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Strategic Planning of Methods for Monitoring and Assessing the Ecological State of Water Bodies

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ABSTRACT

Environmental safety related to ensuring the sustainable functioning of Water Management covers the areas of water protection and reproduction, rational use of Water Resources and development of water management and land reclamation, and contributes to the coordinated development and management of water, land and other related resources within river basins, as well as achieving maximum socio-ecological well-being, taking into account the interests of all water users. Water management is a special, specific branch of the Russian economy, because its development is directly related to the process of providing water to the population and all sectors of the economy. A special feature of the water management industry is its scale and connection with almost all sectors of the economy. Water management is particularly important in creating the necessary social and living conditions for the population. Water management is closely linked to the most important sectors of the economy, primarily the production form: industry and agriculture. Today, it has significant organizational shortcomings. It is managed, financed and technically directed by various ministries, agencies and services, as well as municipal enterprises of local authorities, which introduces a certain inconsistency in the rational use and protection of Water Resources and does not ensure proper order in ensuring environmental safety. Thus, the state of affairs in the field of water management requires drastic changes in the attitude of the state to the development of the water management complex and the reform of the water resources management system, since the development of this sector of the economy and, in general, the socio-economic development of the country depends on state regulation.

Keywords: development, eco-safe system, ecology, water treatment.

INTRODUCTION

It should be noted that the existing water management system in Russia has many inconsistencies regarding the administrative-territorial orientation, in which management is carried out at the level of administrative divisions with a high degree of centralization and Water Resources Management according to the basin Principle (Brack, 2016).

This does not take into account the main natural factors of formation and interrelation of surface and underground water resources within river basins (Morozov, 2018). Thus, the management mechanism is unbalanced, does not comply with the principles of good governance, requires structural and institutional reforms, the introduction of international standards and best international practices in Water Resources Management (Gleick, 2014).

Currently, the water economy as a link of the national economy has not yet been sufficiently studied: the theoretical foundations of water management complex formation, typing and hierarchical structure have not been developed; there is no clear definition of its territorial, functional and sectoral structure; factors of influence have not been sufficiently studied (Escher, 2018). This is explained by the fact that water management has long been studied mainly in the industry aspect.

The modern regulatory framework for surface water monitoring should be integrated with the regulatory framework of advanced European countries, and in recent years Russia has been harmonizing national regulatory documents with the relevant regulatory documents of highly developed countries of Europe and the world (Gao, 2014).

Surface water monitoring systems in different countries of the world differ significantly from each other due to historical, economic and socio-political conditions, various water resource management systems and specific features of water quality formation in certain regions (Kase, 2018).

Analysis of foreign and domestic monitoring and evaluation methods ecological state of water bodies

Despite a wide range of studies devoted to various aspects of the functioning of water management systems, many issues in this area require a more detailed analysis, in particular, regarding management decisions in the system of integrated use of Water Resources, based on integrated management according to the basin principle. An integrated approach to water management allows for balanced management and development of Water Resources, taking into account social, economic and environmental interests.

An integrated approach to water management systems requires the development of methods for assessing the ecological state of Water Resources, which are based on the requirements of the EU Water Framework Directive. Taking into account the fact that the countries of the European Union have committed to implementing a number of joint strategies on Environmental Protection, a number of authors devote their work to problematic issues of implementing WFD.

Practical ways to implement WFD provisions are reflected, and a critical review of the work on introducing new methods is provided, and recommendations are made based on ten years of experience (Muschket, 2018), but no attention is paid to the specifics of each specific country in implementing the above requirements. A number

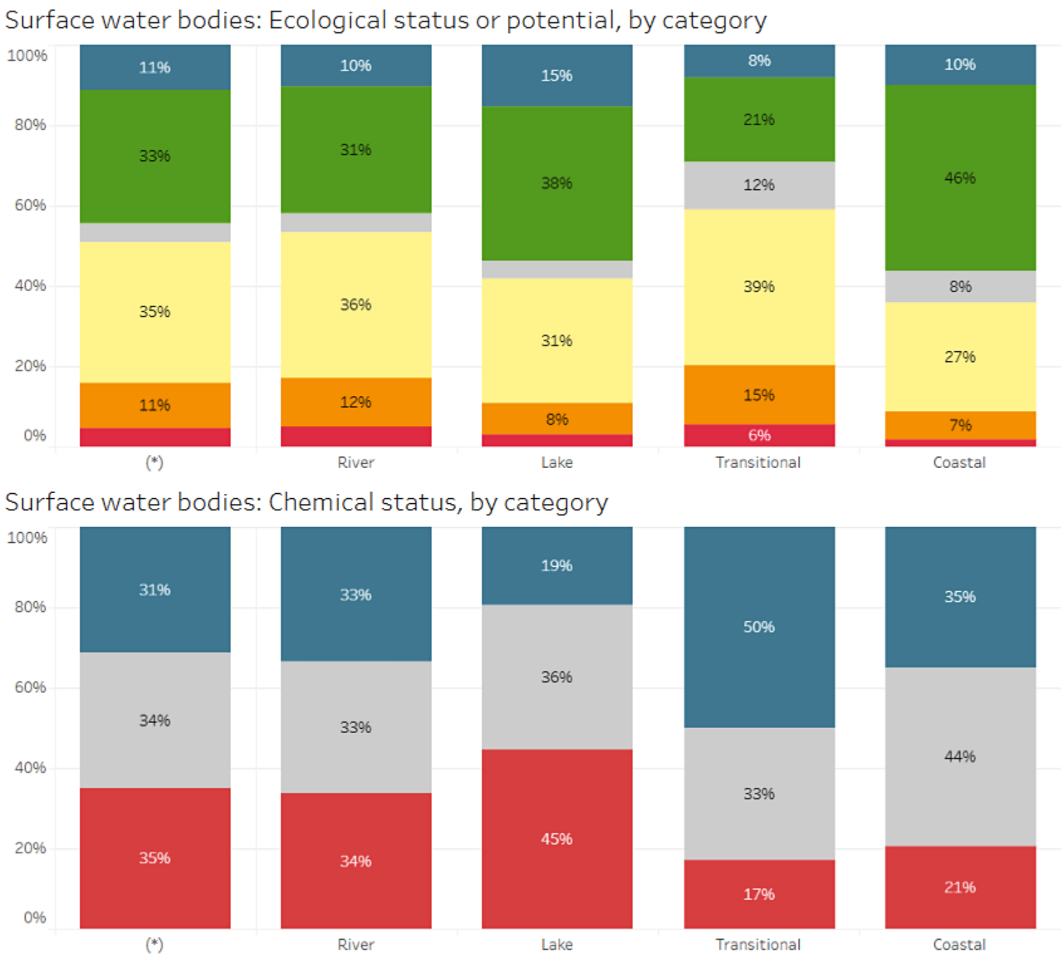

Figure 1. Surface water bodies by ecological status in EU

of authors (Novák, 2018) propose a methodology and tools for a comprehensive assessment of the ecological state of water resources, but only physical-chemical research methods are given.

In the field of water management policy, the actions of the European Union can be caused by reasons due to possible market deformation due to standards that differ in strategic direction.

In France, modern water policy is based on water legislation based on the principles of natural water management. The generalized biological quality index (IQBG) and the biological Total Quality Index (IVG) are used to assess water quality. The classification of water bodies in France distinguishes three classes of water quality (1A - excellent; 1B - good; 2 – acceptable; 3 - mediocre).

The UK has a slightly different water management system from France. In order to improve water management, the UK Government has implemented measures to privatize the water supply service. In terms of monitoring, the state of surface waters is monitored, which are based on the generalization of data on the water quality of rivers and estuaries. Assessment of the state of Water Resources is carried out on the basis of a water typing system that includes 4 classes of water quality, which are characterized by the corresponding species list of aquatic fauna. The system of biological assessment of water quality is based on the use of benthic macro-invertebrates, which is known as RIVPACS (River Invertebrate Prediction Bioassessment Protocols).

In Italy, a modification of the biotic index (EVI) is used to assess the quality of surface water, which takes into account the specific features of the benthic fauna of river waters. The classification used in this case provides for the allocation of 5 classes of water quality, the range of values of which is from 0 to 14.

Spain is implementing EU principles to expand the concept of water management. The leading government agencies in this area are river basin management and the National Water Resources Council.

Germany is expanding the concept of Water Resources Management and making amendments to federal laws: on Water Resources, detergents, waste management. When assessing water quality, the classification of water bodies is used, which provides for the allocation of 4 classes and three intermediate gradations.

In Belgium, the assessment of the ecological state of surface waters is based on modifications of the biotic index and is based on sampling methods, the results of which are used in the development of water pollution prevention programs. The assessment uses a biotic index, the value of which varies from 10 to 0 (from very heavily polluted to slightly or not at all polluted).

In the Netherlands, there is a surface water quality monitoring program that is based on both hydrochemical and hydrobiological levels. Water quality assessment is carried out both by regional modification of the biological assessment and by Unification of individual proposals in order to generalize hydrobiological information.

In Denmark, the classification of water bodies is used to assess and manage water quality, which provides for the allocation of four classes and three intermediate gradations. Water quality assessment is carried out using the saprobability index. A significant amount of water quality assessment work is carried out within the framework of the International Program on the Rhine River, the river basin of which covers the territories of such countries as Germany, Belgium, the Netherlands, Denmark.

Norway attaches an important role to the planning and Construction Act. Assessment of the quality of water bodies involves the allocation of four classes of water quality and three intermediate gradations, characterized by a significant number of biological indicators. In Finland, the general classification of surface water assessment distinguishes 5 classes (from excellent to bad) and is based on biological indicators and the limit of their change [81]. Sweden applies a general classification of water bodies based on the assessment. According to this classification, surface waters are divided into 4 classes and three intermediate gradations between classes. In Switzerland, hydrochemical and hydrobiological methods are used to assess the ecological state of water bodies, predict and manage the quality of Water Resources.

The system of Water Quality Management and monitoring in the Czech Republic and Slovakia, as well as Hungary, Romania and Bulgaria is linked to a multilateral agreement in the field of environmental assessment of surface water quality and cooperation in water quality management within the Danube River Basin. Due to the specifics of multi-factor processes, the standard values of water quality indicators

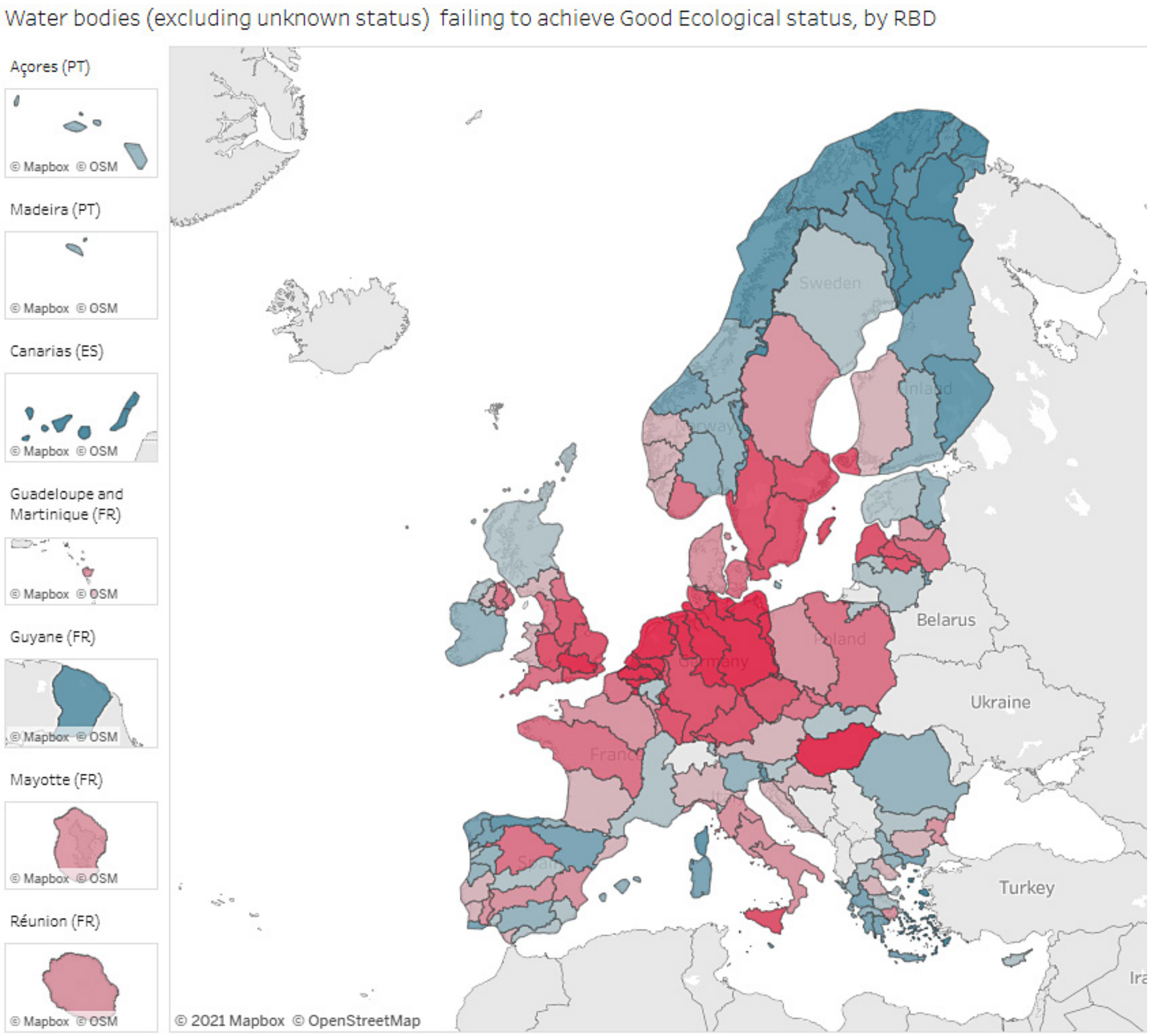

Figure 2. Ecology status of water bodies in Europe

are developed for each class separately for flowing and non-flowing waters. The classifications applied have proved to be very useful for solving many water protection problems, especially in transboundary water basins. It should be noted that Poland has recently been actively implementing WFD requirements for Water Resources Management based on the basin principle. The country has identified two separate river basins (the Vistula and Oder), which are evaluated by introducing requirements for monitoring water according to the corresponding indicators.

In Russia, the state monitoring system is based on the Hydrometeorological Service, which carries out a significant amount of work on monitoring the state of surface waters. The theoretical foundations of surface water quality analysis and the development of monitoring methods are also formed. To unify the methods, a classification is proposed that provides for the allocation of six gradations of the qualitative state of aquatic ecosystems.

The United States policy on the use, protection and reproduction of Water Resources is based on two types of water quality control mechanisms, which are based on technological requirements for pollutant discharges and water quality standards. The end result of water quality analysis is background quality criteria in accordance with state laws on water quality standards. To assess the impact of various types of anthropogenic impact on the qualitative state of water bodies, a fairly large number of different characteristics are used.

In Canada, Water Quality Monitoring pays considerable attention to eutrophication, acidification and toxic surface water pollution. Bioindication methods are used to assess the ecological state of water bodies.

In Japan, when assessing water quality, criteria are used to select aquatic organisms that are most suitable for monitoring purposes. They have certain advantages and disadvantages in terms of water quality control using biological methods.

India has a river monitoring system that includes chemical, biological and bacteriological parameters. Groups of parameters related to specific aspects of pollution are summarized in 9 indices and presented in the form of diagrams.

Summing up the research of existing foreign experience in monitoring and assessing the quality of surface waters, we can note their significant diversity. They differ significantly: in terms of goals, objectives, and methods of organizing observations. They use a rather different composition of indicators, use different methods of generalizing and presenting information and processes for calculating characteristics, the scale of use in water protection and water management activities, and a number of other features.

In order to regulate the actions of the European Union member states in the field of Water Policy, The Water Framework Directive 2000/60/EC (WFD) was adopted, which was the result of agreements between a number of experts, stakeholders and policy makers on the key principles of modern water management. Thus, the European scientific community is faced with a global task that requires coordination of the efforts of specialists in almost all areas, creating a common concept for assessing the aquatic environment, summarizing the entire accumulated body of knowledge about the mechanisms of functioning of aquatic ecosystems, and on its basis – searching for criteria, indicators and characteristics that best meet the solution of the tasks set. WFD sets out a framework for the protection of all bodies of water.

In the ecological classification of surface water quality, the method of establishing and using environmental standards for the quality of surface waters of land and estuaries of Russia is used. Water quality classes and categories defined by these criteria reflect the natural state of water bodies, as well as the degree of anthropogenic load. The initial data for environmental assessment of water quality are the results of systematic monitoring on water bodies, as well as materials of Expedition studies obtained by scientific institutions of an ecological profile. The final results of environmental assessment of the quality of surface water bodies are presented in the form of graphs, tables and special cartographic materials.

Scientific and methodological approaches to assessing the ecological state of water bodies

The use of water for water management needs requires certain conditions for the quality of surface water and is the purpose of a comprehensive assessment of the impact of anthropogenic activities on water bodies, determining certain water protection regulations and reservations, and planning and implementing water protection measures.

To assess the quality of Water Resources, methods based on the use of a complex of physical-chemical, biological and chemical indicators are used. The group of biological indicators includes hydrobiological, biochemical, bacteriological and toxicological characteristics. The group of physical and chemical indicators includes general indicators of the chemical composition and properties of surface waters, which characterize the usual ingredients inherent in aquatic ecosystems, the concentration of which can vary under the influence of anthropogenic factors, as well as indicators of toxic and radiation pollutants that are most common in the surface waters of Russia and affect the functioning of biocenoses.

Existing systems for assessing the state of surface water can be divided into three main groups: environmental, sanitary and hygienic (to meet drinking, recreational needs) and water management (to meet household and other needs), which differ from each other, have different goals and their own special characteristics (Toušová, 2019). Based on the overall assessment the suitability of water for its use for various economic needs is determined.

In Russia, a system of water protection standards is used, which is based on a system of maximum permissible concentrations (MPC), which are established taking into account the categories of water use: sanitary and hygienic, cultural and household and Fisheries. MPC is the concentration of harmful substances in water, which should not have a direct or indirect effect on the body and human health (van-Doren, 2013).

In accordance with the multiplicity of exceeding the actual level of concentrations of substances of their maximum permissible concentrations (MPC) or environmental standards, a class or category of water body quality is assigned (Rodnyansky, 2019).

In practice, two main approaches are used to assess the quality of water bodies: sanitary and hygienic and ecological, and their fundamental

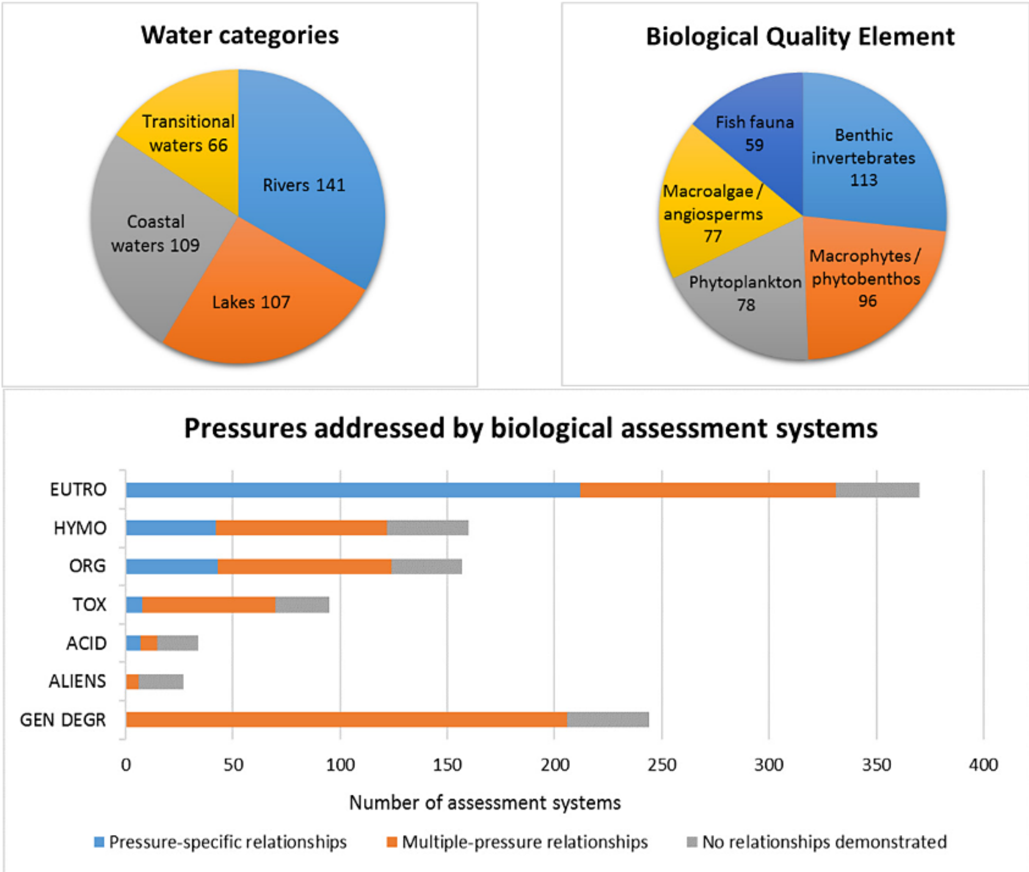

Figure 3. Overview of aquatic assessment methods for the Water Framework Directive (WFD)

difference is that the purpose of sanitary and hygienic regulation is to protect the health of the population, and the purpose of environmental rationing is to preserve the living environment with the condition of observing the stability of natural ecosystems (Neale, 2017).

The main purpose of the sanitary and hygienic approach is to assess the conditions of drinking and cultural water use, the possible degree of its restriction under the influence of anthropogenic factors, and to prevent unsatisfactory effects on human health and sanitary living conditions (Mascarenhas, 2015).

Rationing of surface water quality is fixed by the relevant regulatory documents, and includes general requirements for the composition and properties of surface water for various types of water use (for domestic drinking and municipal water use and for Fisheries purposes).

Hydrobiological methods for assessing the quality of surface water have their own characteristics. With their help, it is relatively easy to detect changes in the structure of groups that are caused by a sudden decline or appearance of several main species or groups. At the same time, they should be organized in such a way that they allow identifying weak, early and hidden changes in the state of groups (species) by ordinary seasonal variations, that is, they should contain elements of scientific research (Kase, 2018).

Bioindication of the ecological state of the reservoir by macrophytes is carried out by evaluating the following characteristics: the species composition of macrophytes; the degree of development of individual species or groups of macrophytes; the presence of individual species indicators and indicator groups; the spatial distribution of thickets on the reservoir.

The value of the macrophyte index is comparable to the water quality classes used in Russia, namely: Class I - very clean (blue), Class II - Clean (Green), Class III - dirty (yellow), Class IV - dirty (orange), Class V - very dirty (red).

To assess the degree of contamination of a reservoir, the Pantle-Bucca method is most widely used, which is based on the ability of organisms to survive in conditions of organic pollution of the environment.

Determination of the ecological state of surface water massifs is based on the use of a complex of biotic and abiotic components inherent in aquatic ecosystems, and is carried out according to biological, hydromorphological, chemical and physical-chemical indicators that generally characterize the ecological state (Ripetskii, 2019).

To classify the ecological state of the surface water array, five classes are used, which are indicated by the corresponding color:

- Class I of the ecological state corresponding to the ecological state "excellent" is indicated in blue;
- Class II of the ecological state corresponding to the ecological state "good" is indicated in green;
- Class III of the ecological state corresponding to the ecological state "Satisfactory" is indicated in yellow;
- Class IV of the ecological state corresponding to the ecological state "bad" is indicated in Orange;

The environmental condition Class V, which corresponds to the "very poor" environmental condition, is indicated in red (Voronova, 2018).

The class of ecological state of a surface water array is determined by biological, hydromorphological, chemical, and physical-chemical parameters. The class definition for each of the indicators is performed by comparing its value with the class limits set in the type-specific classification. The final determination of the ecological state of the surface water array is determined by the worst indicator.

The ecological potential of an artificial or significantly modified surface water array is determined according to the classification established to determine the state of the surface water array of the corresponding category (river, lake, transition Waters, coastal waters), to which this artificial or significantly modified surface water array is the most similar in its characteristics (Shmygaleva, 2019). Four classes are used to classify the environmental potential of an artificial or significantly modified MPV:

- Environmental potential class II, which corresponds to the environmental potential "good", is indicated by Green and gray stripes;
- Environmental potential class III, which corresponds to the environmental potential "Satisfactory", is indicated by yellow and gray stripes;
- Environmental potential class IV, which corresponds to the "bad" environmental potential, is indicated by Orange and gray stripes;
- Environmental potential class V, which corresponds to the "very poor" environmental potential, is indicated by red and gray stripes.

Noting numerous studies, it can be said that an objective assessment of the ecological state of water bodies is possible only with the combined use of hydrochemical hydrobiological and hydrobiological data. In contrast to hydrochemical methods, which determine the intensity of anthropogenic impact on water bodies, hydrobiological methods make it possible to assess the response of biota to the entire complex of anthropogenic impacts to determine the cumulative effect of combined exposure to pollutants.

One of the most important tasks today is to improve information support for monitoring based on the principles of unity of observations and measurements of water quality indicators. Improving the status indicators, evaluation criteria, methodological foundations and methodological approaches, as well as the regulatory framework can be one of the ways to solve this problem.

CONCLUSIONS

Water management systems are a set of interconnected water bodies, Hydraulic Engineering, Water Supply, Sewerage and other structures designed to ensure the rational use and protection of water.

The process of water management complex formation is characterized by objective regularities, as a result of which water management systems are formed in specific conditions. The main factors in the formation of water management systems are the level of water supply and the need to meet the water needs of the population, industry, agriculture, hydropower, Fisheries and other water users.

Analysis of the state of monitoring of water management systems indicates that this component is in unsatisfactory condition. This is reflected in the extremely limited number of observation points, the practical insufficiency of Expedition surveys of water bodies, the use of outdated methods of analysis and generalization of necessary information, and the weak use of water quality control results.

The analysis of foreign and domestic approaches to monitoring and studying the quality of surface water indicates the possibility of obtaining objective results of assessing the ecological state of water bodies, provided that hydrochemical and hydrobiological data are used and regional features of the studied water bodies are taken into account.

This indicates the need to carry out a complex of works to improve the monitoring system of water management systems, primarily to increase its efficiency and harmonize with similar systems in other countries.

In order to achieve the most efficient use of Water Resources, the choice of optimal parameters and operating mode of water management systems, it is necessary to analyze a number of issues in depth and comprehensively, taking into account the prospects for the development of all sectors of the economy.

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