

# Environmental safety management of the territory by means of regional hydro monitoring system

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**Abstract.** The article outlines the results of developing a sound environmental safety management system by means of using the hydrosphere monitoring in these territories. Scientifically substantiated approaches contain methodology of a control system that allows effective decisions to reduce technogenic pollution of the regional habitat. A set of methods consist of integrated system analysis and synthesis to be used as the main analytical tools in a territorial control structure, which allows taking into account the fundamental properties and processes of changing natural and technical systems. Arguments are also given to determine the high efficiency of hydrosphere control with the joint synchronous operation of the control and control blocks. The regional system, built according to the proposed scheme, allows you quick developing and implementing organizational and technical measures to normalize the chemical and biological composition of drainage waters. The implementation of the proposed theoretical and experimental solutions will ensure a significant increase of environmental safety level of humans' life.

## 1 Introduction

Environmental safety of the population, in the light of the modern state doctrine of Russia, is one of the main areas of authorities' activities at all levels. This problem is especially relevant for the industrially developed regions or so called ("techno genic loaded") territories of our country. The essence of the issue is that the introduction of innovative technologies in production and other spheres of human activity along with the improvement of the quality of life is characterized by new poorly studied anthropogenic hazards for the population of a particular territory.

The scale of the described problem determined the need for a comprehensive scientific study of theoretical and experimental nature based on the impact of production processes on all shells of natural space, including the geological environment and the closely related hydrosphere. The analyzes was conducted on the most significant works of such scientists as Belodedov A.A., Golik V.I., Zagorsky L.S., Maslennikov S.A., Mokhov A.V., Norvatov Yu.A., Oparin V.N., Ruban A.D., Shkuratnik V.L. [1-8].

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The monographs and scientific articles of the listed researchers present the results of studying the environmental safety and the impact of technological processes on it. These works contributed to developing of the scientific discipline "Life Safety" and made a significant contribution to the formation of the theory and practice of ecological and hydro physical research. According to the authors of the paper, some fragmentation of the research objects and the use of a limited number of analytical methods are important aspects that do not allow assessing the situation and developing an effective methodology for the formation of habitat control systems. Thus, Professor Golik V.I. and his associates study mainly the negative impact of industrial wastes on soil and water resources [1]. Scientific research made by Norvatov Yu.A., Savelyev D.I. and Yashina A.V. is devoted to the study of underground work impact of coalmines on the underground hydrosphere by means of using geological methods [5]. Scientists from Novochoerkassk Mokhov A.V. and Gavrishin A.I. evaluated the impact of mining technologies on the hydrographic network but exclusively from the standpoint of hydrogeology [7]. Zagorsky L.S. and Shkuratnik V.L. solved particular hydro geological problems by using the theory of mine seismic exploration [8].

These scientific and methodological approaches objectively reduce the reliability of the conclusions obtained from the results of the conducted research. To increase the efficiency of scientific developments, which allows making optimal management decisions, innovative solutions based on other principles are required. In this connection, the authors consider it necessary to present the materials of their research work on the urgent problem of hydrosphere management in techno-genic-loaded regions. The main objective of the research work is to form an effective methodology for managing the current state of the hydrographic network, based on an integrated approach to solving an important regional problem. At the same time, the proposed system should fulfill jointly and synchronously both the functions of control and regulation of the parameters of the considered hydrosphere.

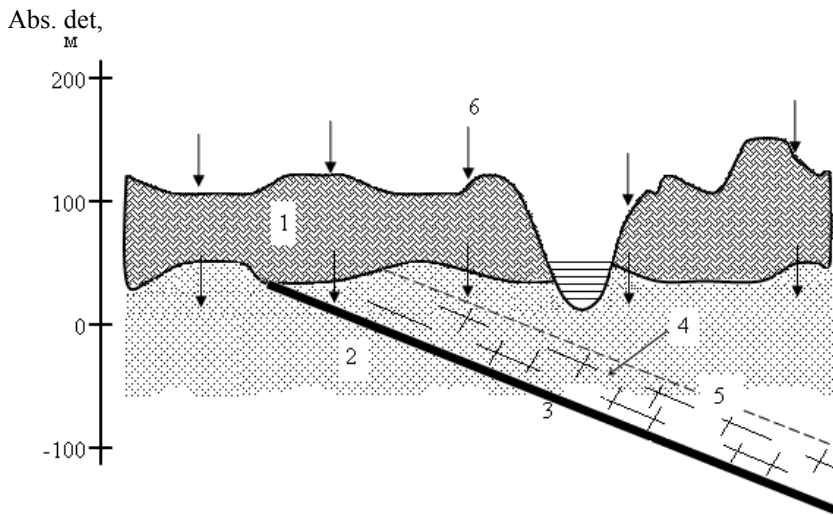
## **2 Materials and methods**

The authors of the article examined in detail aspects of the multifactorial impact of industrial enterprises on the hydrographic network in the Rostov region, which is a large industrial-agrarian region of Russia. A characteristic feature of this territory is a large number of coalmines. The regional hydrosphere, located in a rock mass (RM), consists of many physical objects of various origins, which are combined into a very complicated natural-techno genic complex (NTC) through heterogeneous geological (hydrogeological) and functional connections. This basic characteristic determines an adequate choice of analytical and technical methods and tools for studying the state of the underground and ground parts of the hydrographic network in the territory of a techno genic loaded region. Figure 1 shows a typical layout of an artificial underground water body formed after coal seam mining, which illustrates the above statement about the NTC (Figure 1).

Currently, the scientific community considers a set of methods, including system analysis and synthesis of structure and processes, to be the most effective tool for the study of large natural and of techno genic systems, to which it is quite legitimate to include the regional hydrosphere [9-10]. The authors of this article adhere to the theory of system approach to the problem, according to which in order to assess the state and behavior of these objects it is necessary to perform a detailed joint analysis of all components and functional links of NTC.

It is better to fulfill by a set of methods of different nature, corresponding to the level of complexity of the system under consideration. At the same time, according to the authors, the achievement of reliability of research results can be obtained by carrying out this work

practically synchronously on all elements and subsystems. This research methodology is called by the authors "dual complex analytics".



1, 2 - host rocks; 3 - pond in the worked-out underground space; 4 - zone of fractured rocks; 5 - boundary of the zone of water-conducting fractures; 6 - direction of infiltration of atmospheric precipitation and surface water.

**Fig. 1.** Scheme of techno genic water reservoir location in the rock massif.

The use of integrated systems analysis (ISA) and synthesis of alternatives for managing the state of the hydrosphere in the practice of forming a control and regulatory system (CRS) allows taking into account the full range of fundamental properties of a complex natural-techno genic formation, including emergence, synergy, adaptability and openness.

Detailed analytical work to ensure unconditional observance of the systematic principle for CRS of the regional hydrosphere is characterized by the following stages:

- A regular complex analyses of physical-chemical and biological composition of drainage water coming from IHP.
- A control of sources of pollution of the hydrographic network.
- A development and implementation of organizational and technical measures aimed at improving water quality indicators in accordance with environmental standards.
- Designing of the optimal configuration of observation systems for techno genic processes.
- Monitoring the implementation of the activities.

It should be emphasized that in case of unsatisfactory management results of the control process, an adjustment of the developed measures is required.

The accumulated experience of the authors in the study of environmental safety of the habitat makes it necessary to include the following basic elements in the proposed methodology:

- Performing a detailed analysis of a priori geological, hydro geological, technological and environmental data.
- Analyzing the possibilities of methods for controlling the physical-chemical properties of wastewater, sources of man-made pollution and methods of wastewater treatment of enterprises.
- Scientific and methodological substantiation of analytical tools and ways of presenting research results for management decision-making.

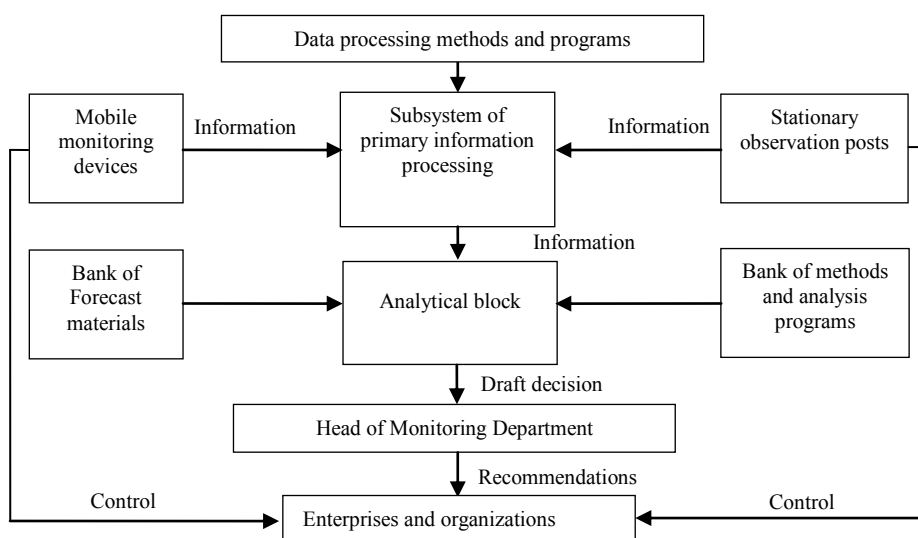
The analysis of publications by hydro geological and geophysical specialists, as well as our own theoretical and experimental studies have convinced us that the most appropriate organizational form of control is a territorial monitoring system [9-10].

### 3 Results

The above-mentioned experimental-theoretical aspects of research methodology allowed performing a representative volume of drainage effluent studies at typical production facilities of Rostov region, including metallurgical, mining and construction enterprises. It should be noted that assessment of the state of such natural-techno genic complex from the point of view of process analytics in the scientific community is considered quite a difficult task due to the complexity and scale of this artificial formation.

Thus, according to the results of a conducted detailed analysis of the hydro geological situation in the Rostov region, the presence of 11 techno genic underground reservoirs formed as a result of long-term large-scale coal mining operations has been established. From the data obtained, it is legitimate to draw an important conclusion for theory and practice about the significant multi factorial impact of these hydro geological complexes on the regional water system. This conclusion determines the adoption as a starting point of the thesis about the real integral structural and behavioral factors inherent in the NTC under consideration.

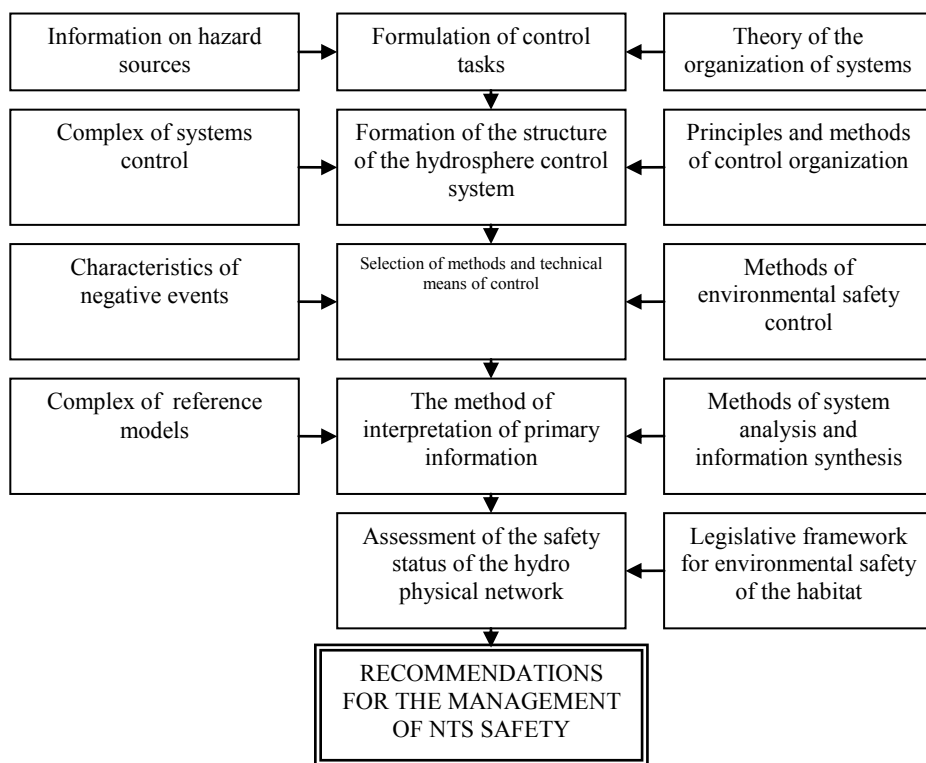
In the context of the presented analytical considerations, firstly, the proposed research methodology was tested in practice. In the course of experimental work, the authors conducted a detailed and comprehensive assessment of the elements of the research methodology at 57 industrial and agricultural production facilities located in the region. The possibilities of using the developed measuring technologies, techniques, instruments, technical means and analytical tools were thoroughly studied in real conditions. In most cases (about 90%), the researchers obtained positive results that allow substantiating and forming a holistic methodology for assessing the actual state of the hydrosphere. Based on a detailed comprehensive analysis of the materials, the authors decided that studies of the state of the regional hydrosphere should be carried out with the involvement of a monitoring system, the block diagram of which is shown in Figure 2.



**Fig. 2.** Block diagram of the analytical system of hydro monitoring.

The system of field observations of the state of RM as a primary link (subsystem) of monitoring is designed based on the actual number of production facilities (sources of the hydrosphere pollution) in the studied area, the level of impact on the regional habitat and the probability of a negative techno genic event. Detailed statistical processing of experimental results according to a set of criteria of assessing the probabilistic characteristics of the risk of techno genic pollution and material damage showed that it is advisable to establish an observation post if the estimated probability of the danger exceeds 60%. When developing the geometric configuration of the observation network for a controlled area, specialists must also take into account the technical characteristics of the devices used and the type of recording of readings (automatic or operator recording).

The second subsystem of regional monitoring, in accordance with the main goal of the research work is the block for regulating the physicochemical and biological composition of drainage waters that enter the regional hydrosphere. A joint analysis of factual materials reflecting the real situation with discharges of industrial wastewater into the regional hydrographic network and existing technologies made it possible to develop a technological scheme for comprehensive water purification from techno genic impurities. Based on the analysis and generalization of the results of experimental and theoretical research on this problem, the authors propose an innovative control and regulatory system for the state of the hydrographic network on a regional scale. This NPS designed to create a comfortable and safe living environment on the territory of an industrial-agrarian region, was based on a system analysis and synthesis of alternative management solutions (Figure 3).



**Fig. 3.** The complex of elements of the control system formation.

Experiments show that the NTS, built according to the proposed methodology, provides effective control and the required quality of regulation of the parameters of the negative impact of the regional production facilities on the environment.

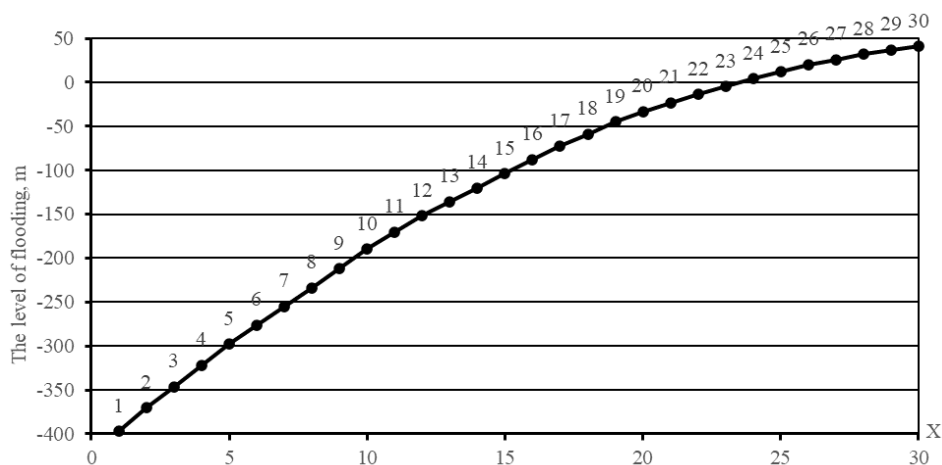
The algorithm of practical work to ensure environmental safety includes the following production and analytical actions:

- Monitoring and analysis of the current state of the hydrosphere.
- Forecasting of the dynamics of groundwater and surface water in the region.
- Regulation of the system functioning.
- Monitoring of the implementation of activities.

Regarding the application of the developed methodology, it is necessary to determine the limitations of its use. In this regard, specialists in hydrogeology and environmental safety should evaluate the following environmental characteristics:

- Geological and hydro geological conditions of the territory.
- Technical conditions for carrying out measurements.
- Geometric dimensions of the controlled environment (length, width, depth).

An essential issue is the assessment of filling of voids (mined-out space of RM) with groundwater. Thus, in the process of control, it is necessary to regularly monitor the groundwater level in the worked-out areas of coal deposits, using for operational assessment the empirical curve obtained by the authors (Figure 4).



**Fig. 4.** Dependence of the level of flooding of the developed space on time: X – normalized time.

The practice of monitoring shows good results of using this method for rapid analysis of the real situation characterized by various techno genic impacts on the habitat and the population of the region.

## 4 Discussion

In the presented article, the authors gave the main results of the conducted research work concerning the formation of a sound and effective methodology for managing of the environmental safety, by means of using the results of regime monitoring of the hydrosphere state of a techno genic loaded region of Russia. One of the organizational and technical tasks of the research was a sound scientific substantiation and selection of analytical, methodological and technical tools, which are used to ensure adequate assessment of techno genic impacts of industrial enterprises on the water environment. Because of large-scale theoretical and experimental studies, appropriate means and tools were selected, which formed a control system that works synchronously in the modes of control and regulation of the state of the hydrosphere.

In order to achieve the goals of research and development in a specific territory, the authors propose to organize the current production operation of the system in the mode of so-called "proactive" monitoring, that is, to work for constant "anticipation" on the realization of a potential danger to the habitat of the population. Carrying out control work according to the specified schedule will allow specialists involved in these issues to quickly predict environmental risks and prevent negative consequences for a particular region of Russia. The synchronous functioning of the organizational and technical blocks of the system significantly reduces the time for development and management decisions in case of a change in the hydrogeological situation in any part of the rock mass. At the same time, computerized high-speed devices, technical means and specialized application programs should be used as a part of the monitoring structure.

Analyzing the results of the research work in a complex, we note that theoretical developments based on the fundamental provisions of the scientific works of Modin I.N., Ruban A.D., Khmelevsky V.K. and Shkuratnik V.L. made it possible to form an effective monitoring methodology. Many of the authors' conclusions correspond satisfactorily with the materials presented in the publications of a number of other researchers of the problem under consideration. In particular, the authors' interpretation practically confirms some significant experimental positions published in [11].

In continuation of this research work, the authors intend to explore issues of comprehensive forecasting of environmental safety of regions, including the scientifically based formation of a system of objective criteria-based assessments of the real environment and the development of software for prompt and reliable interpretation of control results.

It follows from this that the experimental and theoretical approaches developed by the authors differ from similar works of scientists highlighted in the introduction of the article by providing a comprehensive solution to the problem under consideration over the entire range of influence of technogenic factors.

## 5 Conclusion

The scientific and methodological developments presented in this article make it possible to manage reliably the state of the hydrosphere in the industrial and agricultural regions of Russia, where many industrial, infrastructural and agricultural facilities operate and there is a possibility of excessive emissions of various environmental pollutants. In particular, the authors' methodological recommendations, formed with the involvement of the main provisions of the methodology, ensure fully synchronized control operation and regulatory system. In the context of the analytical evaluation of the conducted research, it is legitimate to emphasize the fact that all theoretical and methodological proposals were in the practice of environmental services of the region and municipalities of the Rostov region.

According to the results of the analysis of real static materials obtained over a long period in a number of districts and cities of the Don region, the efficiency of industrial wastewater treatment is 90%. The statement of the stated fact allows us to recommend scientific development for ensuring environmental safety in other regions of Russia.

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