BIOINDICATION AND ITS PLACE IN THE ENVIRONMENTAL MONITORING SYSTEM

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The second half of the XX century was marked by the realization by mankind that it is necessary to create a system for monitoring the state and change of the natural environment on planet Earth. For the first time, the issue of an International program of Global Observations of changes in the Biosphere was considered in 1971 by the Scientific Committee on Environmental Problems. In preparation for the UN Conference on Environmental protection, experts discussed issues related to the creation of a global monitoring system. It was decided to understand monitoring as a system of continuous monitoring, measurement and assessment of the state of the environment. During the conference, a recommendation was developed for the development and a decision was made to create a GSMOS – a global environmental monitoring system.

In the future, the concept of monitoring has expanded somewhat, in connection with which it can be defined as "a system of monitoring and monitoring the state of the human environment in order to develop measures for its protection, rational use of natural resources and warning of critical situations harmful to the existence of living organisms."

The term "monitoring" appeared before the UN Stockholm Conference on the Environment in 1972. It was decided to understand monitoring as a system of continuous monitoring, measurement and assessment of the state of the environment.

Environmental monitoring is a comprehensive system of observations, assessment and prediction of changes in the state of the environment. This term refers to regular observations of natural environments, natural resources, flora and fauna, carried out according to a uniform set program, which make it possible to identify changes in their state and processes occurring in them under the influence of anthropogenic activity.

Environmental monitoring is thus organized monitoring of the natural environment, in which: firstly, a constant assessment of the environmental conditions of the human habitat and biological objects (plants, animals, microorganisms) is provided, as well as an assessment of the state and functional integrity of ecosystems; secondly, conditions are created for determining corrective actions in cases where when environmental targets are not met.

If we talk about the monitoring structure, it looks like this.

The monitoring objectives include: assessment of observed changes and identification of the effect of human activity, forecast of expected changes in the state of the environment, as well as decision-making to prevent negative consequences of human activity and the development of a strategy for the optimal attitude of society to the environment. The tasks of environmental

monitoring are: monitoring the state and change of the natural environment, as well as identifying the causes of changes in the latter.

Currently, environmental monitoring is carried out primarily to control anthropogenic impact on the biosphere.

Since the environment includes a large number of factors that can influence the state of the biotic and abiotic components of the biosphere, environmental monitoring should be based on the following independent elements: monitoring of the natural environment, monitoring of the transformed and artificial environment, as well as monitoring of the anthroposphere. In turn, each of these elements is subdivided into a number of components characteristic of it.

One of the components of environmental monitoring is biological monitoring – a system of observations, assessment and prediction of any changes in biota caused by factors of anthropogenic origin. The structure of biological monitoring is quite complex. It is built from separate subprograms based on the principle based on the levels of organization of biological systems. Thus, genetic monitoring corresponds to the subcellular level of the organization, environmental monitoring corresponds to the population and biocenological levels. Each level has its own set of biological variables.

The primary task of biological monitoring is to monitor the level of pollution of biota. Responses or biological consequences associated with exposure to pollution are recorded within the framework of special subprograms. Biological monitoring is designed to expand and deepen the system of knowledge and methods on the observation, assessment and prediction of the state of the biotic component of the biosphere in order to create a basis for environmental quality management. It includes: development of early warning systems, diagnostics and forecasting. The main stages of activity in the development of early warning systems are the selection of suitable organisms and the creation of automated systems capable of detecting "response" signals with sufficiently high accuracy. Diagnostics involves the detection, identification and determination of the concentration of pollutants in the biotic component based on the widespread use of monitor organisms (indicators). The forecast of the state of the biotic component of the environment can be carried out on the basis of biotesting and ecotoxicology.

The simplest example of an extreme reaction of a living person to a strong impact of harmful factors is the mass death of animals and plants. If we observe mass death of insects, animals, fish or plants in the natural environment, it means that there is a factor in this area that caused this phenomenon. The relevant services should be informed about this case. Take measures to eliminate it.

For example, a medical leech is one of the indicators of pollution of reservoirs. Its range covers vast areas in Ukraine and Belarus, after the Chernobyl disaster in reservoirs that fell into the zone of radioactive contamination, first of all this species died, many other aquatic organisms adapted to the changed environmental conditions [5].

Another type of reaction of living organisms to less severe exposure to harmful factors is manifested in their depressed state, growth retardation, developmental anomalies. So, for example, when an excess of individual elements gets into the soil, the leaves of plants can acquire an unnatural color (from pale yellow to red-purple).

Structure of environmental monitoring

MONITORING		
OBSERVATION	**ESTIMATION**	**FORECAST**
the state of the environment and the factors affecting it	the actual state of the environment	the state of the environment

The so-called indicator species are the most sensitive to certain environmental changes. These species are very sensitive to certain factors and clearly react to their changes, even if other, less sensitive to this factor species easily tolerate such changes.

Bioindication is an assessment of the quality of the habitat and its individual characteristics according to the state of the biota in natural conditions. To account for environmental changes under the influence of anthropogenic factors, lists of indicator organisms are compiled.

A bioindicator is a group of individuals of the same species or community, by the presence or condition of which, as well as by their behavior, natural and anthropogenic changes in the environment are judged.

Since changes in biological systems can often be caused by anthropogenic factors, the very concept of "bioindication" can be formulated as follows: Bioindication is the detection and determination of biologically and ecologically significant anthropogenic loads based on the reactions of living organisms and their communities to them.

Biological methods allow us to obtain information about the direct reaction of organisms, communities or ecosystems to natural or anthropogenic changes, since biota reacts even to minor changes in external conditions. The use of biological methods to assess the environment implies the identification of animal or plant species that are sensitive to a particular type of exposure. Organisms or communities of organisms whose vital functions correlate so closely with certain environmental factors that they can be used for their assessment are called bioindicators [3].

With the help of bioindicators, it is possible to detect places of accumulation in ecological systems of various kinds of pollution; they can be used to track the rate of changes occurring in the environment; only by bioindicators it is possible to judge the degree of harmfulness of certain substances to wildlife. Live bioindicators have a number of advantages over chemical methods for assessing the state of the environment, which are widely used at present:

* they summarize all, without exception, biologically important data about the environment and reflect its state as a whole,

* in conditions of chronic anthropogenic loading, bioindicators can respond to very weak effects due to dose accumulation,

* eliminate the need to register physical and chemical parameters of the environment,

* make it unnecessary to use expensive and time-consuming physical and chemical methods to measure biological parameters; living organisms are constantly present in the human environment and react to short-term and salvo emissions of toxicants, which may not be registered using an automatic control system with periodic

— sampling for analysis,
— record the rate of changes occurring in the surrounding environment,
— indicate the ways and places of accumulations of various kinds of pollution in ecological systems and possible ways of getting these substances into
— human food,
— allow us to judge the degree of harmfulness of human-synthesized substances for nature and humans and allow us to control the effect of these substances,
— they help to normalize the permissible load on ecosystems that differ in their resistance to anthropogenic impact, since the same composition and volume of pollution can lead to different reactions of natural systems in different geographical zones.

Finally, bioindicators reveal trends in the development of the environment.

There are several different forms of bioindication. If two identical reactions are caused by different anthropogenic factors, then it will be a non-specific bioindication. If certain changes can be associated with the influence of any one factor, then this type of bioindication is called specific.

Bioindicators for responses to external influences can also be classified into several types. Firstly, in a number of animal species, the number of populations changes significantly in conditions of environmental disturbance. These will be quantitative bioindicators. Along with them, there are qualitative bioindicators, by the presence or absence of which it is also possible to characterize the biocenosis [3].

The use of living organisms as biological indicators for environmental change necessitates the development of a number of criteria on the basis of which indicator species can be selected. In relation to animals, such criteria may be: availability in a large range of habitats during the season, low migration capacity, nutrition in polluted ecosystems, high metabolism, rapid alternation of generations. These requirements, as well as a number of others, are highly satisfied by soil-dwelling invertebrates that make up 90-99% of the biomass and 95% of the species composition of terrestrial biocenoses. They react to anthropogenic impact more sensitively and earlier than it can be detected on the basis of soil analyses and physical measurements. In agriculture, soil invertebrates can be used to assess the impact of pesticides, mineral fertilizers, agricultural machinery, In urbanized areas they are bioindicators of the spread of heavy metals, radionuclides, acid precipitation, air pollution, and indicate changes

in the water regime of soils during land reclamation. Soil-dwelling invertebrates suitable for bioindication have the following advantages: sufficient abundance in all biotopes, lead a sedentary lifestyle, are accumulators of some elements, have a wide distribution area, methods of their collection are quite well developed. A very important feature of this group of animals is the fact that the development cycles of many of them last for 3-4 years and as a result, even at low concentrations, animals receive a high total dose of the pollutant. It should also be borne in mind that soil-dwelling invertebrates are in contact with soil pollutants almost throughout their entire life.

The importance of this group of invertebrates as bioindicators is great for biogeocenological, agricultural and forestry research, as well as the organization of environmental protection. With their help, it is possible to detect small, but already dangerous deviations in the environment. And, consequently, to take timely measures to eliminate or neutralize the effects of anthropogenic factors [2].

Along with invertebrates, animals of other groups, in particular, some vertebrates, can be used for bioindication purposes. The requirements for this group of organisms differ somewhat from those for invertebrates. This is due to a number of reasons limiting the bioindicative role of terrestrial vertebrates. In the Russian literature, the following criteria are proposed for bioindicator vertebrates: belonging to different trophic units (since the degree of concentration of substances increases from autotrophs to heterotrophs and large predators, it is advisable to take representatives of different units when indicating any environmental pollution); sedentariness; wide distribution area; relatively high eurytopicity; belonging to natural communities (synanthropic species often differ very significantly in microelement composition from the degree of contamination of the region); simple methods of animal extraction. It also takes into account the fact that the number of species should provide a sufficient amount of material for chemical analyses. It is also believed that the number of indicator species for each region should be limited. In this regard, the following species of animals were proposed in the forest zone for bioindication purposes – European and Altai mole, common brown-toothed, red and red voles, brown bear, and moose. Most researchers do not propose the use of birds for the purposes of accumulative bioindication, since most of them migrate or move over long distances and in different directions in search of food, which does not allow assessing the degree of environmental pollution with sufficiently high reliability.

Amphibians and reptiles are quite convenient for bioindication, although they are currently assigned a minor role. At the same time, frogs and lizards can be a clear indicator of the content of many toxic substances in the soil and water. For example, when there was lead in the soil in the amount of 22.4 mg/kg of dry matter, it was 65.2 mg in lichens, and 75.3 mg/kg in lizards. In the body of frogs in the city, the lead content is 8 times higher than in rural areas, and chromium in urban lizards is 15 times more. The best indicator of environmental pollution can

be considered a green toad. The liver of a land-dwelling toad has 70 times more tin than that of green frogs in water [4].

Despite the large number of criteria for the selection of bioindicators among animal organisms, all of them can be reduced into two main groups: the number of animals and their constant connection with the anthropogenic factor. Based on these requirements, it was proposed to use mouse-like rodents, soil mesofauna and soil microfauna as biological indicators of environmental pollution. All these groups of animals are currently quite widely used in the environmental regulation of radioactive contamination of soils.

It should be noted, however, that it is impossible to reliably classify animal bioindicators, to create their universal system for all anthropogenic compounds and any conditions. They react too differently to poisons, industrial pollution and radioactive substances. However, the bioindication system for specific pollution is very real.

Bioindication can be carried out at different levels of the organization of biological systems. With the increase in the level of organization, the complexity of the system also increases, as a result of which the bioindication of a lower level is included in a higher one. The levels of bioindication include: biochemical and physiological reactions, anatomical and morphological, behavioral and biorhythmic deviations, floral and faunal changes in the community, cenotic and biogeocenotic changes, as well as landscape changes.

The use of bioindication to assess environmental changes puts forward a number of requirements, compliance with which is very necessary to obtain reliable results. Among the latter are the following: the relative speed of research, obtaining sufficiently accurate and reproducible results, the presence of objects used in bioindication in large quantities and with homogeneous properties, as well as the error range compared to other testing methods is no more than 20%.

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