Information-measuring system for the eutrophication estimation of the water body

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Abstract. The paper describes the information-measuring system to assess the eutrophication extent of a water body using the example of the Gulf of Taganrog of the Sea of Azov. This system allows a comprehensive assessment of the eutrophication of the reservoir and its biogenic load. In particular, it includes information capturing by various sensors, system analysis using a variety of devices and technical means, the solution of the most important tasks of environmental monitoring in this field of knowledge and the eutrophic status of the water area forecasting.

1. Introduction

The results of geo-ecological studies clearly indicate that marine pollution is one of the most important tasks of the environmental monitoring. Excessive eutrophication of the water body leads to a serious disruption in the functioning of the aquatic ecosystem, causes waterlogging of the territory, fish kill, which, in turn, has an effect on humans [1].

The eutrophication of natural water bodies is understood as the process of growth in the total productivity of the ecosystem of a water body, including water masses, bottom sediments, organisms inhabiting them and the relationships between them. The process of eutrophication leads to the increase in the total content of the organic matter in water [2].

The eutrophication extent of a reservoir depends on the magnitude of its external and internal biogenic loads (particularly, phosphorus and nitrogen) and can be slowed down by its reducing. Ways to reduce the external biogenic load on the Gulf of Taganrog of the Sea of Azov were discussed by us earlier [2-4]. In this work, we developed a comprehensive information-measuring system for geo-ecological assessment of the eutrophication status of a light salted shallow water body using the example of the Gulf of Taganrog of the Sea of Azov.

Waters eutrophication is a peculiar phenomenon of the ecosystem, which is achieved by the enrichment of the biogenic organic matter, which, as a rule, stimulates the growth and flowering of algae, and this, in turn, leads to the deterioration in the quality and condition of natural waters. In recent decades, this has become a global environmental problem. Therefore, to develop measures to reduce eutrophication of the water area, first, it is necessary to understand its processes.

Thus, it is important to organize the appropriate system for modeling and forecasting the ecological situation of the water area from the position of eutrophication. The solution to these problems requires the operating reliable information.
The developed information-measuring system to assess the eutrophication extent of a water body is a component of system for environmental monitoring, which includes the following basic procedures [5]:

- the allocation of the monitoring object and its key parameters;
- the research of the allocated water area including planning and measurements conducting;
- the compilation of a database of the studied water area;
- the construction and verification of the information and mathematical model for the object under the study;
- the assessment of the state of the water from the position of the eutrophication;
- the forecasting of change in the state of the reservoir;
- the systematization of the information received.

2. Materials and methods

The information-measuring system for environmental monitoring itself does not include environmental quality management activities. Nevertheless, it is a source of information so necessary for the correct assessment of the ecological state of the studied object and the adoption of the environmentally significant decisions.

The perspective information-measuring and automated systems for environmental monitoring are created as the integrating superstructure for existing monitoring systems [6].

In structure of information and measuring system of monitoring it is possible to allocate some components:

- the information and measuring system of the data capture of the ecological information which is a group of sensors for measurements and the computer with the special software, operating post;
- the subsystem of transfer and storage of information on the central server which represents the computer on which the server of databases and the specialized software is installed;
- the subsystem of processing, analysis and display of information which is a computer on which the specialized software for processing and the analysis of information is installed [7].

For a comprehensive geo-ecological assessment of the eutrophication extent of a reservoir, the following functional components are used in our work:

- Sensors for determining the hydrogen index, water salinity, concentrations of oxygen, nitrate, nitrite, phosphate, ammonium ion dissolved in water, as well as the temperature of the water masses;
- GPS system to determine the coordinates of water sampling sites;
- Center of modeling;
- Center of comparison, analysis and forecasting;
- Center of cartographical display of data;
- Center of systematization of data.

Information-measuring system of the assessment the eutrophication status of a water body works as follows.
1. The object for a complex geoecological assessment of the eutrophication status of the water body gets out.
2. The area of the research (a geographical zone with certain coordinates) is allocated.
3. The coordinates of the sampling points on the map and time are determined and indicated (for example, for the Gulf of Taganrog of the Sea of Azov, measurements were taken during the vegetative period (from early April to late October) at 20 sampling points).

4. The short characteristic of the water area including the review and the analysis of the literary data on the hydrodynamics of the water object, temperature, salinity, hydrogen indicator, the concentrations of the dissolved oxygen and biogens (ammonium ion, nitrate, nitrite and phosphate) is compiled.

5. Water sampling and determination by sensors of the hydrogen indicator, water salinity and the concentrations of oxygen, nitrate, nitrite, phosphate, ammonium ion dissolved in water, as well as the temperature of the water mass according to plan. For the analysis, various sensors and instruments were used, such as Ecotest-2000 and KFK-3 spectrophotometer.

6. The collected data is sent to the center of modeling where, using a special software and hardware complex, for example, «Statistica», a mathematical information model to determine the eutrophic index of the water body is constructed and its verification is carried out.

7. The obtained data of modeling come to the center of comparison, analysis and forecasting where occurs:

- the analysis of the collected database of the hydrogen indicator, water salinity and the concentrations of oxygen and biogens (nitrate, nitrite, phosphate, ammonium ion) dissolved in water;
- the calculation of the eutrophic index of the water body;
- the assessment of the magnitude of the external and internal biogenic loads (phosphorus and nitrogen) of the aquatic ecosystem;
- the analysis and assessment of environmentally acceptable concentrations of the biogenic matter and their environmental reserves;
- the forecasting of the ecological state of the water object under various conditions from the an position of the eutrophication.

Ecologically permissible concentrations are the concentrations of the harmful substances in the environment coming from the anthropogenic sources and not violating the homeostatic mechanisms of the ecosystem self-regulation. The ecological reserve of the water body is the difference between the environmentally acceptable (maximum) and actual statuses of the ecosystem [8].

8. Further data from the center of comparison, analysis and forecasting come to the center of cartographical display of data where on the basis of the ArcGIS software various map schemes are constructed to visually display the results of the study.

9. At the final stage, all data are systematized and submitted in a form, convenient for the study.

3. Results
The work uses the results of analyzes of samples of sea and wastewater for the Gulf of Taganrog of the Sea of Azov including the determination of the water temperature, salinity, dissolved oxygen, hydrogen indicator, nitrate, ammonium ion, nitrite and phosphate obtained during the vegetative period. For the analysis, various sensors and instruments were used, such as: "Ecotest-2000" with separate ion-selective electrodes to determine each indicator and the KFK-3 spectrophotometer.

Thus, uniqueness of a collected database is caused by:

- the unified sampling and analysis methods;
- the wide coverage of observation points on the water body (figure 1);
- the optimized intra- and inter-annual sampling periods needed to assess the temporal variability of the state of the aquatic ecosystems;
- the wide range of indicators defined in the analysis of the surface waters.
The subsystem of comparison, analysis and forecasting is a software module that is installed on the operator’s workstation and after entering the received primary data displays information about the ecological state of the reservoir from the position of eutrophication. The subsystem is built on the basis of a personal computer using the modern software.

Therefore, for the Gulf of Taganrog of the Sea of Azov it is possible to draw the following conclusions:

1. The most significant factors influencing the eutrophication of the waters at the present stage are temperature, salinity, as well as the concentrations of nitrate, ammonium ion and phosphate.
2. A model for changing the eutrophic index of water for the Gulf of Taganrog of the Sea of Azov, constructed on the basis of the developed information-measuring system of the assessment the eutrophic status of a water body, has shown that at present the waters of this water area are predominantly in the mesotrophic state, turning into the eutrophic one.
3. The greatest contribution to the total external biogenic load of the waters the Gulf of Taganrog is made by the river runoff.
4. The ecological reserve of the waters of the Gulf of Taganrog is currently exhausted for such biogenic substances as nitrate, ammonium ion and phosphate.

![Figure 1](image.png)

**Figure 1.** Places of water sampling in the Gulf of Taganrog of the Sea of Azov.

The results of the assessment the eutrophication status of a water body on the example of the Gulf of Taganrog of the Sea of Azov made it possible to visually display the functions and advantages of this information-measuring system:

1. The information about the eutrophic state of the reservoir can come in real time, which makes it possible, if necessary, to conduct the operational analysis of the geo-ecological situation of the water area from the position of the eutrophication.
2. When systematizing, the data are presented in a form convenient for the study: mathematical models, graphs, tables, diagrams, maps, equations.
3. All received data is accumulated and archived. Thus, a regularly updated database is created, which includes the information search capabilities.

4. Mathematical modeling is carried out for the various environmental processes that allow the most complete assessment of the water quality from the position of the eutrophication.

5. A detailed analysis and assessment of the water body from the position of the eutrophication is carried out, forecasting tasks are carried out.

4. Conclusions
The design of the proposed information-measuring system for environmental monitoring to assess the degree of eutrophication of the water body is based on the use of the known elements that are relatively cheap. There are no technical difficulties to implement this design.

Thus, the developed algorithms made it possible to create such an information-measuring system of the assessment the eutrophication status of a water body, which includes data gathering by directly measuring various indicators (temperature, salinity, concentrations), its processing, displaying, analyzing and systematizing the received environmental information about the eutrophic status of the water body.

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