблеми.

Answer the questions

1. *What are the principles of environmental monitoring classification?*
2. *What are the hierarchal levels of environmental monitoring?*
3. *What is paleomonitoring?*
4. *What are the bioecological monitoring specific features?*
5. *What regions of interest can be considered for different monitoring levels?*
6. *What geoecological monitoring is about?*

1.5. Background Monitoring, its role in assessing and forecasting the global state of the biosphere

The Concept and Tasks of Background Monitoring in Ukraine.
Abiotic and Biotic Components of the Background Monitoring Program.

1.5.1. The Concept and Tasks of Background Monitoring in Ukraine

Background environmental monitoring is a long-term comprehensive study of specially identified objects of protected areas in order to assess and predict changes in the state of ecosystems remote from industrial and economic activities, or to obtain information to determine the average (background) level of environmental pollution in anthropogenic conditions.

The most difficult task today is to study environmental change and manage environmental monitoring at the background level, which includes observations in areas remote from any local sources. The background monitoring in Ukraine has begun from monitoring research in the biosphere reserves included the study, control and forecast of anthropogenic changes in the state of the biosphere. In biosphere reserves it was proposed to conduct comprehensive studies of both external environmental factors and internal processes and phenomena occurring in ecosystems.

The main task of background monitoring is to capture and identify indicators that characterize the natural background, as well as its global and regional changes in the course of the biosphere evolution. The background global state of the biosphere is studied at background stations based in biosphere reserves. In Ukraine, these are the Askania-Nova, the Black Sea Biosphere Reserve, the Carpathian, the Danube, and the Chornoby l biosphere reserves. The background state of the environment in the past, before the beginning of human influence, can be studied according to the analysis of rings of dead or old trees, samples of glaciers, bottom sediments (historical monitoring).

The program of background environmental monitoring on the basis of biosphere reserves contains the following chapters.

1. Monitoring of environmental pollution and other factors of anthropogenic impact.

2. Monitoring of biota responses to anthropogenic impacts, and above all background levels of pollution.

3. Observation of changes in functional and structural characteristics of virgin (reference) natural ecosystems and their anthropoid modifications.

1.5.2. Abiotic and Biotic Components of the Background Monitoring Program

The background monitoring program is divided into *biotic and abiotic parts*. Measurements of hydrometeorological indicators belong to the abiotic part of background monitoring.

The organization of observations in this part should be carried out so that the results obtained provide sufficient information on the concentration of various impurities in the environment, the migration processes and the cycle of these substances, their accumulation and transformation.

The following criteria should be considered when choosing substances for monitoring program in biosphere reserves: distribution (abundance) of substances, their stability and mobility in the environment; and ability of substances to influence biological systems.

Some of pollutants entered the environment components can change the natural geochemical balance.

To assess the change in the natural cycle of substances caused by anthropogenic activities, the following are evaluated:

1) coefficient of technophility, which is determined by the ratio of annual production of the chemical element to its average content in the lithosphere;

2) coefficient of geochemical equilibrium, which shows the ratio of total emissions of any substance in the environment to its average content in the lithosphere.

The list of chemicals to be studied at background monitoring stations and in biosphere reserves is summarized in Table. 1.3.

Table 1.3

List of chemical substances to be studied at background stations and in biospheric reserves

Chemical substances	Components of the environment				
	Atmo-sphere	Atmo-spheric Precipita-tions	Surface and Under-ground Waters	Soil	Biota
1. Suspended substances	+				
2. Sulfur dioxide	+				
3. Ozone	+				
4. Carbon dioxide	+				
5. Nitrogen oxides	+				
6. Carbohydrates Benzpyrene	+				
7. Benzpyrene	+	+	+	+	+
8. Organochlorine compounds (DDT, etc.)	+	+	+	+	+
9. Heavy metals (lead, mercury, cadmium, arsenic)	+	+	+	+	+
10. Freons	+				
11. Biogenic elements		+	+	+	+
12. Radionuclides		+			

Hydrometeorological and geophysical characteristics should include data on wind speed and direction, atmospheric pressure and temperature, humidity and precipitation, solar radiation intensity, including data on ultraviolet radiation, water loss and level, water temperature, humidity and soil heat balance. *Biological observations* include the assessment of the biota condition (determination of the reproduction rate), the forecast of the corresponding reactions of the biota (establishing the dependence of the sensitivity of the biota to anthropogenic pollution in the dose-response system). Background monitoring covers *observations, experimental programs and mathematical modeling programs*.

In the 60's of XX century. The World Meteorological Organization (WMO) has established a global network of background monitoring stations (*Background Air Pollution Monitoring Network*). Its purpose is to obtain information about the background levels of atmospheric components concentration, their variations and temporal changes, which can be judged on the impact of human activities on the atmosphere. This system allows you to accumulate material to assess possible climate change, movement and precipitation of harmful substances, to assess the atmospheric part of biological cycles.

Terminology to chapter 1.5:
background monitoring program — програма фонового моніторингу;
biota responses to anthropogenic impacts — відгук біоти на антропогенний вплив;
virgin (reference) natural ecosystem — незаймана (еталонна) природна екосистема;
heavy metals — важкі метали;
suspended substances — завислі речовини;
atmospheric precipitations — атмосферні опади.

Answer the questions

1. *What do we call background monitoring?*
2. *Where are the background monitoring stations located?*
3. *How do we calculate the coefficient of technofility?*
4. *What is a coefficient of geochemical equilibrium?*
5. *What parameters are included in meteorological observations?*
6. *What chemical substances are included into the list to be studied at the background monitoring stations?*

1.6. Climate Monitoring

The *climate system* encompasses the atmospheric and oceanic processes that control the global distribution of winds, precipitation, and temperature.

Climate monitoring is the collection of data, analysis and assessment of natural and man-made changes and climate fluctuations. It involves the measurement of major meteorological parameters, the study and analysis of atmospheric phenomena and processes that characterize the relevant weather regime, the response of the climate system and its elements to natural and anthropogenic influences. The

internal and external factors that affect the climate and the state of the climate system are also studied, and the sources of these influences are monitored.

Analysis, assessment of the present day climate, forecast of its possible fluctuations require a large amount of data, set the task of comprehensive analysis of the state and modeling of climate. Thus, the most important *tasks of climate monitoring* are as follows: systematic data collection on climate system of a given region; analysis and assessment of natural and anthropogenic climate change and fluctuations (including comparison of the climate in the past and present); identification of anthropogenic effects in those aspects of climate changes where it can be detected; identification of natural and anthropogenic factors that affect climate change; identification of critical elements of the biosphere, the impact of which can lead to climate change.

All *basic climate data and information* needed to analyze climate change should be grouped by section. The *first section* should include: measurement of air temperature, atmospheric pressure, humidity, wind speed and direction, precipitation intensity. These data are obtained by the national meteorological services from the relevant stations. The other section should include the receipt of hydrological data, data on snow cover, soil moisture, depth of soil freezing and some others. All these data are obtained both at meteorological stations and at hydrological stations and posts.

The *World Weather Service* consists of a global surveillance system, a global telecommunications system, and a global data processing system. The system is designed to store and provide the accumulated information. The global surveillance system consists of terrestrial and satellite subsystems. *The terrestrial subsystem* is based on the basic synoptic network. The information of this subsystem also includes data from ships and aircraft, meteorological radars, various atmospheric sensing systems. *The satellite subsystem* consists of two parts: satellites in orbit, and geostationary meteorological satellites. The stations receive information from satellites, which includes data on vertical profiles of temperature and humidity, sea surface temperature, land surface and cloud cover, snow cover, radiation balance.

The *second section* of climate monitoring is very important and wide — monitoring the state of the climate system. The construction of

this system should be such that it is possible to identify those effects directly related to anthropogenic climate change. This includes monitoring of *climate-forming factors*, as well as the values that characterize the response of the climate system and its elements to various actions — mostly anthropogenic. It is necessary to obtain data on energy and mass transfer between the atmosphere and the underlying surface, to study the water balance on a large scale and its impact on climate change. *Monitoring of the ocean* is provided by measuring the temperature of the surface and the upper layer of the ocean, salt content and chemical composition of water, currents at different depths. To obtain data on the interaction of the atmosphere and the ocean, conduct regular marine climatological measurements of air and sea temperature, dewdrops, visibility, wind direction and strength, atmospheric pressure.

The *third section* combines the monitoring of factors that affect the climate system conditions. These factors can be divided into *external and internal*, and the sources of internal factors are natural and anthropogenic. External influences include factors caused by the *sun and cosmic radiation*.

The intensity of external factors depends on solar activity, the parameters of the Earth's orbit, and the speed of the Earth rotation. The effects of the impact are determined by the intensity of the outflow factors, the properties and composition of the Earth's atmosphere, the properties of the earth's surface.

Internal factors that affect the climate and climate system include thermal emissions and emissions of various substances into the biosphere or their redistribution between different environments — natural (volcanic eruptions) and anthropogenic factors. These factors lead to changes in the properties of the climate system — changes in the albedo of the underlying surface and atmosphere, moisture, heat and gas exchange of the underlying surface with the atmosphere. Heat emissions cause the atmosphere to heat up. Air temperature is being monitored in the suburbs of the big city and in the city itself.

Terminology to chapter 1.6:
climate-forming factors — кліматоутворюючі фактори;
dewdrop — крапля роси;
earth's surface — поверхня Землі;
visibility — видимість;
wind direction — напрямок вітру;

atmospheric pressure — атмосферний тиск;
salt content — вміст солі (*в океанічній воді*);
World Weather Service — Всесвітня служба погоди;
sun and cosmic radiation — сонячне і космічне випромінювання.

Answer the questions

1. Give the definition of climate monitoring.
2. What are the tasks of climate monitoring conduction?
2. What does the World Weather Service consist of?
4. What are the climate-forming factors?
5. What sections are climate data grouped in?
6. What do the intensity of external climate-forming factors depend on?

1.7. Global Environmental Monitoring

The Concept of Global Environmental Monitoring.
The main Tasks of Global Environmental Monitoring.

1.7.1. The Concept of Global Environmental Monitoring

Changes in the environment of our planet in a natural way due to the interaction between climate and the flow of basic chemicals occurred constantly for millennia. These interactions are united by global hydrological cycles, significantly influenced by the existence of life on Earth, and in recent millennia — human anthropogenic activities.

Pollution of the territories of different countries is not intentional from the point of international law view, because it is caused by the ability of many substances to spread spontaneously over large distances, beyond national borders. Negative changes in wildlife due to this phenomenon require the organization of large-scale studies of transboundary pollution. Such research was possible only with the international cooperation of many countries.

The refore, in 1971, the principles of building a *global system for monitoring* the state of the biosphere were formulated. A pamphlet entitled *Global Environmental Monitoring* was published. In 1972, the UN Stockholm Conference on the Environment approved the basic principles of building a global monitoring system and recommended the organization of monitoring stations for biosphere pollution, as well as tasked the UN to establish an international environmental monitoring system.

Subsequently, the UNEP (UN Environment Program) program in 1973–1974 developed the basic provisions for the establishment of the Global Monitoring System for the Environment (GEMS), the main purpose of which was to provide the information needed to ensure current and future health protection, well-being, human security and wise management of the environment and its resources.

Global environmental monitoring (GEM) is a system of monitoring the state of the environment and forecasting possible changes in global processes and phenomena, including anthropogenic impacts on the biosphere as a whole, the development of a global environmental monitoring strategy. It provides for long-term global observations based on space and terrestrial capacity building, as well as coordination of various relevant bodies and organizations and the implementation of the Comprehensive Global Observation Strategy, which provides access to space and other Earth observation data and their use, and improved weather and climate forecasting based on the expansion of international cooperation in the field of application of meteorological satellites.

The most significant processes that reflect the impact of human activities on the environment are considered changes in the *accumulation of gases in the atmosphere* that lead to the greenhouse effect; the influence of ocean circulation on the temporal and spatial distribution of these changes; the role of vegetation in regulating water flows between the Earth and the atmosphere.

The second important component of natural processes on Earth is the *global circulation of the main chemical elements* most important for life – carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur and their transformation. In the form of compounds such as carbon dioxide, methane and nitrogen oxides, they greatly affect the global climate. Even before human influences, the Earth's climate and chemical processes in nature underwent abrupt, closely related changes, reflected in the variegated sediments of sea basins, annual rings of fossil trees, and etc. In addition to these natural phenomena, human activities have led to disturbances in global chemical flows, which are manifested in the form of smog, acid rain, depletion of the ozone layer in the stratosphere, etc.

The third component is the hydrological cycle, which covers the processes of evaporation and precipitation, drainage and circulation. Water is the main agent of topographic changes and a constant regulator

of global chemical flows of matter, as well as climate. Among the factors influencing human activity on the hydrological cycle, pollution of groundwater, the surface of water basins and oceans, the redistribution of water flows on the earth's surface and the potential change in sea level as a result of global warming deserve special attention.

The fourth component, life, has found rich opportunities for the development of biological species in the natural environment of the planet. Life also plays a key role in regulating global environmental processes, influencing them through chemical and hydrological cycles. One of the forms of life — the human species — has jumped just in a few centuries from the inconspicuous role to the most important factor in global environmental change. Much is already known about the interactions between individual components of the global environment and different types of human activities, which in most cases lead to pollution.

1.7.2. The main Tasks of Global Environmental Monitoring

The purpose and main tasks of the GEM, defined at the international meeting in Nairobi (Kenya, 1974), are the following:

– development of an augmented warning system for the prevention of impact on human health;

– assessment of global air pollution and its effects on climate;

– assessment of the biosphere pollutants, especially food chains;

– assessment of critical problems arising from agricultural activities;

– assessment of the terrestrial ecosystems response to environmental pollution;

– assessment of the ocean pollution and its impact on the marine ecosystems;

– creation and improvement of the international system for natural disaster prevention.

The Global Monitoring System must address global environmental issues, such as global warming, ozone depletion, forest conservation, global desertification and soil erosion, floods, droughts, and etc. It provides for the systematic study of the environment according to uniform rules and uniform methods at regional stations located in different parts of the globe: continental, background, and biosphere stations. The system covers all natural areas, as well as areas that are

potentially hazardous in terms of the pollution of certain environment components (atmosphere, aquatic environment, etc.). At the global level the observations, assessments and forecasts are carried out: for identification of changes in natural processes, energy and heat balance of the Earth, monitoring of radiation, carbon dioxide, ozone depletion, background pollution of the atmosphere and the World Oceans, climate change, migration of birds and animals, etc.

Creating such a system in full is the task for the future as many countries do not yet have their own national systems.

The monitoring system at the global level selectively covers the subsystems of regional and local monitoring level. For example, the Tropical Forests program assessed the rainforests of Africa, Latin America, and Asia. Target monitoring of glaciers, marine biological resources and others was also carried out.

In 1975, the UNEP Board of Governors improved the lists of common pollutants, made recommendations on the location of background monitoring stations in biosphere reserves, and outlined plans for the development of GEM system, including the improvement of simulation models, the development of environmental management strategies. In 1979, the Convention on Long-range Transboundary Air Pollution was signed at the Pan-European Conference on Environmental Pollution in Geneva.

Terminology to chapter 1.7:

accumulation of gases in the atmosphere — концентрація газів в атмосфері;

augmented warning system — розширена система попередження;

background stations — базові станції глобального МД;

biosphere stations — біосферні станції глобального МД;

continental stations — континентальні станції глобального МД;

Convention on Long-range Transboundary Air Pollution — Конвенція про транскордонне забруднення повітря на великі відстані;

evaporation — випаровування;

global environmental monitoring system — система глобального екологічного моніторингу;

greenhouse gases — парникові гази;

precipitation — осадження;

redistribution of water flows — перерозподіл водних потоків;

variegated sediments — строкаті відкладення.

Answer the questions

1. *What is the concept of GEM?*
2. *What are its main tasks?*
3. *Give examples of global environmental problem to be monitored at global level.*
4. *What stations are organized to carry out monitoring research at global level?*
5. *What is the UNEP program about?*
6. *What Convention was signed in 1979 in Geneva?*

1.8. Environmental Monitoring in Ukraine

National policy in the field of environmental Monitoring.
Structure of the national environmental Monitoring system.
Objects of the national environmental Monitoring system.

1.8.1. National policy in the field of environmental Monitoring

The realization of human rights to a healthy and prosperous environment is the main goal of sustainable balanced social, economic and environmental development in Ukraine. Despite the fact that in recent years there has been a tendency to reduce the anthropogenic load on the environment, the level of man-made load remains high and the environmental situation is unsatisfactory. The purpose of environmental monitoring is to provide information and analytical support for management decisions aimed at compliance with environmental safety, environmental protection and environmental management.

Functions for monitoring in Ukraine are entrusted to the national environmental monitoring system of Ukraine, the creation and operation of which is based on the principles of:

– systematic receipt of information on the environment state;

– objectivity of primary data, analytical and forecast information;

– timeliness and efficiency of receipt of information from the units performing observations to the user of information, who is responsible for making management decisions;

– the complexity of the use of environmental information in space and time;

– availability of environmental information for the population of Ukraine and the world community.

Implementation of the basic principles of the national environmental monitoring system (NEMS) is achieved by attracting the potential of all monitoring entities, ensuring the continuity of observations of environmental components, consistency and progress of regulatory, methodological, technical and organizational support of observation networks, use of advanced information technologies and creation of long-term databases, special internet sites and publishing reporting information.

1.8.2. Structure of the national environmental Monitoring system

The structural organization of the NEMS is based on the scientific substantiation of the system of complex observations, identification of monitoring entities and objects. The national environmental monitoring program covers a regional program (within the administrative-territorial district), which takes into account geographical, socio-economic and administrative characteristics. Depending on the specific objectives, the following is carried out: routine (*загальний*); crisis (*оперативний*), background (*фоновий, науковий*) monitoring of environmental components.

According to the "Regulation on the National Environmental Monitoring System", approved by the Cabinet of Ministers of Ukraine № 391 of 30.03.1998, the components of the national monitoring of Ukraine are the monitoring of certain environmental components (*objects*): air, water, land, biodiversity, forests, waste, physical factors, geological environment (Fig. 1.3).

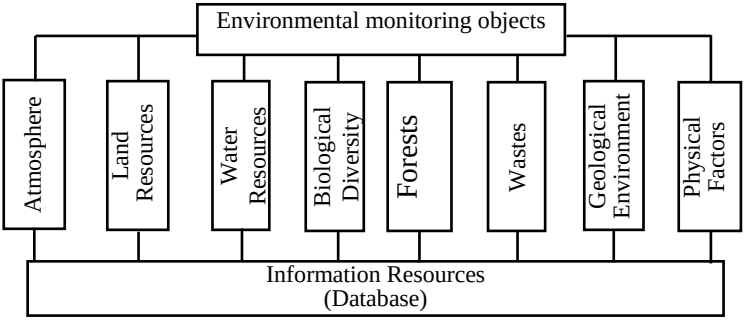


Fig. 1.3. Objects of the National Environmental Monitoring System

Each of the environment components (*object*) has to be observed, analyzed and assessed in terms of their pollution and hazard level for the population and the environment. It is necessary to implement the following types of monitoring: routine, crisis, and background (Fig. 1.4).

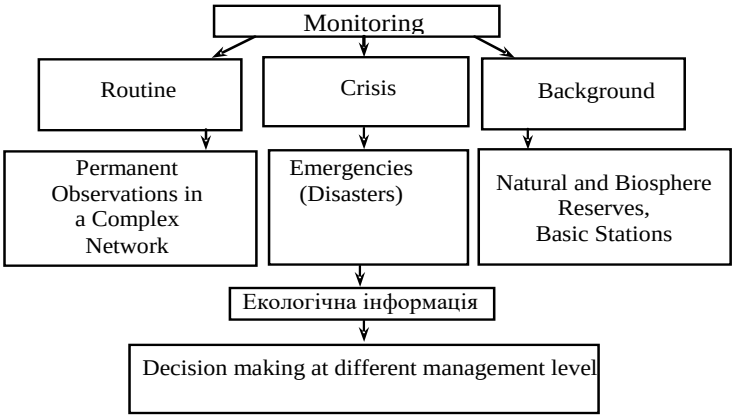


Fig. 1.4. National Environment Monitoring Types and their Content

1.8.3. Objects of the National Environmental Monitoring system

Atmospheric air monitoring is a system of measures that allows us observing and controlling the content of hazardous chemical, radioactive and biological substances in the atmosphere.

Monitoring in the field of air protection is carried out in order to obtain, collect, process, store and analyze information on the level of air pollution, assess and predict its changes and the level of hazard, and to develop scientifically sound recommendations for decision-making in the field of air protection.

What objects are exactly monitored? They are as follows:

- atmospheric air of residential areas, urbanized areas and zones of environmental emergency;
- atmospheric air of protected and recreational areas;
- precipitations;
- sources of man-made emissions of pollutants into the atmosphere;
- other sources of air pollution that can be monitored;
- transboundary transport of pollutants through the air.

As a result of air monitoring, the following are obtained: primary data on emission control and pollution monitoring; generalized data on the level of pollution in a particular area over a period of time; generalized data on the composition and volumes of pollutant emissions; assessment of levels of hazard for the population and the environment.

Monitoring of land resources (land monitoring) is a system of monitoring for the state of the land fund, including lands located in zones of ecological emergency and radioactive contamination, in order to timely identify its changes, assess them, prevent and eliminate the consequences of negative processes. The object of land monitoring is the entire land fund of Ukraine, regardless of the form of land ownership.

The components of land monitoring include:

• lands for various purposes, including: agricultural use, forest resources, irrigated and drained areas, protected areas, settlements; zones of ecological emergency and radioactive contamination, etc.;

• negative processes on the earth's surface and in the soils of the aeration zone associated with changes in soil fertility and degradation, including the development of water and wind erosion, loss of humus, deterioration of soil structure, waterlogging and salinization, pollution by toxic substances and radionuclides;

• soil contamination on agricultural lands;

• negative processes related to flooding of settlements and territories;

• changes in the state of landscapes due to the processes associated with the formation of ravines, landslides, mudslides, earthquakes, karst and other phenomena;

• state of coastlines of rivers, seas, lakes, bays, reservoirs, estuaries, hydraulic structures.

Monitoring of water resources (water monitoring) is a system of measures that allows us observing and controling the pollution of the water bodies with hazardous chemical, radioactive and biological substances.

The components of water monitoring include:

• land surface waters, including waters of natural and artificial reservoirs, watercourses, including drainage waters of reclamation systems and other water bodies;

- groundwater, including drinking, mineral, industrial, thermal and their deposits;
- subsoil water (the first aquifer from the surface) and aeration zone water;
- sources of pollution of land surface waters, sea waters, groundwater;
- bottom sediments as a factor of secondary pollution of surface waters;
- sources and systems of drinking water supply;
- sources of pollution and redistribution of surface and groundwater runoff, including water use systems;
- coastal zones of rivers, lakes, bays, reservoirs, estuaries, hydraulic structures as potential sources of negative impact on water systems;
- transboundary transfer of pollutants with surface waters.

The components of ***biodiversity monitoring*** include:

- ✓ vegetation cover of lands;
- ✓ forest vegetation;
- ✓ agricultural plants;
- ✓ greenery in cities and towns;
- ✓ terrestrial and aquatic ecosystems;
- ✓ biosphere reserves (complex observations);
- ✓ farm and domestic animals;
- ✓ wildlife of natural origin;
- ✓ other biological formations, including at the microbiological level.

When choosing species-indicators of biological diversity, it is necessary to give preference to those representatives of flora and fauna that most adequately reflect the state of the environment. Indicators also include species listed in the International Red Book and Red Book of Ukraine, as well as quarantine species that may lead to undesirable changes in the natural environment.

Biodiversity monitoring can be carried out at different levels: genetic, species, ecosystem, etc.

Forests monitoring. Forest nature is a holistic natural complex in which vegetation, fauna, soils, surface waters and surface atmosphere are inextricably linked. They all together form specific and extremely important for the society and the biosphere as a whole, the

environmental functions of forests that support the balance of biosphere regulation and form a favorable environment for life.

The object of forest monitoring is the forest fund of Ukraine, regardless of ownership, including land plots that are not covered with forest vegetation, but provided for the needs of forestry.

The components of the forest monitoring subsystem include:

• forest vegetation;

• forest fauna, including hunting fauna;

• forest soils.

Monitoring in the field of waste management is carried out based on the Laws of Ukraine "On Wastes", "On Approval of the Regulations on Control over Transboundary Movements of Hazardous Wastes and their Disposal".

The components of wastes monitoring are as follows:

o quantitative and qualitative indicators of waste generation, treatment and disposal;

o sites and objects of waste disposal, location and disposal;

o impact on the natural environment of sites and objects of formation, location, treatment, utilization, and disposal of waste;

o transboundary waste management.

Monitoring of geological environment is based on the Law of Ukraine "On the State Geological Survey of Ukraine".

Lithosphere monitoring is a system of measures that allows us monitoring and controlling the level of hazardous chemicals, radioactive and biological substances in the lithosphere.

The object of monitoring the geological environment is the subsoil — the part of the earth's crust that is located below the land surface and the bottom of reservoirs and extends to depths available for geological study and development.

Geological environment monitoring is carried out in order to:

- resource and cadastral assessment of mineral resources of the earth bowels, including groundwater (drinking, mineral, industrial, thermal waters and their deposits);
- detection of changes and trends dangerous for the environmental situation occurring in the earth's crust that may pose a real or potential threat of crises or emergencies, lead to environmental pollution and other catastrophic consequences.

Monitoring of physical factors of impact (фізичних факторів впливу) is carried out in the vicinities of residential areas, areas designated for construction, as well as within the sanitary protection zones and restricted areas around the sources of physical factors affecting the environment.

The components of state monitoring of physical factors include:

– acoustic pollution, including noise and vibration;

– ionizing radiation, including radiation;

– non-ionizing radiation, including electromagnetic fields.

Monitoring of physical factors is carried out as a background one before putting the object into operation, or during reconstruction of old objects and as a routine one after putting the object into operation.

Terminology to chapter 1.8:
acoustic pollution — акустичне забруднення;
basic guidelines (*of environmental monitoring*) — принципи організації national environmental monitoring system (NEMS) — державна система моніторингу довкілля (ДСМД);
biodiversity — біологічне різноманіття;
geological environment — геологічне середовище;
land resources — земельні ресурси;
level of hazard — рівень небезпеки;
monitoring entities — суб'єкти моніторингу;
monitoring objects — об'єкти моніторингу;
physical factors — фізичні фактори (*впливу*);
put into operation — вводити об'єкт в експлуатацію;
wastes — відходи;
water resources — водні ресурси.

Answer the questions

1. *What is the concept of national environmental monitoring?*
2. *What are its main tasks?*
3. *What is the main idea of national policy in the field of environmental monitoring?*
4. *What are the national environmental monitoring objects?*
5. *What is the monitoring of physical factors about?*
6. *What components are included in the monitoring of physical factors of impact?*

1.9. Classification of methods for environmental parameters measuring 40

Classification and characterization of basic methods.
Biological methods used for environmental Monitoring.

1.9.1. Classification and characterization of basic methods

Research methods are divided into qualitative and quantitative. The task of qualitative analysis is to identify a particular chemical element or compound or to establish the composition of the test substance, quantitative — to determine the exact content of the substance in the test sample or to establish quantitative relationships between the constituent parts of the substance. Qualitative analysis usually precedes quantitative determination.

Based on the measured parameters, the methods of quantitative analysis are divided into chemical, physico-chemical, physical and biological (Fig. 1.5).

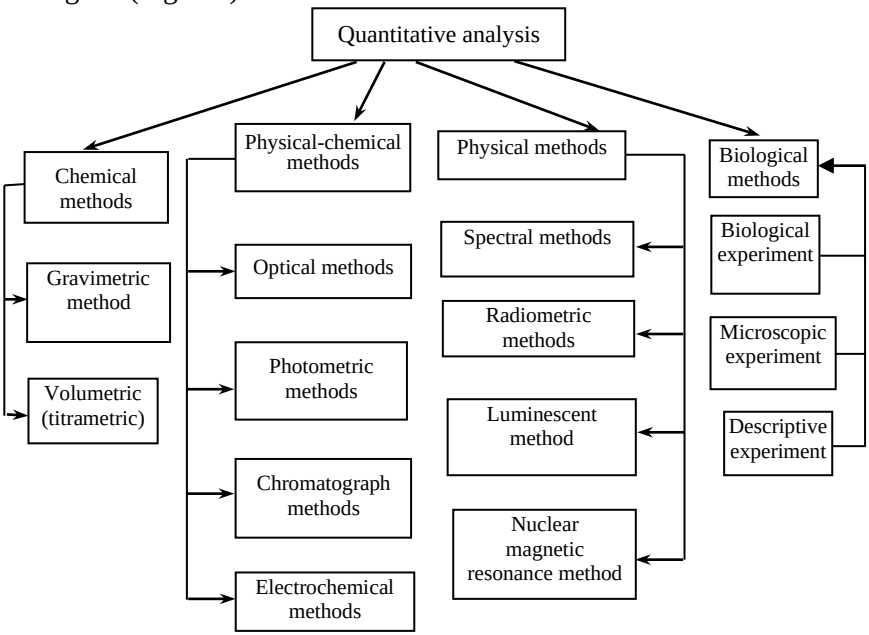


Рис. 1.5. Classification of methods of quantitative analysis

Chemical methods are based on the use of chemical reactions to determine the composition of the system. Thus, using the reaction characteristic of a particular ion with the formation of a colored complex, precipitate, poorly dissociated compound, it is possible to conduct qualitative and quantitative chemical analysis.

Quantitative determination of a substance by chemical methods consists of three stages.

The first stage is the measurement of a certain amount of substance for analysis. To do this, the substance is weighed or the volume of its solution is measured.

The second stage is a chemical reaction. As a result of the chemical reaction the component that determines is transformed into a compound with certain chemical and physical properties.

The third stage is the measurement of an indicator of a physical property, the value of which leads to the conclusion about the amount of the determined component.

Physico-chemical methods are based on the dependence of physical properties on the chemical composition of the analyzed environment.

Physical and physic-chemical methods are united by the common name of instrumental methods of analysis. The method of physical and chemical analysis is mostly the same and it is as follows:

- depending on the analyzed system, the necessary method of analysis is chosen;
- a number of standard solutions (series) are prepared;
- physical properties of solutions on the corresponding device are measured;
- based on the obtained data, a calibration graph is constructed in the composition-property coordinates;
- physical property of the analyzed sample is measured and its composition is determined according to the graph available.

Physical methods **determine a property that directly** depends on the nature of atoms and their concentration in the system, such as the intensity of radioactive irradiation.

When using physical methods of analysis, qualitative detection or quantitative determination of the constituent parts of a substance is carried out by observing or measuring certain indicators of its physical properties. There are no chemical reactions in physical methods or they are of secondary importance. Common to physical and physicochemical

methods of analysis is the use of more or less complex equipment for measuring the optical, electrical or other properties of matter. Depending on the studied physical phenomenon and the measured physical property, these methods of analysis are divided into: *spectral, radiometric, X-ray spectral, luminescent analysis, nuclear magnetic resonance method.*

1.9.2. Biological methods used for environmental Monitoring

Biological methods. The basis of biological and biochemical research methods is the reactions of plants, animals and microorganisms to the action of a certain factor. Changes can occur at different levels.

Bioindication is an assessment of the state of the environment by the reaction of living organisms. Depending on the properties of the bioindicator used, there are specific and nonspecific bioindication. Nonspecific bioindication is when different anthropogenic factors cause the same reactions. If the changes that occur can be attributed to only one factor, it is a specific bioindication.

Animals, plants, bacteria and viruses are used as bioindicators.

Bioindicators — living organisms, the presence, condition and behavior of which can be concluded about the degree of environmental change, including the presence of pollutants. Living indicators have significant advantages. They summarize all, without exception, biologically important data on pollution; indicate the rate of change, ways and places of accumulation of various toxicants in ecosystems, to judge the degree of harmfulness of certain substances to wildlife. Lower and higher plants, microorganisms, various species of animals (for example, rodents) are used for bioindication. Lichens and mosses are particularly sensitive indicators of air pollution, taking into account the peculiarities of their biology and physiology.

Anthropogenic changes in the atmosphere significantly affect higher plants, often leading to changes in leaf color, necrosis, leaf fall, changes in growth and branching (Table 1.4). Thus, when the atmosphere is polluted with sulfur dioxide, the typical signs of damage are: in Scots pine — browning of the tips of pine needles, in American ash — extensive interstitial discoloration of the leaves.

Of the ornamental plants, the most reliable indicators of hydrogen fluoride are gladiolus, tulip, daffodil, lily of the valley. The most sensitive varieties of tobacco, tomatoes and citrus are good indicators of

ozone. These bioindicators can be used to monitor the state of the environment and carry out environmental measures, in particular in forestry, taking into account the impact of anthropogenic air pollution.

Table 1.4

Main plants-indicators of environmental pollution

Pollutant	The most important tree species	Agricultural and ornamental plants
Sulfur dioxide Діоксид сірки	Spruce (European, Serbian), European fir, Scots pine, American ash Ялина (європейська, сербська), ялиця європейська, сосна звичайна, ясен американський	Wheat, barley, alfalfa, peas, clover, cotton, violet Пшениця, ячмінь, люцерна, горох, конюшина, бавовник, фіалка
Hydrogen fluoride Фтористий водень	European spruce, European fir, Scots pine, walnut Ялина європейська, ялиця європейська, сосна звичайна, горіх волоський	Grapes, apricot, parsley, gladiolus, tulip, narcissus, rhododendron Виноград, абрикос, петрушка, гладіолус, тюльпан, нарцис, рододендрон
Ammonia Аміак	Hornbeam, linden heart-shaped Граб звичайний, липа серцевидна	Celery, shag Селера, махорка
Hydrogen chloride Хлористий водень	European spruce, Caucasian fir, sticky alder, common hazel Ялина європейська, ялиця кавказька, вільха клейка, ліщина звичайна	Beans, spinach, radish, currant Квасоля звичайна, шпинат, редька, смородина
Ozone Озон	Weymouth Pine Сосна Веймутова	Tobacco, potatoes, soybeans, tomatoes, citrus Тютюн, Картопля, соя, томати, цитрусові
Heavy metals Важкі метали	Canadian hemlock, smooth elm, hawthorn Тсуга канадська, в'яз гладкий, глід звичайний	Orchids Орхідеї

One of the promising objects of bioindication is lichens. They are distributed around the globe and can be monitored at all levels.

Lichens are highly sensitive to environmental pollution. They are selectively affected primarily by substances that increase the acidity of the environment (CO_2, HF, HCl, NO_x, O_3). Heavy metals and radioactive isotopes are relatively harmless to lichens.

Pine can also be used as an indicator to detect air and soil pollution. Pollutants that affect the growth and vitality of the tree can accumulate in the bark, wood and needles.

Methods based on two main principles are used to assess the pollution of water bodies according to the state of the phytoplankton group: indicator value of species and species diversity of the group.

Based on the results of biotesting of water bodies, based on the study of water toxicity, water pollution is assessed on a scale with three degrees of gradation: extremely polluted, moderately polluted and slightly polluted water bodies.

Terminology to chapter 1.9:
American ash — ясень американський;
ammonia — аміак;
anthropogenic changes — антропогенні зміни;
bark of a tree — кора дерева;
bioindication — біоіндикація;
browning of the tips of pine needles — побуріння кінчиків голок хвої;
heavy metals — важкі метали;
hydrogen chloride — хлористий водень;
hydrogen fluoride — фтористий водень;
interstitial discoloration of leaves — міжжилкове знебарвлення листків;
ozone — озон;
sulfur dioxide — діоксин сірки;
Scots pine — сосна звичайна.

Answer the questions

1. *How are the methods for environmental parameters measuring classified?*
2. *What are the chemical, physic-chemical, and physical methods about?*
3. *What are the biological methods about?*
4. *What do we call bioindication?*
5. *What plants are used as bioindicators?*
6. *Give an example of agricultural and ornamental plant as a bioindicator.*

1.10. Regulatory and legal support of environmental monitoring in Ukraine

Legal regulation in the field of environmental monitoring is carried out in accordance with the provisions of:

- Laws of Ukraine "On Environmental Protection" and "On Fundamentals of National Security of Ukraine";
- Resolutions of the Verkhovna Rada of Ukraine of 05.03.1998 № 188/98-VR "Main Directions of the State Policy of Ukraine in the Field of environmental protection, use of natural resources and ensuring ecological safety and dated 20.02.2003 № 565-IV", "On recommendations of parliamentary hearings on compliance with the requirements of environmental legislation in Ukraine";
- Resolutions of the Cabinet of Ministers of Ukraine "Regulations on the state system of environmental monitoring" of 30.03.1998 № 391, "On the unified state system of prevention and response to emergencies of man-made and natural nature" of 03.08.1998 № 1198.

The Law of Ukraine "On Environmental Protection" (Articles 20, 22) provides for the establishment of a system of monitoring and observation of the state of the environment, the level of its pollution.

Given the trend of Ukraine's foreign policy on the prospects of joining the European Union, the main direction of further development in the legislative and legal support of the NEMS should be consistent harmonization of relevant elements of environmental legislation with EU legislation, taking into account the strategic objectives of sustainable socio-economic and environmental development.

Improving the NEMS, it is necessary to strive for harmonization with the indicators of environmental monitoring of the European community. This approach will be able to ensure the development of standardized indicators in Ukraine and the future integration of the NEMS into the pan-European environmental monitoring system. This requires the modernization of equipment for the monitoring networks using modern automated systems, appropriate equipment that can be widely and effectively used in both stationary and field conditions.

In 2003–2004, the conceptual principles of the NEMS were developed taking into account the main objectives of Ukraine's national policy in the field of monitoring, environmental protection, use of natural resources and environmental safety.

This Concept is a document in which:

✓ the basic concepts of NEMS as a complex organizational and technical information system, normative and legal bases of its creation, functioning, development, sphere of application of the received information are defined;

✓ the basic principles of structural and functional organization of NEMS, peculiarities of interaction with other systems (governmental, non-governmental, interstate and other states) where the similar functions are available;

✓ the principles of management, purpose and main tasks of the national program of environmental monitoring are determined.

Among the recently approved legal national legislation it is worth considering the Law of Ukraine "On National Security of Ukraine" as of 2018. It is a current legislative document that defines and delimits the powers of state bodies in the field of national security and defense, as well as determines among the fundamental national interests of EU and NATO membership.

Decree of the President of Ukraine №111/2021 On the decision of the National Security and Defense Council of Ukraine of March 23, 2021 "On challenges and threats to national security of Ukraine in the environmental sphere and priority measures to neutralize them".

In determining the place of environmental safety in the national safety system of the country (higher level national interest) an important aspect of this methodological task is to study the strategic environmental policy planning and determining the features of the formation of the relevant projected strategies as part of a comprehensive system of comprehensive guarantee of national security of the state on medium and long term. Note that in the basic Law of Ukraine on improving the environmental situation and raising the level of environmental safety "On the basic principles (strategy) of state environmental policy for the period up to 2030" the main tasks are a number of tasks to increase the level of environmental safety by introducing an integrated approach to risk assessment, prevention and minimizing the consequences of natural disasters in accordance with the Johannesburg Plan of Action and the Global Goals sustainable development until 2030.

In order to ensure the national interests of Ukraine in relation to sustainable economic development, civil society and the state, respect for the constitutional rights and freedoms of man and citizen, the President of Ukraine has issued an Order "On the goals of sustainable development of Ukraine until 2030", which includes implementation of

17 items proclaimed by the UN General Assembly on September 25, 2015 № 70/1 and their adaptation taking into account the specifics of Ukraine's development.

At present days, the national environmental monitoring system has the following top-level entities, including the Ministry of Ecology and Natural Resources of Ukraine, the Ministry of Agrarian Policy and Food of Ukraine, the Ministry of Communities and Territories Development of Ukraine, the State Emergency Service of Ukraine. Agency of Ukraine for Exclusion Zone Management, State Agency of Water Resources of Ukraine, State Agency of Forest Resources of Ukraine, State Service of Ukraine for Geodesy, Cartography and Cadastre, Ukrainian Geological Survey, and some others.

1.11. Legislation in the field of environmental monitoring

The need to improve the national system of environmental monitoring is determined by Ukraine's foreign policy course towards European integration and is recognized by a number of strategic documents. In particular, the relevant provisions on the development of the environmental monitoring system are present in *the Law of Ukraine* On the Basic Principles (Strategy) of the State Environmental Policy of Ukraine for the period up to 2030 (Information of the Verkhovna Rada (VVR), 2019, № 16, p.70) — Закон України «Про Основні засади (стратегію) державної екологічної політики України на період до 2030 року» від 28 лютого 2019 року № 2697-VIII.

The Concept of reforming the system of state supervision (control) in the field of environmental protection, approved by the order of the Cabinet of Ministers of Ukraine of May 31, 2017 № 616-r — Концепція реформування системи державного нагляду (контролю) у сфері охорони навколишнього природного середовища, схвалена розпорядженням Кабінету Міністрів України від 31 травня 2017 р. № 616-р.

Action plan for the implementation of the Concept of reforming the system of state supervision (control) in the field of environmental protection, approved by the order of the Cabinet of Ministers of Ukraine of May 23, 2018 № 353-r — План заходів щодо реалізації Концепції реформування системи державного нагляду (контролю) у сфері охорони навколишнього природного середовища, затверджений

розпорядженням Кабінету Міністрів України від 23 травня 2018 р. № 353-р.

Resolution of the Cabinet of Ministers of of September 19, 2018 № 758 “On approval of the Procedure for state water monitoring” — Постанова Кабінету Міністрів від від 19 вересня 2018 р. № 758 «Про затвердження Порядку здійснення державного моніторингу вод».

Resolution of the Cabinet of Ministers of August 14, 2019 №827 “Some issues of state monitoring in the field of air protection” — Постанова Кабінету Міністрів від 14.08.2019 року № 827 «Деякі питання здійснення державного моніторингу в галузі охорони атмосферного повітря».

Order of the Ministry of Environmental Protection and Natural Resources of Ukraine of February 25, 2021 N 147 “On approval of the form of the State Monitoring Program in the field of air protection” — Наказ Міністерства захисту довкілля та природних ресурсів України від 25.02.2021 «Про затвердження форми Програми державного моніторингу у галузі охорони атмосферного повітря».

The procedure stipulates that the program of national monitoring in the field of air protection is approved for each zone and agglomeration.

The program is developed for a period of five years and should include:

- information on the *air quality management bodies* that developed the program;
- information on the *network of air quality monitoring* and air monitoring laboratories available in the area or agglomeration, including the list of observation points, their addresses and geographical coordinates, maps with the layout of observation points, addresses of available air monitoring laboratories;
- *a list of pollutants assessed* at observation points in the area or agglomeration, methods used to measure, calculate, forecast or assess the level of pollutants at observation points and the established assessment regime (data on which the assessment regime was established);
- information on *planned activities* for the establishment of observation points and / or improvement of existing air quality monitoring networks, creation and / or improvement of air monitoring laboratories, including a list of observation points planned for

installation, their addresses and coordinates, maps with layout observation points,

- information on *the entities (subjects) of atmospheric air monitoring*, who plan to establish observation points and/or create laboratories for monitoring the state of atmospheric air;
- *stages, mechanism and deadlines* for planned activities.

Terminology to chapters 1.10 and 1.11:
Ministry of Ecology and Natural Resources of Ukraine — Міністерство захисту довкілля та природних ресурсів України;
Ministry of Agrarian Policy and Food of Ukraine — Міністерство аграрної політики і продовольства України;
Ministry for Communities and Territories development of Ukraine — Міністерство розвитку громад та територій України;
Ministry of Health Protection — Міністерство охорони здоров'я;
State Emergency Service of Ukraine — Державна служба України з надзвичайних ситуацій;
State Agency of Ukraine on Exclusion Zone management — Державне агентство України з управління зоною відчуження;
State Water Resources Agency of Ukraine — Державне агентство водних ресурсів України;
State Forest Resources Agency of Ukraine — Державне агентство лісових ресурсів України;
State Service of Ukraine for Geodesy, Cartography and Cadastre — Державна служба України з питань геодезії, картографії та кадастру
Ukrainian Geological Survey — Державна служба геології та надр України

Answer the questions to chapters 1.10 and 1.11

1. *What are the legislative laws and regulations in support of NEMS?*
2. *What environmental issues are specially emphasized in the Decree of the President of Ukraine as of March, 2021?*
3. *What are the recent important documents after 2017 should be noted?*
4. *What is the resolution about atmospheric air monitoring as of 2019?*
5. *What are the state (national) monitoring entities (subjects) who are responsible for environmental monitoring at national level?*
6. *What items should be included into the State Monitoring Program in the field of air protection?*

Part 2
QUALITY CONTROL OF ENVIRONMENTAL COMPONENTS

2.1. The essence and conditions of use for different methods of environmental parameters measuring

Devices and means for research of environmental parameters.
Level 1 devices (devices for express control).
Level 2 devices (stationary devices).
Level 3 devices (industrial devices).

2.1.1. Devices and means for research of environmental parameters

At the present state-of-the-art of monitoring systems, a large number of different control devices have been developed, which are used to assess the state of the environment. To orient in this field of knowledge, it is expedient to classify devices. The following is information on the main, most widely used devices used in the practice of environmental research.

The classification of devices can be considered according to the environment component under research; according to the method applied; based on the conditions of the equipment application; or on the training approach (in which way the equipment is used for training and professional purposes).

The equipment classification *according to the environment component under research*: devices for measuring the concentration of harmful impurities in *the atmosphere* (gas analyzers of various types, chromatographs, mass spectrometers); devices for determining *water quality* (photo-electro-calorimeters, ionometers, refractometers); devices for studying the condition of *soils and solid particles* (spectrometers, fluorometers, radiometers).

The equipment classification *according to the method applied:*

- *chemical* — reagents and equipment of stationary chemical laboratories, which have been assigned a generalized name of *"wet chemistry", physico-chemical*;
- *optical* (spectrophotometers, photo-electro-calorimeters);

- e*lectrochemical* (ionometers, conductometers, polarographs);
- *chromatographic* (liquid and gas chromatographs);
- *physical* (radiometers and dosimeters; electromagnetometers; mass spectrographs; noise meters etc.)

The equipment classification *based on the conditions of the equipment application*: *stationary devices* for atomic and molecular spectral analysis, chromatographs (these devices are precision and require special conditions for the work and training of service personnel); *portable devices*, which are often called rapid analysis devices and are used, in particular, in mobile environmental laboratories (radiometers, nitrate meters, kits for quality analysis of water and soil), have a relatively low accuracy.

The equipment classification *based on the training approach* (in which way the equipment is used for training and professional purposes). These are *devices of the 1-st educational and practical level* of relatively low cost and low accuracy, which should be used in the school environmental groups and expeditions; *devices of the 2-nd educational-professional level*, designed for the implementation of professional environmental education in the specialty "Ecology" in universities of 1–2 levels of accreditation; *devices of the 3-rd professional level* (expensive and high-precision devices) intended for use in industry, environmental inspection departments, sanitary inspection services and science.

2.1.2. Level 1 devices (devices for express control)

Devices for rapid control of atmospheric air quality, water, and soil quality are widely used at the environmental equipment market. There follows some examples of them.

Device for rapid determination of *water toxicity "Biotox"*. The Biotox device is a portable bioluminometer that uses the Ecolum biosensor to determine the index of general chemical toxicity of aqueous samples, including heavy metals, pesticides, herbicides, mineral fertilizers, household chemicals, etc.

EBIK (Morion) is designed to measure the total content of nitrates in fresh fruits and vegetables. This device also allows you to determine the acidity of the soil. It is used in everyday life, agriculture and catering.

Ecoline 4000 is a compact, multifunctional portable microprocessor device, which consists of a flue gas analyzer and an indicator of the parameters of the measured medium. It allows you to simultaneously measure the concentration of four gases with built-in electrochemical sensors: oxygen (O_2), carbon monoxide (CO), nitrogen monoxide (NO), nitrogen dioxide (NO_2) or sulfur dioxide (SO_2).

During the analysis of the sample, the temperature of the exhaust gases, the temperature of the combustion air is measured, and also calculated: the concentration of carbon dioxide (CO_2), excess air, heat loss with exhaust gases (q_2), (combustion efficiency of fuel). If a NO sensor is installed but a NO_2 sensor is not installed, the display shows the NO concentration and the estimated NO_2 value, which consists of the measured NO concentration and the calculated NO_2 concentration.

Comet series gas analyzers are designed to monitor hazardous concentrations of flammable and toxic gases in the atmosphere of working areas of industrial facilities. Scope of application of portable gas signaling devices "Comet": during carrying out works and inspection of wells of cable and thermal networks, water supply and sewerage facilities; to search for leaks and places of emission of relevant gases; assessment of workplaces on the composition of the air.

2.1.3. Level 2 devices (stationary devices)

A device, all parts of which are installed for long-term operation in a certain place, is called a stationary device. These are not portative equipment for rapid detection of any device.

Stationary multi-component gas analyzer is a multi-channel device of continuous operation, which is intended for automatic control of gas contamination with toxic and explosive gases (carbon monoxide, methane, propane, ammonia, oxygen, oil vapors and gasoline). A stationary multi-component or multi-channel gas detector is a gas control system that determines the gas concentration in the air in real time and, when the threshold value is exceeded or the pre-explosion concentration of flammable liquids or flammable gases vapors is reached, emits sound and light signals.

Radioisotope analyzer "Prize-2", a dust measurer, is an equipment for measuring the dust in the environment. Dust is not guilty of being radioactive or acidic.

Technical characteristics of the device: measuring range: 1–500 mg/m^3; measurement duration — 0.45–4 minutes; warm-up time of the device — 1 min, error of readings of the device — ± 20 %.

At the Kyiv Thermal Power Plant-6, a stationary gas analyzer MARS-5 was tested. Conducted testing of the fixture showed the stability of the indications of the work for the hour of operation, the indications of the air quality do not go beyond the international passport data. The device can be used for the installation of gas analysis of the stationary source (heat and power facility) and can be switched on to the warehouse of an automated system and control and monitoring of the gas release for the object.

The SPECTRUM-4 gas analyzer is intended for continuous measurement of mass concentration: nitrogen oxide (NO), nitrogen dioxide (NO_2), sulfur dioxide (SO_2), carbon monoxide (CO), methane (CH_4). The main area of application of the device is environmental monitoring of harmful gaseous emissions into the atmosphere, as well as control of exhaust gases in technological processes in order to ensure optimal fuel combustion or the specified efficiency of gas purification systems in industrial emissions. In the field of household waste incineration technology, the SPECTR-4 gas analyzer allows to significantly reduce energy losses due to precise and dynamic adjustment of the power plant.

The SPECTRUM-4 is an infrared spectral device with a multi-pass optical cuvette for measuring the concentration of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NOx) in a wide range of measured concentrations. Thus optical on the scheme allows to reach high sensitivity and insignificant error of measurements, to realize the principle of multichannel measurement of concentrations of gases in one device.

2.1.4. Level 3 devices (industrial devices)

Industrial stationary devices of the 3-d level include the following devices: IR spectrophotometers and spectrometers: spectrophotometers IR spectrophotometers M80/M85, “Specord”, IR-Fourier, spectrometers Brooker, as well as monochromators and spectrophotometers for the visible and UV regions etc.

Ukranalit Research Institute has developed and put into operation a *two-level system of environmental monitoring* and optimization of

combustion processes using the latest advances in high technology sensors and computer information processing.

The first level of the system is a set of gas analytical technological complexes TC-1. Each complex consists of a highly sensitive gas analyzer 151 EX02, which measures the concentration of oxygen (O_2) in the area of the combustion products of each boiler. In addition, the complex includes a multi-channel gas analyzer 325 FA01, which measures carbon monoxide (CO), carbon dioxide (CO_2) and methane (CH_4).

The second level of the system is the ecological complex EK-1, which is installed on the exhaust ducts, after the dust electrostatic precipitators. The basis of the complex is the gas analyzer "SPECTRUM-4", which incorporates a multi-pass optical cuvette to measure the concentration of carbon monoxide (CO), sulfur dioxide (SO_2), nitrogen oxides (NO_x) in a wide range of measured concentrations. Such an optical circuit allows to achieve high sensitivity and insignificant measurement error, to implement the principle of multichannel measurement of gas concentrations in one device.

The system of automated emission control (AEC) is designed for continuous monitoring, registration on the required media and long-term storage of data on emissions of harmful gases: NO, NO_2, NO_x, CO, SO_2, as well as additional parameters with reference to time and emission measurement point.

It is used for environmental monitoring of harmful gases emissions from industrial enterprises, boilers of thermal power plants, pulverized coal boilers, as well as equipment that burns fuel oil, coal, gas or combinations thereof in the process.

The number of gas analyzers and auxiliary sensors is determined by the individual consumer and can be grouped into subsystems from 1 to 4 devices of each type in the subsystem. The system allows changing a configuration and a complete set without deterioration of the system characteristics. Gas analyzers MARS-5 and 151EX02 are included in the State Register of Measuring Equipment.

Terminology to chapter 2.1:
emission measurement point — точка вимірювання викидів;
harmful gases — шкідливі гази;
auxiliary sensors — допоміжні датчики;

stationary multi-component gas analyzer system — стаціонарний багатокомпонентний газоаналізатор;
multifunctional portable microprocessor device – багато-функціональний переносний мікропроцесорний прилад.

Answer the questions

1. What classification types are used for environmental monitoring devices?
2. What are the devices for express control?
3. Give example of gas analyzers.
4. Give examples of stationary devices.
5. What are industrial devices designed for?
6. What type of gas analyzer was used at Kyiv Thermal Power Plant-6?

2.2 Methodological, technical, technological, and software support of the environmental monitoring

Scientific and methodological support of the environmental monitoring system.
Technical, technological, and software support of the environmental monitoring system.

2.2.1. Scientific and methodological support of the environmental monitoring system

Scientific and methodological support of the environmental monitoring system (EMS) covers a range of research, design and engineering work aimed at developing:

- new means of monitoring, collecting, accumulating, transmitting and storing information on the state of the environment and their implementation;
- methodical recommendations on the analysis and generalization of information, forecasting changes in the state of the environment;
- methods of mathematical modeling, statistical information processing, database management systems and other types of computer accumulation and generalization of information;
- standards and other normative documents regulating the functioning of the EMS in each country.

Priority areas of the modern EMS system are the development of methods for monitoring the levels of pollution (chemical, radiation, bacteriological, thermal, etc.) in the components of the environment (air, surface water, drinking water sources, etc.) and monitoring exogenous and endogenous geodynamic processes that create or may pose certain threats to the population, certain elements of the biosphere and various economic systems and structures in the future. In view of this, the main purpose of the EMS is not only quantitative and qualitative assessment of multicomponent man-made environmental impact, but most importantly — assessment and prediction of the consequences of the response of environmental elements to determine levels of environmental safety and protection measures for the population and territories. Therefore, the EMS should be considered as one of the components of environmental safety, which ensures the overall safety of each state and the sustainable operation of potentially hazardous facilities.

This approach determines the need to identify and study the relationships between types and levels of man-made loads, dynamic parameters of natural processes, vegetation, living organisms, human health and psychological state and changes in socio-economic processes in society. This strategy requires the development of new conceptual principles for building a system of integrated EMS. This is especially true for sites of high environmental risk and regions with significant anthropogenic (man-made) loads.

Solving this problem involves:

- ✓ division of the general monitoring system into a number of independent but interconnected units;
- ✓ definition of the structural hierarchy and system of interaction between these blocks;
- ✓ establishing the structure of individual monitoring subsystems and parameters of information flows for each of these components.

2.2.2. Technical, technological, and software-support of the environmental monitoring system

It is important to identify real *technical, technological, scientific and software-hardware* capabilities that can ensure the implementation of practical tasks in the study of environmental objects, as well as to

establish the priority and sequence of stages of practical improvement of the modern EMS.

Currently, the EMS declares such progressive principles of its construction as *objectivity and reliability*, systematic observations of the environment and objects of its impact, multilevel, consistency of regulatory and methodological support, consistency of software and hardware, complexity in assessing environmental information, efficiency of information passing between separate links of the system and timely informing of state executive bodies, openness of ecological information for the population. According to *functional tasks*, the modern monitoring system is actually divided into two blocks: 1) *obtaining and storing primary information*; 2) *processing, analysis and presentation of information in the form of the final product*.

Each of these units at the level of individual subjects of monitoring has its own structural and organizational, scientific and methodological, technical and technological support.

The main *disadvantages* of the current monitoring system are:

– departmental division and responsibility for information collection and processing;

– lack of expert-analytical and forecasting-modeling centers where all information would be collected and comprehensive environmental forecasts and expert assessments of environmental risk would be developed;

– lack of efficiency in the flow of data to users of information (except for hydrometeorological information);

– scatter of data on different monitoring entities;

– difficulties in collecting and analyzing primary monitoring data for practical application in the process of solving environmental risk assessment tasks;

– no crisis monitoring subsystem is available.

The Resolution of the Cabinet of Ministers of Ukraine of 30.06.1998 № 139 "Regulations on the State Environmental Monitoring System" stipulates that environmental monitoring is "... *a system of observation, collection, processing, transmission, storage and analysis of information on the state of the environment, forecasting its changes and development of scientifically sound recommendations for decision-making on prevention of negative changes in the state of the environment and compliance with environmental safety requirements"*.

The concept of "*integrated environmental monitoring*" (IEM) is used when it comes to types of monitoring that go beyond the scope of this regulation (*for example, seismic, geophysical, hydrogeological*).

The main results of the practical implementation of the IEM system for environmental facilities should be:

- creation of unified software and hardware and information support;
- development of networks of automated stations and checkpoints of environmental monitoring;
- zoning of the territory according to the degree of risks of man-caused ecological hazard and substantiation of the primary network of observations;
- creation of the expert-analytical computer center;
- creation of a subsystem of socio-economic eco-monitoring.

Terminology to chapter 2.2:
environmental monitoring system (EMS) — система екологічного моніторингу;
integrated environmental monitoring (IEM) — комплексний екологічний моніторинг довкілля (КЕМД);
monitoring network — мережа постів моніторингу.

Answer the questions

1. *What is the essence of scientific support of EMS?*
2. *What is the essence of software-hardware support of EMS?*
3. *Give the concept of environmental monitoring system from the Resolution of the Cabinet of Ministers as of 1998.*
4. *What is an integrated environmental monitoring?*
5. *What are the disadvantages of current EMS in Ukraine?*
6. *What are the main results of practical implementation of IEM?*

2.3. Current state of atmospheric air, sources and types of its pollution

The sources of air pollution are diverse for each city agglomeration and depend on the development of transport system and the stationary enterprises located nearby. Currently, the sources of air pollution in the city of Kyiv are energy companies: Darnytska Thermal Power Plant (ThPP — ТЕЦ), joint-stock energy generating companies "Kyivenergo"

ThPP-5, ThPP-6, “Heat Networks”, a branch of Zhytloteploenergo, a branch of the plant “Energy”, machinery and chemical industry; light, food and processing industries, construction industry: Polymer Materials Plant “Ukrplastyk”, Darnytskyi Car Repair Plant, Civil Aviation 410 Plant, and some other air polluting companies, and also the transport complex of the city. Emissions from vehicles account for more than 80 % of total emissions. Monitoring of air pollution in the city is carried out at sixteen stationary posts located in eight sites of the city.

According to the UNEP recommendations, in order to minimize the negative health consequences of air pollution, the strategies should be developed for the development of integrated air quality assessment and control systems taking into account priority pollutants, especially PM_{10} ($PM_{2.5}$), ground-level ozone, sulfur dioxide (SO_2) and nitrogen oxide (NO_x). These measures should develop a realistic approach to improving environmental monitoring (with a special focus on air quality monitoring and emission monitoring).

The air quality assessment and regulation system should include a clearly defined organizational structure — the air monitoring system and provide for the existence of management bodies responsible for coordinating all activities in this system. The main purpose of such modern systems is to meet the information needs of local governments and the public.

In Ukraine: the list of mandatory indicators for identification of air quality within cities agglomerations and in general should include the following pollutants: *sulfur dioxide, nitrogen dioxide and nitrogen oxides, benzene, carbon monoxide, lead, solids (PM_{10}, $PM_{2.5}$), arsenic, cadmium, mercury, nickel, benzene(a)pyrene, ozone*, as well as components of precipitation: *ammonium ions, bicarbonate ions, calcium ions, total acidity, magnesium ions, nitrate ions, chloride ions, pH, in accordance with the Resolution 2019.* It is meant the Resolution of the Cabinet of Ministers of August 14, 2019 № 827 “Some issues of state monitoring in the field of air protection” — Постанова Кабінету Міністрів від 14.08.2019 року № 827 «Деякі питання здійснення державного моніторингу в галузі охорони атмосферного повітря». The list of additional indicators is also defined in the Resolution.

The governmental entities responsible for air protection monitoring are the Ministry of Ecology and Natural Resources of Ukraine, the Ministry of Health Protection, the State Emergency Service, the State

Environmental Protection Agency, Kyiv city state administrations, executive bodies of city councils.

Mandatory indicators are defined as limit values, targets for a certain averaging period and long-term targets for ozone.

Limit value (*гранична величина*) is the level of pollutants determined for: sulfur dioxide, nitrogen dioxide and nitrogen oxides, benzene, carbon monoxide, lead, solids (PM_{10}, $PM_{2.5}$), which is set to avoidance, prevention or reduction of harmful effects on human health and/or the environment in general.

The State monitoring in the field of air protection is intended for:

– ensuring the collection, processing, storage and analysis of information on air quality;

– assessment and forecasting of its changes and level of hazard;

– development of scientifically sound recommendations for management decisions in the field of air protection;

– informing the population about the quality of atmospheric air, the impact of its pollution on the health and livelihoods of the population.

Information on regional air monitoring systems may also be transmitted to the subjects of cross-border cooperation of Ukraine at the request of the central executive bodies, which are responsible for cross-border cooperation in the field of environmental protection.

2.4. Atmospheric air monitoring

> Organization of the atmospheric air monitoring.
> Procedure for determining of assessment regimes for each zone and agglomeration.
> Atmospheric air monitoring networks.
> Information and analytical system of air quality data.

2.4.1. Organization of the atmospheric air monitoring

The organization of atmospheric air monitoring is as follows:

➢ the list of zones and agglomerations for the purposes of air quality monitoring and management on the territory of Ukraine has been established and published in the Resolution of the Cabinet of Ministers of Ukraine, 2019 mentioned above;

➢ in each zone and agglomeration, a responsible for air quality management body should be identified; this governmental body is supposed to be responsible for coordinating monitoring entities, analyzing air quality, developing air quality management measures, drawing up air quality improvement plans and short-term action plans, introduction a mechanism for mandatory regular provision of information. In each zone (agglomeration) analytical studies of air quality for mandatory indicators should be conducted and additional, specific for the zone (agglomeration) of pollutants should be determined, which should be included in the list of substances to be monitored.

2.4.2. Procedure for determining of assessment regimes for each zone and agglomeration

Assessment of ambient air quality in a zone or agglomeration is necessary in order to determine which measurements should be used for observations in the monitoring system of a given zone or agglomeration. Atmospheric air quality assessment is performed for each pollutant from list A, item 1 of the Resolution, 2019 separately on the basis of data on pollutants levels for the previous five years.

For evaluation, it is possible to combine the results of short-term measurement activities for one year in the areas with the highest pollution level with the data from the register of emissions and apply modeling methods.

The procedure for assessing air quality in the area or agglomeration is as follows:

- collection and processing of information from the posts of the observation network, from the posts of indicative measurement and analysis of simulation results;
- comparative analysis for each of the received levels of pollution (concentrations in the air at a certain time) with the values of the upper and lower thresholds of the pollution;
- determination of the assessment regime in this zone for each pollutant.

The assessment regime is established by the air quality management body of the relevant zone or agglomeration in the state monitoring program, in accordance with the following criteria:

– if the level of pollution exceeds its upper threshold or long-term targets for ozone are exceeded, a fixed measurement regime is used to assess this pollutent or ozone in a given zone (agglomeration);

– if the level of pollution is below its upper assessment threshold, the combined assessment regime is used to assess this pollutant in this zone (agglomeration). Combined assessment is performed by combining fixed measurements and a method of modeling or indicative measurements in accordance with data quality objectives;

– if the level of pollution is below its lower assessment threshold, the mode of modeling or objective assessment is applied.

The assessment threshold is considered to have been exceeded if it has been exceeded for at least three of the five years.

Fixed measurements are performed at fixed observation points for air pollution on a constant basis or by random sampling to determine the level of pollution. Fixed measurements are carried out using the reference methods defined in paragraph 4 of Annex 3 of the Regulation, 2019 and compliance with data quality objectives for fixed measurements defined in Annex 3 of the same Regulation. Fixed measurements should be mandatory for zones and agglomerations where long-term ozone targets are exceeded or thresholds for estimating limit values for other pollutants are exceeded. Additionally, modeling methods or indicative measurements can be used.

Combinatory assessment (*комбінование оцінювання*) is carried out by combining fixed measurements and the method of modeling or indicative measurements in accordance with the data quality objectives set out in Annex 3 of the Regulation. To assess the limit values and targets, it is necessary to choose the maximum measured or maximum simulated indicators in each zone.

The simulation method is used to obtain information on the spatial variability of pollutants concentrations in air by mathematical modeling of impurity scattering processes in atmospheric air. Mathematical modeling assumes the availability of reliable data on meteorological features and emission parameters. Modeling error is interpreted as the appropriate limit value (or target in the case of ozone) applied in the zone or agglomeration.

The method of objective assessment (*метод об'єктивного оцінювання*) is presented as mathematical methods for calculating the concentration, based on values measured elsewhere, or obtained on the basis of scientific knowledge about the distribution of concentration.

The suitability of the models for real conditions is checked according to network or specially organized observations. The calculated concentrations must be the same as those observed at the sampling points.

2.4.3. Atmospheric air monitoring networks

The network of observations is the basis for obtaining primary information on air quality in the region. The observation network should provide the following information requirements:

– measurement results must be regular over time;

– measurements must be reliable and valid;

– reliability of information — an indicator of the quality of information, which means its completeness and overall accuracy, completeness of information is ensured by the number of posts, accuracy and reliability — instruments and reference methods of measurement.

– the data obtained must be representative of climatic conditions;

– the results must be comparable and meet the metrological requirements for uniformity of measurements.

Measurement of concentrations of all pollutants should be carried out by reference methods, which are established by regulatory documents. The observation network of the zone (agglomeration) consists of observation networks of monitoring entities, including networks subordinated to local governments (if any). The observation network includes stationary *automated observation post* (AOP), *indicative posts* (IOP) and *route site* based on mobile laboratories).

Stationary AOP is designed for fixed measurements of a pollutant in the current time (online) or regular sampling of air for further laboratory determination of the content of the main and most common and specific pollutants and meteorological parameters in the air of populated cities.

IOPs are of secondary importance to the main network of stationary AOPs. IOP should provide indicative measurements in the automatic mode of monitoring air quality in a fixed area for the minimum required number of pollutants from the mandatory list, the most typical for this area. Indicative measurements are measurements that meet data quality requirements that are less stringent than the requirements for fixed measurements obtained on stationary AOPs.

Mobile (route, transport) post is designed for regular determination of air quality indicators and sampling at fixed points in places where it is impossible or impractical to install a stationary post (for example, on city streets to determine air pollution by vehicle emissions). The order of detours (pre-selected fixed points on the ground) should be the same, so that the observations at each point are determined at the same time of day.

Observations at route posts should be carried out with the help of a mobile laboratory, which should be equipped with certified measuring and sampling tools.

The number of stationary posts in the area (agglomeration) is determined by: the population, relief feature; type of industry developed in the area; functional structure (residential, industrial, green area, etc.), spatial and temporal variability of fields of harmful substances concentrations; a specific set of installed measuring instruments; type of pollution sources (scattered, point), and others (if any).

It is recommended to determine the locations of stationary and route observation posts on the basis of preliminary studies of pollution emission sources; according to the results of the indicative method of research of the enterprise impact zone; based on the results of calculations of scattering fields of maximum pollutants concentrations (modeling method).

Sufficient number and rational location of monitoring network and sampling points ensure the completeness and reliability of the information.

Each post, regardless of category, is located on an open, ventilated area with a non-dusty surface: asphalt, hard ground, lawn — so as to avoid distortion of measurement results by the presence of greenery, buildings and etc.

2.4.4. Information and analytical system of air quality data

An information-analytical data system of atmospheric air quality data is created to ensure information interaction between the subjects of atmospheric air monitoring and prompt publication of the results of atmospheric air monitoring.

Creation and functioning of the IADS on air quality is provided by: Ministry of Environment — at the national level, and air quality management bodies — at the level of zones (agglomerations).

The monitoring entities (subjects) publish data on atmospheric air quality on the basis of IADS:

- information on atmospheric concentrations of nitrogen dioxide and nitrogen oxides, sulfur dioxide, particulate matter (PM_{10}, $PM_{2.5}$), ozone and carbon monoxide — daily, and if possible — every hour;
- analytical data on the state and assessment of air quality, forecasts of the state of atmospheric air and its changes — daily;
- information on the levels of lead and benzene in the air — monthly;
- information on —he levels of arsenic, cadmium, nickel, benzo(a)pyrene in the air — annually;
- information on the impact of pollutants levels in the atmosphere on the life and health of the population, including information on the impact on the health of the population of exceeding the limit values, targets, information threshold, hazard thresholds and recommended behavior for the population — constantly.

Atmospheric air quality control bodies:

- provide access to the results of air monitoring to the executive authorities exercising state control in the field of air protection and control over compliance with hygienic requirements for ambient air;
- ensure coordination of subjects of atmospheric air monitoring and quality management at the level of the zone or agglomeration;
- approve plans for improving air quality and short-term action plans for the relevant zone (agglomeration);
- take measures to improve the atmosphere and measures that can be implemented as soon as possible to reduce the risk or duration of exceeding the danger thresholds in the area concerned;
- ensure the publication of approved air quality improvement plans within five working days of their approval and short-term action plans within 24 hours of their approval;
- develop programs for zones and agglomerations in the form established by the Ministry of Environment, and submit them for consideration and opinion to the commissions on state monitoring in the field of air protection and air quality management in the relevant zones (agglomerations).

Terminology to chapters 2.3 and 2.4:
air observation post — пост спостережень за станом атмосферного повітря;
automated observation post (AOP) — автоматизований пост спостережень за станом об'єкта довкілля;
detour — об'їзд;
indicative observation post (IOP) — індикативний пост спостережень;
information-analytical data system (IADS) — інформаційно-аналітична система даних;
limit value — гранична величина;
fixed measurements — фіксовані вимірювання;
combinatory assessment — комбіноване оцінювання;
method of objective assessment — метод об'єктивного оцінювання;
observation post — пост спостережень;
preliminary studies — попередні дослідження;
route site (post) — маршрутний пост спостережень.

Answer the questions

1. What are the main sources of air pollution in agglomeration?
2. How is the atmospheric air monitoring organized?
3. What are the assessment regimes for each zone or agglomeration?
4. How is the atmospheric monitoring network organized?
5. What types of atmospheric air observation posts do you know?
6. What is the information-analytical data system about?

2.5. Current state of surface water bodies, sources and types of their pollution

Water bodies in Ukraine are mostly polluted with nitrogen compounds, oil products, phenols, and heavy metals. The most polluted rivers in Ukraine are the rivers of the Western Bug, the Siversky Donets, and the Priazov basins. The most common pollutants that enter water bodies are sulfate ions, chlorine, ammonium, bicarbonates, nitrates, calcium, sodium, potassium and magnesium.

The quality of the waters of the Black sea and the sea of Azov is characterized by the level of their pollution with petroleum

hydrocarbons, phenols, synthetic surface active substances, organochlorine pesticides, availability of oxygen dissolved in water.

Classification of water bodies is introduced in accordance with the "*Methodology for assigning surface water massif to one of the classes* of ecological and chemical states of surface water massif, as well as assigning artificial or significantly altered surface water massif" (*Methodology*), approved by the Order of the Ministry of Ecology and Natural Resources of Ukraine 14.01.2019 № 5. Наказ Міністерства екології та природних ресурсів України від 14.01.19 № 5. «Про затвердження Методики віднесення масиву поверхневих вод до одного з класів екологічного та хімічного станів масиву поверхневих вод, а також віднесення штучного або істотно зміненого масиву поверхневих вод до одного з класів екологічного потенціалу штучного або істотно зміненого масиву поверхневих вод».

To classify the environmental status of the surface water bodies, five classes of environmental status are used:

- Class I corresponds to the environmental condition "excellent";
- Class II corresponds to the environmental condition of "good";
- Class III corresponds to the environmental condition "satisfactory";
- IV class o corresponds to the environmental condition "bad";
- Class V corresponds to the environmental condition "very bad".

Criteria for assigning the surface water massive to one of the classes of environmental status are given in Annex 2 of the Methodology.

At classification of an environmental status of the surface water bodies condition of waters from physical and chemical indicators the *environmental standard of quality* (ESQ) is entered.

This standard meets the conditions established for the normal functioning of aquatic ecosystems. ESQ should be determined for each type of surface water and take into account hydromorphological, biological and hydrochemical characteristics of water bodies.

Prior to the determination of ESQ, its value is set at the level of *maximum permissible concentrations* (*MPC*) for surface water bodies of the relevant type of water use (drinking, communal, household, fishery).

When assessing the state of surface waters, the *environmental potential of the water body* is determined.

Environmental potential of artificial or significantly altered surface water massif is an integrated indicator of the state of artificial or

substantially altered surface water body, which is determined by biological indicators using hydromorphological, chemical and physicochemical indicators.

Four classes are used to classify the environmental potential of surface waters: “good”, “satisfactory”, “bad”, “very bad”. Determination of ecological potential is carried out in accordance with Section IV of the *Methodology*.

The reference conditions set for an artificial or substantially altered surface water massif are the values corresponding to the *maximum environmental potential (MPE)*.

Determination of the environmental potential of water body is carried out according to the same indicators used to determine the environmental status of the surface water massif of the corresponding category (river, lake, transitional waters, coastal waters).

Terminology to chapter 2.5:
environmental standard of quality (ESQ) — екологічний норматив якості (ЕНЯ);
maximum permissible concentrations (MPC) — гранично допустимі концентрації (ГДК);
environmental potential of water body — екологічний потенціал водного об’єкта;
maximum environmental potential (MPE) — максимальний екологічний потенціал (МЕП).

Answer the questions

1. *What are the main pollutants of the surface water bodies in Ukraine?*
2. *What are the most polluted surface water bodies?*
3. *What are the classes of environmental status of the surface water bodies in Ukraine?*
4. *What is the environmental standard of quality?*
5. *What is the environmental potential of the water body?*
6. *How is the environmental potential of the water body determined?*

2.6. Monitoring of surface water bodies

General provisions in the field of water monitoring.
Water monitoring types.

2.7.1. General provisions in the field of water monitoring

State water monitoring is carried out in order to collect, process, preserve, summarize and analyze information on the state of water bodies, forecast its changes and develop scientifically sound recommendations for decision-making in the field of water use, protection and reproduction of water resources. It corresponds to the commitments in the environmental part of the Association Agreement with the EU and includes the results of the implementation of the Joint Strategy for the Implementation of the Water Framework Directive 2000/60/EC.

The legislative basis for water monitoring in Ukraine is:

– Joint Strategy for the Implementation of the Water Framework Directive (2000/60/EC). Guide №10. Rivers and lakes — typology, reference conditions and classification systems. 2003;

– Resolution of the Cabinet of Ministers of Ukraine dated 19.09.2018 № 758 "On approval of the Procedure for state water monitoring";

– RD 211.0.8.107-05 "Methodical recommendations on the creation of environmental monitoring systems at the regional level", approved by the Order of the Ministry of Environmental Protection of Ukraine dated 16.12.2005 № 467;

– Order of the Ministry of Ecology and Natural Resources of Ukraine dated 14.01.2019 № 5. "On approval of the Methodology for assigning surface water massif to one of the classes of ecological and chemical states of surface water, as well as assigning artificial or significantly modified surface water body to one of environmental classes the potential of artificial or significantly altered surface water massif;

– Order of the Ministry of Ecology and Natural Resources of Ukraine dated 06.02.2017 № 45 "List of pollutants to determine the chemical status of surface and groundwater and the environmental potential of artificial or significantly altered surface water".

The objects of water resources monitoring are:

✓ massifs of surface waters (surface water bodies or their parts), including coastal waters and zones (territories) subjected to protection;

✓ massifs of groundwater (groundwater bodies or parts thereof), including areas (territories) to be protected.

The entities (subjects) of state water monitoring are:
the Ministry of Ecology and Natural Resources, the State Water Agency, Ukrainian Geological Survey, the Ministry of Internal Affairs, and State Agency of Ukraine on Exclusion Zone management.

2.7.2. Water monitoring types

The *water monitoring program* should include: information on the object of water monitoring (code, name of the object, location, hydrological and other characteristics), as well as biological, physicochemical, chemical and hydromorphological indicators, frequency of monitoring, information on the subject and executor of water monitoring .

Types of water monitoring determined in the Resolution of the Cabinet of Ministers of Ukraine dated 19.09.2018 № 758 are as follows: *diagnostic, operational monitoring, and research monitoring*. This terminology is a specific one and needs explanation.

Diagnostic monitoring is carried out for surface and groundwater massifs in order to:

– supplement and confirm the main anthropogenic impacts on the quantitative and qualitative state of surface and groundwater, including from point and diffuse sources;

– develop of a state water monitoring program;

– establish reference conditions and assess their long-term changes;

– assess long-term changes caused by anthropogenic impact on the quantitative and qualitative state of surface and groundwater, including from point and diffuse sources;

– assess long-term trends in changes in the level and concentration of pollutants in groundwater due to natural changes and anthropogenic impact on their condition.

Reference conditions are conditions that reflect the state of the environment in case of absence or minimal anthropogenic impact. The reference conditions established for the artificial or substantially altered surface water mass are the values corresponding to the maximum ecological potential.

In general diagnostic monitoring is carried out during the first year as far as monitoring program started.

Operational monitoring is carried out (each year between the time of diagnostic monitoring) for surface and groundwater massifs where there is a risk to achieve environmental objectives, as well as surface and groundwater massifs, water intake from which to meet drinking and household needs averages more than 100 cubic meters per day, in order to:

- determine ecological and chemical state of surface water massifs and quantitative and chemical state of groundwater massifs;
- assess changes in the ecological and chemical state of surface water massifs (in the ecological potential of artificial or significantly changed surface water massifs), as well as in the quantitative and chemical state of groundwater massifs as a result of the river basin management plan;
- identify long-term trends in increasing concentrations of pollutants in groundwater massifs due to anthropogenic impact on their condition.

Research monitoring is carried out for surface water massifs in order to:

- establish the reasons for deviations from environmental goals;
- find out the scale and consequences of accidental water pollution;
- establish the reasons for the risk of failure to achieve environmental objectives identified in the process of diagnostic monitoring before the start of operational monitoring.

Terminology to chapter 2.6:

water monitoring program — программа моніторингу вод;
maximum permissible concentrations (MPC) — гранично-допустимі концентрації (ГДК);
environmental potential of water body — екологічний потенціал водного об'єкта;
maximum environmental potential (MPE) — максимальний екологічний потенціал (МЕП);
reference conditions — референційні умови;
diagnostic monitoring — діагностичний моніторинг;
operational monitoring — операційний моніторинг;
research monitoring — дослідницький моніторинг.

Answer the questions

1. *What environmental legislation is currently in force for water monitoring?*
2. *What is the main approach towards water bodies monitoring given in Resolution "On approval of the Procedure for state water monitoring"?*
3. *What do we call "reference conditions" for a water body?*
4. *What is diagnostic monitoring of water body and in what purpose is it carried out for?*
5. *What is operation monitoring of water body and in what purpose is it carried out for?*
6. *What is research monitoring of water body and in what purpose is it carried out for?*

2.7. The current state of soil cover and peculiarities of soil monitoring

The current state of soils in Ukraine.
General provisions in the field of land (including soil) monitoring.
Soil monitoring tasks.
Legislation, soil monitoring objects and governmental bodies.

2.7.1 The current state of soils in Ukraine

Soils are polluted with pesticides, heavy metals and other chemicals of industrial origin, radionulides, and with specific chemical elements because of current military activities.

Pesticides include insecticides to control unwanted insects, herbicides to kill weeds, and fungicides to control fungal diseases. In addition, there are fumigants and repellents (substances that increase crop yields). The use of pesticides helps to increase yields by 20–60 % at a cost of 1–5 % of total costs. Being biologically active, they often affect the environment.

Before taking soil samples, a brief description of the location of the section and soil horizons is made up (moisture, color, mechanical composition, structure, impurities, development of root systems, animal tracks, permafrost and others).

Continuous surveying of contaminated soils is not always required to assess the degree of soil contamination due to the extremely high

complexity and cost of the work performed. It is better and more economical to trace the paths of *air and water pollution* of the soil, analyzing the pooled samples that should be taken in key areas located in sectors-radii along the predominant air flows.

The *key area* is the area (*1–10 ha and more*), which characterizes the typical, constantly recurring in the area, the combination of soil conditions and conditions of relief, vegetation and other components of the physical and geographical environment. The main part of the *key areas* should be located in the direction of the two extreme directions (rhumbs) of the wind rose. In case of indistinct wind rose, the areas should characterize the territory evenly in the direction of all rhombuses of the wind rose. If there is reason to believe that the migration of heavy metals is associated with water flows, the direction of the rays should be consistent with the vector of water migration. The total number of studied areas is 15–20.

2.7.2. General provisions in the field of land (including soil) monitoring

Soil monitoring is a system of monitoring the condition of soils in order to timely identify changes, assess them, prevent and eliminate the consequences of negative processes.

The purpose of soil monitoring is to obtain information for making decisions aimed at stabilizing and improving soil quality, greening agricultural activities and achieving the end result in the form of enhanced fertility reproduction.

Soil monitoring is the most important part of environmental monitoring (assessment of the environment as a whole), agri-environmental monitoring (monitoring the quality of crop and livestock products) and land monitoring (when the object of observation are all categories of land — agricultural land, forestry, territories of nature reserves, reclaimed dumps of rocks, etc.).

Depending on the purpose of observations and the degree of coverage of the territories, the soil cover monitoring is carried out at the following levels:

- national — on all lands within the territory of Ukraine;
- regional — in areas characterized by the unity of physical-geographical, environmental and economic conditions;
- local — on separate land plots and in separate parts (elementary structures) of landscape-ecological complexes.

Land monitoring consists of systematic observations of the state of lands (agrochemical certification of land plots, land survey), detection of changes in it and also assessment of:

– processes associated with changes in soil fertility (development of water and wind erosion, loss of humus, deterioration of soil structure, waterlogging and salinization), overgrowing of agricultural land, contamination of land with pesticides, heavy metals, radionuclides and other toxic substances;

– the state of the shorelines of rivers, seas, lakes, bays, reservoirs, estuaries, hydraulic structures;

– processes associated with the formation of ravines, landslides, mudslides, earthquakes, karst, cryogenic and other phenomena;

– the state of lands of settlements, territories occupied by oil and gas facilities, sewage treatment plants, manure storages, storage facilities for fuel and lubricants, fertilizers, parking lots, disposal of toxic industrial waste and radioactive materials, as well as other industrial facilities.

2.7.3. Soil monitoring tasks

There are three tasks of soil monitoring: *information, forecast, and managerial*.

The information task is the collection of available information. Monitoring is developed *on the basis of soil-cartographic materials* (soil map, soil sketch, different types of zoning, recommendations for rational use of soil cover), *on materials of land management design* (organization of territory, agricultural lands, crop rotations, recommendations for soil erosion control, land assessment data — land cadastre and soil grading, aerial photography materials), *analytical materials and cartograms of periodic agrochemical surveys* (recommendations for the use of organic and mineral fertilizers, microfertilizers, other chemicals, radiological and toxicological control materials), *agro-climatic information* with characteristics of weather elements and the probability of catastrophic phenomena — downpours, landslides, floods, hurricanes, tornadoes, etc., on the available hydrogeological information, information on possible sources of pollution, the direction and intensity of agricultural land use.

Forecasting task is the task of near and far forecasting of soil conditions. For this purpose various methods of forecasting (normative,

trends, modeling, Box-Jenkins) are used. However, reliable forecasting, at least in the early stages of monitoring, is difficult to do due to lack of information (the main requirement for information to be suitable for forecasting is a long series of equidistant observations). Therefore, it is important to develop simulation and mathematical modeling on a computer.

Managerial task. This task is to issue decisions, recommendations, consultations in the form of warnings about the sources and causes of soil problems, undesirable activities, change its direction, ways to increase efficiency, warnings about emergencies and ways out of them, as well as proposals for the size and location of the most rational investment. The monitoring service should systematically assess the state of soil cover, fertility, forecast their development, especially operational material to prevent irreversible changes in soil processes.

2.7.4. Legislation, soil monitoring objects and governmental bodies

The main provisions of soil monitoring are determined by the Resolution of the Cabinet of Ministers of Ukraine № 661 of 20.09.1993 "On approval of the Regulations on soil monitoring". The soil monitoring governmental bodies are as follows:

Ministry of Ecology and Natural Resources of Ukraine — soils in protected areas (pollutants' content, including radionuclides);

State Emergency Service of Ukraine — soils for various purposes (residual content of pesticides and heavy metals);

State Agency of Ukraine for Exclusion Zone Management — soils and landscapes (pollutants'content, radionuclides, spatial distribution);

Ministry for Communities and Territories development of Ukraine — soils for agricultural use (radiological, agrochemical and toxicological research, residual pesticides, agrochemicals and heavy metals);

State Forest Resources Agency of Ukraine — soils of forest lands (radiological research, residual pesticides, agrochemicals and heavy metals);

State Water Resources Agency of Ukraine — irrigated and drained lands (depths and mineralization of groundwater, the degree of salinity and salinity of soils);

State Service of Ukraine for Geodesy, Cartography and Cadastre — soils and landscapes (pollutants' content, manifestations of erosion and other exogenous processes, spatial pollution of lands by objects of industrial and agricultural production); irrigated and drained lands (secondary flooding and salinization, etc.);

State Space Agency of Ukraine — the state of territories according to remote sensing data (tracking of thermal anomalies, flood anomalies, etc.).

Terminology to chapter 2.7:
fumigants and repellents — фуміганти та репеленти (*речовини, що підвищують врожайність сільськогосподарських культур*);
agricultural lands — землі сільськогосподарського призначення;
forestry lands — лісові ґрунти;
territories of nature reserves — території заповідників;
reclaimed dumps of rocks — рекультивовані відвали гірських порід;
irrigated and drained lands — зрошувані і осушені землі;
residual pesticides — залишкова кількість пестицидів;
depths and mineralization of groundwater — глибина залягання та мінералізація ґрунтових вод;
soil salinity — солонцюватість ґрунту;
remote sensing — дистанційне зондування Землі.

Answer the questions

1. *What environmental legislation is currently in force for soil monitoring?*
2. *What levels the soil monitoring is carried out at?*
3. *What are the main soil contaminants?*
4. *What are the tasks for soil monitoring?*
5. *What governmental bodies are involved in soil monitoring and what are their responsibilities?*

2.8. Soil monitoring

Soil monitoring types.
Soil monitoring network.
Selection of indicators to monitor the soil condition and soil monitoring programs.

2.8.1. Soil monitoring types

According to the monitoring content, spatial and temporal measurements, efficiency, and methods techniques for working with a consumer in the framework of monitoring, the following types of soil monitoring are distinguished: *background (reference) monitoring; production (basic, standard, current); crisis; special purpose; scientific (prognostic) monitoring.*

Background (reference) monitoring is the initial assessment of the area of observation, conditionally taken as a zero point, for which comparisons are made within the current definitions. Due to the fact that in relation to the soil that has been used in production for a long time, it is almost impossible to obtain such an assessment. That is why the characteristics of soils on virgin land, protected area, in the forest are taken as zero. If it is impossible to obtain this estimate due to the absence of such an area, the background monitoring can include the initial cycle of observations, which are conditionally considered to be zero.

Modal (the most common) physical, chemical, biological characteristics, as well as the average content of elements in the rock (Clark) can also be considered as background in soil agrochemical and environmental studies. Such zero estimates may be sufficient to conclude on the spatio-temporal differentiation of the soil or may indicate accumulative trends in anthropogenic soil pollution.

Natural soil characteristics, such as the ability to produce organic matter from climatic resources or bioproductivity (without additional investments), can be used as a reference.

The optimal parameters of soils in the root-containing layer can act as standards, under which cultivated plants are able to realize their full potential. Such standards are used in the formation of requirements for the most modern technologies and technical means of soil processing.

Production (basic, standard, current) monitoring is a systematic current observation of the object in space and time. There should be consistency of measurement programs and methods with other types of monitoring between agencies. Standard monitoring makes higher demands on the level of governmental body as standard monitoring has become a task for different agencies in Ukraine.

Crisis monitoring is dedicated to especially operational control of maximum permissible levels, discharges, emergencies and rapid response (prevention and localization of catastrophic phenomena).

Crisis monitoring of soils is considered to be a system of assessments of the soil state, which has significantly impaired environmental and productive functions (compared to the achieved average long-term level) and which has moved to the degradation path of development.

Special purpose monitoring is essentially departmental, fragmentary, as a system of observation of one or more processes in soils, the intensive use of which causes significant changes. Special purpose monitoring may include reclamation monitoring — observation, mainly, of individual (so-called reclamation) properties of soils, for example, the level and mineralization of groundwater; radiation monitoring — observation of the behavior of radionuclides in the system "soil — plant — livestock products".

The same type includes monitoring of certain categories of land: *urban monitoring* is a relatively new type of observation of artificial soil-like substrates and "closed" soils in settlements; monitoring of soils under perennial plantations — in forests, orchards, vineyards, pastures, reclaimed lands, lands of special purpose (military training grounds, land near water bodies — lands of water fund, transport, reserve, recreational lands and others). This kind of monitoring in each case has its own specifics, which consists primarily in the list of controlled indicators and methods of measuring them.

Scientific (forecasting) monitoring include observations that provide information of increased accuracy and capacity, with which you can qualitatively enrich production monitoring, significantly clarify the content of management decisions and, most importantly, create significantly more reliable forecasting models. Such monitoring should be represented by special field experiments, balance and lysimetric studies, simulation and mathematical models, special types of remote sensing (radiometric, radar, infrared and other types of control).

2.8.2. Soil monitoring network

When forming a soil monitoring network, two methods of locating soil monitoring sites are used — *regular and irregular* ones.

It is recommended to use the *regular method* for large areas with relatively balanced climate, topography and the same type of economic specialization. The parameters of such a network depend on the degree

of heterogeneity of relief, soil cover, landscape, land use, manifestations of degradation processes and environmental threats and the scale of the final cartographic information. The regular method allows the independence of the choice of objects from the type of landscape, soil type, land use and environmental threats. A vector method can be considered, when monitoring objects are placed in certain directions from the source of pollution at some distance from each other.

Irregular method means the choice of the object on the principle of typical natural and economic features. The network of observations and sampling by this method is organized taking into account landscapes (automorphic, transit and accumulative) land use systems (forest, arable land, floodplain, reclaimed and non-reclaimed soils), soil condition (degraded or cultivated options).

Types, subtypes, and varieties of soils, which reflect the levels of anthropogenic loads in the maximum (and proportional) degree, act as objects of monitoring in this case. The irregular method allows the use of areas adjacent to sources of various industrial emissions, opencast mining, wastewater storage facilities, military training grounds and others as monitoring objects.

The irregular method allows, on the one hand, to adapt sites to typical landscapes, different types of land use, soil structure, and on the other – to sources that worsen the environmental condition and lead to soil degradation.

Irregular method involves the active use of all previously accumulated information about the soil cover. An irregular monitoring network can be formed by local specialists who have relevant attributive and cartographic information in detail.

2.8.3. Selection of indicators to monitor the soil condition and soil monitoring programs 79

Soil condition is diagnosed by information on changes in soil structure, land transformation, assessment of rates of change in key soil indicators (*humus, pH, absorption capacity, physical, water and nutrient regime, pollution, biological activity of soils*), assessment of intensity of erosion processes indicators of reclaimed land quality (*irrigation water quality, groundwater level and mineralization, salinity of soils and rocks of the aeration zone, secondary salinization, assessment of*

drainage rates of drained peatlands, transformation of organic matter, secondary iron ore, etc.), as well as assessment of effective yield fertility crop products.

The most popular indicators used in soil monitoring are: *total carbon, macronutrients, heavy metals, nitrates, pH, particle size distribution and cation exchange capacity*. Less popular — *structure density, aggregate composition, porosity, electrical conductivity, chemical composition of soil solutions*. Least used — *fractional composition of organic matter, microbiological indicators, emissions from soil.*

The soil monitoring program, in accordance with the requirements of the standards, consists of:

✓ general considerations;

✓ elements of the monitoring program, which include: the status of monitoring sites, changes in monitoring sites, interpretation of the status and changes and selection of sites;

✓ sampling and measurement, which consists of: general provisions, design and identification of the site, description of the soil and site, sampling, field and laboratory measurements, sample bank and time interval between samplings is carried out in accordance with ISO 16133.

Terminology to chapter 2.8:
background/reference monitoring — фоновий (еталонний) моніторинг;
production (*basic, standard, current*) monitoring — виробничий (базовий, стандартний, поточний) моніторинг;
crisis monitoring — кризовий моніторинг;
special purpose — спеціальний моніторинг;
scientific (*prognostic*) monitoring — науковий (*прогностичний*) моніторинг;
reclaimed and non-reclaimed soils — меліоровані й немеліоровані ґрунти;
arable land — рілля;
floodplain — заплава;
particle size distribution — гранулометричний склад;
cation exchange capacity – ємність катіонного обміну.

Answer the questions

1. What are the types for soil monitoring?
2. What do we call production soil monitoring?
3. What do we call scientific (forecasting) soil monitoring?
4. What indicators are included in soil monitoring program?
5. What is the regular method for forming soil monitoring network about?
6. What is the irregular method for forming soil monitoring network about?

2.9. Environmental monitoring in the field of waste

General provisions for waste monitoring.
Environmental monitoring in the field of waste at the regional level.
Wastes monitoring for the certain environmental components (air and land monitoring).
Environmental monitoring in the field of municipal solid wastes management.

2.9.1. General provisions for waste monitoring

Waste monitoring is carried out in order to:

– ensuring the collection, processing, storage and analysis of information on waste generation and their impact on air, water, soil;

– assessment and forecasting of changes in environmental components;

– development of scientifically sound recommendations for making management decisions in the field of waste management;

– informing the population about the impact of waste on the environment, health and livelihoods.

According to Article 29 of the Law of Ukraine "On Waste" monitoring of waste generation, storage and disposal is part of a single system of National Environmental Monitoring. The basic principles of functioning of the National Environmental Monitoring System are defined in the Resolution of the Cabinet of Ministers of Ukraine of March 30, 1998 № 391 "On Approval of the Regulations on the National Environmental Monitoring System" (NEMS). Organizational integration of the monitoring system governmental bodies is carried out by the Ministry of Ecology and Natural Resources of Ukraine, regional, Kyiv city state administrations, executive bodies. At the regional level, the establishment and operation of environmental monitoring systems are carried out in accordance with the Guidelines for the establishment

of environmental monitoring systems at the regional level, approved by the order of the Ministry of Ecology and Natural Resources of Ukraine of December 16, 2005 № 467.

2.9.2. Environmental monitoring in the field of waste at the regional level

Environmental monitoring in the field of waste at the regional level is carried out by places or objects of waste management:

- places and facilities where the total amount of waste treatment or disposal is 100 tons per year or more;
- waste storage sites and facilities;
- waste disposal sites and facilities where they are stored for more than 2 years;
- solid waste management facilities (SWMF).

Governmental bodies responsible for environmental monitoring at the regional level develop Regional environmental monitoring programs and agree them with the Ministry of Ecology and Natural Resources.

Regional environmental monitoring programs are subject to strategic environmental assessment in accordance with the requirements of the Law of Ukraine "On Strategic Environmental Assessment".

When organizing and conducting environmental monitoring in the field of waste, the objects of the environment that are monitored are:

– atmospheric air;

– groundwater and surface water;

– land in the area of impact of waste management sites or facilities.

When developing waste monitoring sections, the monitoring strategy in the area of impact of waste management sites or facilities should address the following information objectives:

✓ determine the indicators of the state and dynamics of pollution of environmental objects;

✓ determine the qualitative and quantitative indicators of impact factors influencing environmental objects and their dynamics.

The following parameters are defined in the waste monitoring sections:

– number of the point (points, sections, zones) of observations on registration in the departmental observation network/*номер пункту*

(*точки, ділянки, зони*) *спостережень за реєстрацією у відомчій мережі спостережень*;

– number of the point (points, sections, zones) of observations on registration in the regional environmental monitoring system/*номер пункту* (*точки, ділянки, зони*) *спостережень за реєстрацією у регіональній системі моніторингу довкілля*;

– location and coordinates of the point (points, areas, zones) of observations/*місце розташування та координати пункту (точки, ділянки, зони) спостережень*;

– the name of the organization and its structural unit that is to conduct observations/*назва організації та її структурного підрозділу, що має проводити спостереження*;

– frequency of sampling;

– terms of observations;

– list of indicators for observation.

2.9.3. Wastes monitoring for the certain environmental components (air and land monitoring)

Normative documents on the atmospheric *air monitoring* are:

o *Resolution of the Cabinet of Ministers of Ukraine* dated 14.08.2019 № 827 "Some issues of national monitoring in the field of air protection";

o *Methodical recommendations* on the establishment of a regional environmental monitoring system, approved by the order of the Ministry of Environmental Protection 16, 2005 № 467;

o *Order* of the Ministry of Environmental Protection and Nuclear Safety of Ukraine dated 14.01.1999 № 12 "On approval of the Instruction on the content and preparation of the passport of waste disposal sites".

Information data for air monitoring of waste management facilities (the major ones from the full list) are as follows:

- full name of the owner of the place or object and the NSRUEO code (National State Registry of Ukrainian Enterprises and Organizations);
- location of the site or object of waste management from the indication of geographical coordinates;
- distance and direction of location relative to the nearest settlement, indicating its name;

➢ code, name, group of waste disposed at this site, according to the State Waste Classifier of Ukraine SC 005-96 “Waste Classifier”;

➢ qualitative and quantitative composition and properties of waste that is treated, disposed of, stored and utilized;

➢ the level of the waste hazard to the environment and human health;

➢ availability of sanitary protection zone and its size;

➢ list of pollutants subject to monitoring, assessment thresholds, limit values and other levels of pollutants for which air quality assessment is carried out;

➢ data from the protocols of the latest air quality observations in the area of waste disposal sites or facilities;

➢ developed measures to reduce the load on the air of the most harmful factors and assess their effectiveness.

Information data for *land monitoring* of waste management facilities are close to mentioned above but the special ones are as follows:

– agrochemical certification of land plots, survey and observations;

– assessment of processes related to changes in soil fertility (development of water and wind erosion, loss of humus, deterioration of soil structure, waterlogging and salinization);

– assessment of land pollution by pesticides, heavy metals and other toxic substances;

– list of pollutants subjected to monitoring, assessment thresholds;

– average data from the protocols of the latest observations on soil quality in the area of impact of places or objects of waste management;

– developed measures to reduce the load on the land of the most harmful factors and assess their effectiveness.

Land monitoring is carried out in the following order:

o performing special land surveys;

o identification of negative factors, the impact of which requires control;

o assessment, forecast, prevention of negative processes.

2.9.4. Environmental monitoring in the field of municipal solid wastes management

The monitoring system in the field of *municipal solid waste management* should cover environmental objects, namely: groundwater and surface water, atmospheric air, geological environment and soils,

flora and fauna, which are located within the objects of solid waste management or related to them. Governmental bodies or other entities responsible for *municipal solid waste* (MSW) management organize and carry out observations at all stages of their management, from collection, transportation to sites or facilities for processing or disposal, monitoring of landfills and ensuring sound assessment of environmental risks of closure and reclamation of landfills.

A separate block of the observation network is developed for each environmental object, which includes points (sections, zones), indicators and frequency of observations.

Governmental bodies or other entities responsible for *municipal solid waste* monitoring at local level are organizations responsible for waste generation sites, waste disposal sites. They organize and conduct primary production control over the state of waste monitoring at subordinate facilities.

Governmental bodies or other entities responsible for *municipal solid waste* monitoring at regional level process, analyze the obtained data of operational monitoring information and provide information content of their own databases of operational monitoring information on waste management, namely:

– databases of operational monitoring information on environmental facilities in places or facilities for waste management;

– databases of operational monitoring information on environmental facilities in the field of solid waste management.

They are local state administrations, as well as executive bodies of village, settlement, city councils within their competence exercise control over the state of waste monitoring in the jurisdiction.

State control over the environmental monitoring in the field of waste is entrusted to the State Environmental Inspectorate and its territorial bodies. Regional waste monitoring entities are developing and implementing a system of informing the public about the state of waste management in the region.

Terminology to chapter 2.9:

solid waste management facilities (SWMF) — об’єкти поводження з твердими побутовими відходами (ТПВ);

Strategic Environmental Assessment (SEA) — стратегічна екологічна оцінка (СЕО);

frequency of sampling — періодичність відбору проб;
terms of observations — терміни проведення спостережень;
list of indicators for observation — перелік показників для спостереження.

Resolution of the Cabinet of Ministers of Ukraine "Some issues of National Environmental Monitoring in the field of air protection" — Постанова Кабінету Міністрів України «Деякі питання здійснення державного моніторингу в галузі охорони атмосферного повітря».

Methodical recommendations on the Regional Environmental Monitoring System — методичні рекомендації з питань створення системи моніторингу довкілля регіонального рівня.

Order of the Ministry of Environmental Protection "On approval of the Instruction on the content and preparation of the passport of waste disposal sites" — Наказ Міністерства охорони довкілля «Про затвердження Інструкції про зміст і складання паспорта місць видалення відходів».

National State Registry of Ukrainian Enterprises and Organizations (NSRUEO) — Єдиний державний реєстр підприємств та організацій України (ЕДРПОУ) closure and reclamation of landfills — закриття та рекультивації полігонів

Answer the questions

1. *What the main governmental regulations in environmental monitoring in the field of wastes management?*
2. *What are the peculiarities of municipal solid wastes monitoring at regional level?*
3. *What are the governmental bodies or entities responsible for wastes monitoring?*
4. *What information is needed when atmospheric air wastes monitoring?*
5. *What information is important when land wastes monitoring?*
6. *What are the municipal solid waste management facilities?*
7. *What is National State Registry of Ukrainian Enterprises and Organizations?*
8. *How is the list of indicators for observation determined?*

2.10. Types of special purpose monitoring

Crisis monitoring and monitoring of hazardous natural phenomena.
Monitoring in case of environmental emergencies.
Public environmental monitoring.

2.10.1. Crisis monitoring and monitoring of hazardous natural phenomena

Crisis environmental monitoring is an observation organized under special programs for the following purposes: control of natural objects and sources of man-made impact, located in areas of environmental tension, in areas of accidents and dangerous natural phenomena; ensuring prompt response to crisis and environmental emergencies; analysis and assessment of risks as a quantitative characteristic of danger to the population and the environment; forecasting possible negative consequences and making decisions on their elimination; creation of normal conditions for life of the population and economy.

Objectives of crisis monitoring:

✓ timely protection of the population and territories from emergencies of man-caused and natural character, prevention them, response to them from the relevant central and local executive bodies;

✓ creation and maintenance in constant readiness of national and territorial systems of supervision and control with use of available forces and means of control;

✓ organization of collection, processing and transmission of information on the state of the environment, contamination of food, food raw materials, fodder, water with radioactive, chemical substances, microorganisms and other biological agents.

Some of the grounds for declaring a separate area an environmental emergency zone are as follows:

– *significant exceeding* of the maximum allowable norms of quality indicators of the environment, defined by the legislation;

– *negative changes* that have occurred in the natural environment over a large area and *which cannot be eliminated* without the application of emergency measures from the governmental bodies;

– *negative changes* that have occurred in the natural environment and *which significantly limit or exclude* the possibility of living and doing business in this area, and others.

Monitoring of natural phenomena is a system of monitoring the processes of natural or combined origin of powerful destructive force, which periodically occur in almost all subsystems of the environment and differ in places of manifestation and development, impact and scale of damage. *Natural processes and phenomena* are usually beyond

human control, their occurrence can cause significant economic damage and lead to catastrophic consequences *(cyclones, tornadoes, lightning, floods, tsunamis, earthquakes, volcanic eruptions, landslides, etc.)*.

Despite the deep differences in the mechanisms of occurrence, most natural phenomena are subjected to three common laws:

- certain types of natural phenomena have a specific spatial and territorial adaptation;
- natural phenomena are characterized by recurrence over time;
- with a certain probability it is possible to determine the dependence of the destructive effect of a natural disaster on the *scale, duration and intensity* of geological and hydrometeorological processes.

According to these laws, the monitoring of natural phenomena has specific tasks: fixing the places of manifestation of natural processes; determination of their parameters and periodicity of manifestation (cyclical process); assessing the nature of the consequences and the extent of losses.

Regardless of the source of origin, all natural phenomena are characterized by significant power and different duration of the manifestation of destructive forces.

2.10.2. Monitoring in case of environmental emergencies

Crisis situations arise not only due to accidents or natural disasters, but also due to integrated anthropogenic pressure on the environment in interaction with the conditions of natural systems functioning.

The levels of integrated anthropogenic load and levels of risk to human health are determined by *environmental zoning* of the territory according to various indicators and criteria, which is a component of crisis monitoring.

This type of monitoring research is a means of assessing the level of environmentally dangerous genetic changes in the natural environment and its subsystems, identifying problematic sectors of the economy and enterprises with the most negative impacts on the environment and public health.

The results of *environmental zoning* specify the conditions for the development of crisis situations — their areas, spatial localization, on the basis of which complexes of preventive environmental measures are developed and the order of their implementation is determined.

Depending on the consequences of man-made and natural emergencies, the amount of technical and material resources required for their elimination, the levels of emergencies *national, regional, local, detail* are determined.

Environmental emergency is an emergency situation in which negative changes in the environmental components have taken place in a certain area, which require the application of emergency measures from the governmental bodies. Thus the separate district of Ukraine on which there was an environmental emergency, can be declared *as a zone of environmental emergency.* The decision on whether or not to determine environmental emergency zone is made by the relevant commission on technogenic and environmental safety (*state, regional, district*).

In the event of environmental emergency, the relevant commission (emergency headquarters) should organize permanent monitoring of the national, regional, local and detail level within the affected area and adjacent territories, as well as forecasting the zone of possible spread of emergencies and the scale of possible consequences.

For measurements and sampling of environmental components it is possible to use *remote sensing methods* that allow you to quickly obtain information about the environmental condition over large areas.

Stationary automatic points for measuring environmental indicators or sampling are implemented as needed. If automated monitoring systems are available, their data should be used to assess the situation.

Thus, the governmental bodies responsible for environmental monitoring during the emergency, measure the pollution of environmental components, assess the state of the environment, exchange information and provide information to the relevant commission.

This information is provided to the National Commission for man-made and environmental safety and emergencies, which coordinates the activities of central and local executive bodies.

2.10.3. Public environmental monitoring

Public environmental monitoring is a separate type of monitoring. It is not part of the national environmental monitoring system, but its results can be taken into account when assessing the state of the environment and including in a particular area.

Public environmental monitoring is the monitoring of special programs initiated by public environmental organizations, independent control of the quality of the environment or its individual components in a particular area (or facility) to assess, analyze and forecast the state of the environment and determine the level of environmental hazard for local population. The results of such monitoring are mostly used by the public to protect their environmental interests and influence the relevant public administration bodies responsible for technogenic and environmental safety.

Non-governmental organizations (NGOs) and *voluntary associations* can contribute to environmental monitoring, especially on inventories of animal and plant species, monitoring changes in the condition of small rivers, pollution levels in recreational areas, parks and landscapes, and more. A new promising task of public monitoring is the analysis and assessment of the real environmental consequences of various projects and their comparison with the impacts that took place at the stage of project development.

Positive consequences of public environmental monitoring:

– creation of an alternative information channel;

– increasing the efficiency of environmental control and the effectiveness of public awareness of environmental emergencies;

– conducting observations of facilities that are not included in national and regional programs;

– drawing attention to environmental issues not previously mentioned;

– development of environmental education.

The educational value of public environmental monitoring is very important. The concept of "environmental education" is given here in a broad sense. Public activities in the field of environmental monitoring help to increase the level of environmental education of all participants in public dialogue: the population, managers and ordinary employees of enterprises, government officials.

NGOs can properly use information about the state of the environment to form a conscious, environmentally sound position of society as a whole. The public has the right to send its comments and suggestions to the representative, advisory and consultative bodies in due time. Proposals and comments of the public on draft regulations should be considered and taken into account under current legislation.

Terminology to chapter2.10:
cyclones — циклони;
tornadoes — торнадо;
lightning — блискавка;
floods — повені;
tsunamis — цунамі;
earthquakes — землетруси;
volcanic eruptions — виверження вулканів;
landslides — зсуви;
destructive forces — руйнівні сили;
environmental emergency — надзвичайна екологічна ситуація (НЕС);
public environmental monitoring — громадський екологічний моніторинг;
monitoring in case of environmental emergencies — моніторинг довкілля при надзвичайних ситуаціях;
monitoring of hazardous natural phenomena — моніторинг стихійних природних явищ.

Answer the questions

1. *What do we understand under crisis monitoring?*
2. *What are the objectives of crisis monitoring?*
3. *What emergencies of natural character do you know?*
4. *What are the specific features of monitoring in case of environmental emergencies?*
5. *What environmental non-governmental organizations in Ukraine do you remember?*
6. *What are the peculiarities of public environmental monitoring?*
7. *What are its objectives? How is it integrated into National Environmental Monitoring system?*

2.11. Radiation and transboundary environmental monitoring

Radiation monitoring.
Transboundary Monitoring.

2.11.1. Radiation monitoring

Radiation monitoring is a system of observation, collection, processing, transmission, storage and analysis of information about the radiation status of the environment, forecasting its changes and effects on humans, as well as preparing scientifically sound recommendations for management decisions.

The purpose of radiation monitoring is to obtain knowledge, in the presence of which a person will be protected from radiation without unreasonable restrictions on the activities of profitable industries, some workers of which receive additional doses relative to the background.

Knowledge is needed not only about current exposure, but also about potential exposure during some critical events in the future

Human exposure occurs as a result of a whole chain of events. This chain starts from the radiation source. Then in different ways radioactive substances get into the environment inhabited by a man, and then irradiated a whole group of people. If we take into account natural sources of radiation, it turns out that everyone is exposed to radiation from several sources. Thus, radiation monitoring is necessary both in the creation of new sources of radiation and in all ways of redistribution of existing materials and substances containing radionuclides, not excluding the monitoring of the existing background radiation status of the human habitat. As part of the conventional monitoring, radiation monitoring is based on the following principles: objectivity and reliability, systematic observations of the radiation status of the environment, the impact on the environment and population from various sources; multilevel, consistency of regulatory and methodological support; complexity in the assessment of radiological information; efficiency in transmitting information and informing the executive authorities; openness of radiological information. Depending on the radiation situation, radiation monitoring is divided into three types: *conventional, potential and crisis*. Each type of monitoring is based on special principles.

Basic principles of *conventional radiation monitoring* of human activity in normal conditions:

- any practical activity that causes human exposure is not prohibited if it benefits the exposed person or society as a whole more than it harms (*the principle of justification*);
- exposure levels from all regulated practices should not exceed the established dose limits or risk values for potential exposure (*non-exceedance principle*);

▪ individual doses, the number of exposed persons and the probability of exposure in cases where there is no information about the time of their occurrence, for each radiation source should be as low as possible, taking into account economic and social factors (*optimization principle*).

Conventional radiation monitoring provides us knowledge about the exposure of the population when creating new sources, changing their location, creating new ways of human exposure or changing existing ways when there is an increase in individual radiation doses or the number of irradiated people.

Potential radiation monitoring is based on the following principles:

– any practical activity that may expose people should be prohibited if it does not benefit individuals and society as a whole more than the harm it can do to both present and future generations in the face of critical events;

– all practical activities should not lead to exceeding the values of dose levels or risks of potential exposure;

– the probability of critical events, the dose of potential exposure, the number of people who may be affected by such sources should be as low as possible, taking into account economic and social factors.

Potential radiation monitoring provides knowledge about the exposure of the population in the event of any crisis situations that cause changes in existing sources and ways of affecting them to the population.

The system of *crisis radiation monitoring* is based on the following principles:

o the proposed intervention may be more beneficial than harmful, i.e. it reduces the damage by reducing radiation doses and should not exceed the harm and economic costs, including social, arising from the intervention;

o the form, scale and duration of the intervention should be optimized so that the benefit of reducing the dose compared to the damage is maximized.

Crisis radiation monitoring provides knowledge about the exposure of the population by removing existing sources, changing the ways they affect the population or reducing the number of exposed persons.

Social aspects of radiation monitoring. Monitoring in general, and radiation in particular, is, in fact, a difficult process, as the goals and interests of the individual and society in general may not coincide.

Because the benefits and harms of radiation are unequally distributed in society, injustice arises — some have more benefits, others more harm. This injustice can be partially remedied by intensifying monitoring in an environment populated by people at high radiation risk.

Components of radiation monitoring. In order to gain knowledge about a particular source in radiation monitoring, we can distinguish its component — *source monitoring*, and in order to gain knowledge about the protection of the individual from the effects of many sources — *individual monitoring*.

Radiation monitoring has some peculiarities due to the fact that there are *four groups* of potential sources to be monitored:

- sources of potential exposure that may cause exposure to an individual or a limited group of people;
- sources related to possible radiation accidents, as a result of which large groups of the population may be irradiated and (or) pollution of environment components may occur;
- sources that arise in the future at facilities that are not subject to radiation control, due to natural abnormal processes and disasters, as well as unintentional human interventions, which exposes the population at the time of such an event and threatens to irradiate future generations;
- sources of potential exposure of people during radiotherapy and radiodiagnostic procedures. This type of monitoring is carried out by the Ministry of Health Protection.

Source monitoring makes it possible to assess the extent to which the benefits of using the source outweigh the harm caused to the population through irradiation, the correctness of measures to protect the source, as well as assess the dose, probability of exposure, the number of exposed. However, according to the results of this type of monitoring, it is impossible to determine the full doses of exposure of the individual from all possible sources. *Individual monitoring* makes it possible to estimate the total radiation doses received by an individual, which is necessary to assess the likelihood of stochastic effects and determine whether there is a threshold of non-stochastic effects exceeded.

Radiation control as an integral part of radiation monitoring. Since there are three types of human exposure (*occupational, medical and public exposure*), radiation monitoring of these parameters can also be divided into three types:

– radiation control in the workplace, which provides knowledge about the exposure of professionals;

– radiation control during medical irradiation, which provides knowledge about the irradiation of patients;

– radiation control of the population, which gives knowledge about all other types of radiation.

Governmental bodies responsible for radiation monitoring.

Radiation monitoring on the territory of Ukraine is carried out by the governmental bodies of national and regional level and agencies, which are entrusted with the functions of radiation monitoring.

Ministry of Health Protection of Ukraine carries out radiation monitoring of food, building materials, drinking water, air, radiation.

State Emergency Service of Ukraine carries out radiation monitoring of the territory of Ukraine, as well as the radiation situation at the locations of radioactive waste disposal sites. *The Hydrometeorological Service* measures the level of gamma measurement background, activity in precipitation and water bodies on the territory of Ukraine.

Ministry of Agrarian Policy and Food of Ukraine carries out radiation monitoring of agricultural plants and products thereof, farm animals and products thereof, surface waters and agricultural soils.

Ministry of Ecology and Natural Resources of Ukraine carries out radiation monitoring of territories in the sanitary protection and 30-kilometer zones of the NPP.

State Service of Ukraine for Geodesy, Cartography and Cadastre conducts radiation monitoring of soils and landscapes, irrigated and drained lands, vegetation.

State Forest Resources Agency of Ukraine performs radiation monitoring of forest soils, plants, and vegetation.

Ukrainian Geological Survey is responsible for radiation monitoring of groundwater in terms of presence of radionuclides.

State Water Agency carries out radiation monitoring of seas, rivers, reservoirs and surface sources of water supply, groundwater and seawater.

National Space Agency of Ukraine monitors the radiation status of natural objects with the help of aerospace technology.

Enterprises working with radioactive materials in the open form carry out radiation monitoring of emissions and discharges for the presence of radionuclides, territories and sanitary protection zones of enterprises.

2.11.2. Transboundary Monitoring

Transboundary monitoring (TBM) is carried out by agreement of two or more stakeholders, which are border states. The basis for the organization of transboundary monitoring are international conventions ratified in Ukraine, international and interstate agreements.

In Ukraine as for today the TBM is carried out on water, atmospheric air, biological diversity, forests, wastes management.

The implementation of TBM is usually planned within the framework of international projects and agreements under special programs. The purpose of the projects under which the TBM programs are implemented is, first of all, to coordinate and implement joint decisions and measures for stakeholders to prevent environmental hazards and improve management methods in the field of environmental protection. The effectiveness of projects is assessed by environmental targets — environmental indicators of the state of the environment, the impact of factors on environmental change, socio-economic progress and implementation of joint management decisions in the field of environmental protection and environmental safety.

The TBM programs should provide the following:

✓ information needs for the implementation of tasks within special international projects, including the definition of indicators;

✓ the possibility of calculating the transboundary movement of pollutants and (or) other factors of negative impact on the environment of border countries;

✓ assessing the effectiveness of measures taken by stakeholders — border countries — to improve environmental conditions on their territory.

The following issues are taken into account when developing TBM programs and setting their priorities: sources of conflicts between border countries; multifunctional approach; plans of economic activity of the parties in the border area; national features of management of nature protection activities of the parties; identification of their information needs; evaluation methods based on monitoring results.

An important aspect of the effective functioning of the TBM subsystems as part of the NEMS is the use of:

– unified means of measuring equipment and standardized equipment;

– agreed and unified within the TBM subsystems methods of determining the status of the objects under observation;

– agreed on indicators and terms of implementation of observation programs;

– unified methods of collecting and processing information, assessment, modeling and forecasting of environmental processes.

The TBM subsystems are the most acceptable for determining the feasibility, efficiency and technological features of aerospace and automated methods of observation, information collection, early warning of extreme levels of pollution, in particular, in the monitoring of surface and sea water, atmospheric air monitoring.

Terminology to chapter 2.11:
human exposure — опромінювання людини;
radionuclides — радіонукліди;
background radiation status — фоновий радіаційний стан середовища;
objectivity and reliability — об'єктивність і надійність;
conventional radiation monitoring — загальний радіаційний моніторинг;
potential radiation monitoring — потенційний радіаційний моніторинг;
crisis radiation monitoring — кризовий радіаційний моніторинг;
principle of justification — принцип виправданості;
non-exceedance principle — принцип не перевищення;
optimization principle — принцип оптимізації;
source monitoring — моніторинг джерела;
individual monitoring — моніторинг окремого індивідуума;
stochastic effect — стохастичний ефект.

Answer the questions

1. *What is the concept of radiation monitoring? What are its objectives?*
2. *What is conventional radiation monitoring about?*
3. *What is potential radiation monitoring about?*
4. *What is crisis radiation monitoring about?*
5. *What are the principles of radiation monitoring?*
6. *What are the governmental bodies in Ukraine responsible for radiation monitoring? What exactly are they responsible for?*
7. *What do we call transboundary environmental monitoring?*
8. *What do the TBM programs should provide?*

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