

A systematic approach to the assessment of the water facility influence zones ecological state as a factor of environmental safety

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Abstract. The purpose of this article is to assess the ecological state in the considered space and time in basin geosystems as the most important factor of environmental safety in the influence zones with the technogenic component, which includes various types of hydraulic structures (HTS), referred to as "Activity Objects" as a part of natural and technical systems "Natural environment - Activity Object - Population" on the use of water resources in various sectors of economic activity. To assess the ecological state in space and time in the considered river basin geosystem, within which quantitative and qualitative indicators of water resources are formed, based on the categorical basic concept "System", which is integrated into the categories "Behaviour" and "Structure" and the concept of the category "System approach" as a research method for assessing the impact of the "Activity Object" on the "Natural environment" and the life of the living "Population", on the basis of the results of integrated systemic environmental monitoring (ISEM) in the influence zones of the "Activity Object", a classification characteristic of the types of monitoring studies for an objective assessment of "Natural environment" necessary at the stage of making a decision on the construction or further operation of the "Activity Object".

1 Introduction

The current stage of scientific research development on the use of water resources in various sectors of economic and other activities is characterized by the development and implementation of new methods for studying the process of technogenic components interaction (various types of hydraulic structures) with natural environments and the population within the basin geosystem under consideration, where quantitative and qualitative indicators of water resources, as a part of natural technical systems (NTE) "Natural environment - Activity Object - Population" («NE-AO-P»).

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NTE «NE-AO-P» on the use of water resources and protection belong to a special class of systems in which the structure, organization of interconnection, interaction and relationship between its components play a decisive role from the negative impact of natural waters (flooding, waterlogging, mudflows and landslides, etc.) ("Natural environment", "Activity Object" in the form of a complex of hydraulic structures and "Population") (Fig. 1). The existing NTE «NE-AO-P» determines in itself, on the one hand, the creation of an optimal structure of interconnection, interaction and relationship between the constituent components and their constituent elements, and on the other hand, ensuring **environmental safety** in the «AO» influence zones within the considered basin geosystem [6].

Functional structure of NTE «NE-AO-P» is characterized by a complex of necessary hydraulic structures (HTS), directly interacting with «NE» (surface layers of the atmosphere, river hydrographic network within the catchment area, upper layers of the lithosphere and pedosphere) and residents «P» in the area under consideration, as well as with the nature of the intra-basin movement of flows of matter, energy and information (MEI), defining themselves as **ecological state** in space and «AO» time influence zones, as an important factor of **environmental safety** [4].

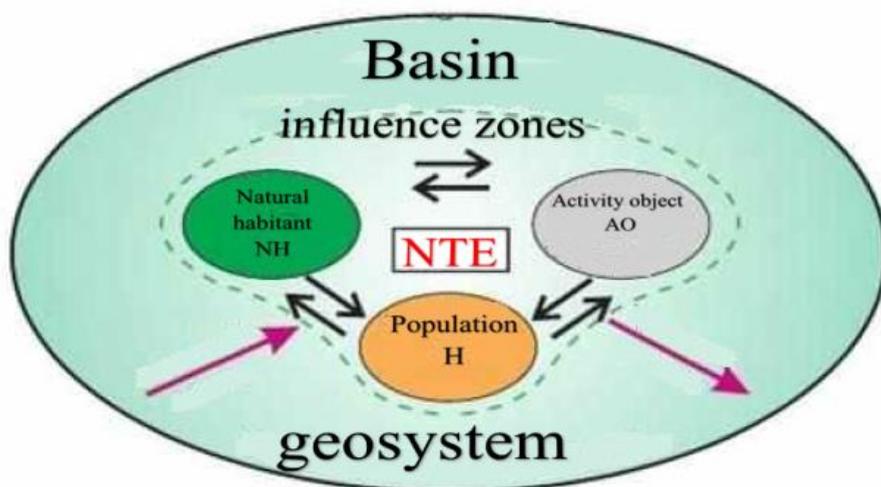


Fig. 1. Diagram of the model of interaction of components in the NTE "Natural environment - Activity Object - Population" within the spatial limits of the geosystem basin.

Natural and man-made flows movements of matter, energy of information (MEI) in space and «AO» time influence zones are divided into three groups: physical, chemical and biological.

Spatial structure NTE «NE-AO-P» is determined by the nature of the location in the drainage area of the «AO» basin geosystem hydrographic river network (reservoirs, water intakes, water transporting, regulating and other types of HTS).

Temporary structure NTE «NE-AO-P» is expressed by the functional use of «AO» during the seasonal periods of the year.

Within the river basins of the geosystems of the Kuban, Terek and lower Don rivers, about 30 thousand different types function HTS, included in NTE «NE-AO-P» on the use of water resources in the sectors of economic activity of SFD and NCFD. We can consider the following results of the study found that the main distinguishing features of the functional complexity of structural formations and the organization of the relationship, interaction and relationship between the components and their constituent elements in the considered NTE «NE-AO-P» (Fig. 1):

-The presence of a large number of interconnections, interactions and relationships between the components and the elements of natural origin (plant, animal, ichthyofauna species, etc.) and individual structural elements of the technogenic component, as well as the living population.

- The complexity of the functions performed in the technological processes of using water resources (on irrigation systems, in technical water supply systems HPP, APS, to HEPS and PSHS, etc.).

- Separation NTE capability on the subsystems that are subordinated to the general goal of satisfying the water user or water consumer in providing the estimated consumption of water taken from water bodies as from water sources.

-Direct and indirect interaction of the "Activity Object" with "Natural environments" (atmosphere, hydrosphere, upper layers of the lithosphere, pedosphere) in the spatio-temporal limits of the basin geosystem.

- Occurrence of the ability to manage the components in the composition NTE «NE-AO-P» based on the basic principle of operation, the environmental acceptability of the technogenic component and ensuring **environmental safety** in the zones of its influence.

To provide **environmental safety** in the «AO» influence zones as a part of NTE «NE-AO-P» in theoretical and practical terms, it has caused the need for the study and development of the technical theory foundations, based on modern trends in the development of water industry in the use and protection of water resources.

Based on the research results of interconnection, interaction and relationship processes «AO» with the natural environments of the basin geosystems of the Kuban, Terek and Lower Don rivers by the method of integrated systemic ecological monitoring (ISEM) in impact assessment «AO» on the environment (IAE) revealed the main properties of the technical theory foundations (TTF) existing and emerging NTE «NEAO-P» based on the concept «**System**» and is considered as the theory of abstract models, which covers many specialized theories, where concrete classes of models are considered. For the class NTE «NE-AO-P» TTF uses advances in mathematics, biology, ecology and other sciences and determine the area of scientific research in the study of the processes of interconnection, interaction and interrelation of models «AO» as a whole and their constituent elements with natural environments, for example, protection against the ingress of various types of fish in the selection of estimated water flow rates ($Q \text{ m}^3/\text{s}$) from a water body to technological schemes for the use of water resources.

Processes of interconnection, interaction and relationship «AO» with «NE» and «P» cause certain changes in the movement of flows of matter, energy and information (MEI), which shape and define **ecological state**, as a factor **environmental safety** in the «AO» influence zones. The nature of the movement and the exchange of flows MEI between the surrounding «NE» and living «P» represents monitoring studies belonging to the category «**Behavior**» material formation - «**AO**», and the movement of flows itself **MEI** defines the «**AO**» study category «**Buildings**» [7, 8].

Basic concept «**System**» integrates the categories «**Behavior**» and «**Structure**». When researching a class NTE «NE-AO-P» concept «**System**» reflects the objective reality for each component and their constituent elements (water intake structure, river ichthyofauna, etc.) that make up the system under consideration - category «**Behavior**» and «**Structure**». Systemic class research NTE «NE-AO-P» found to depend on category understanding «**systematic approach**», as a research method that makes it possible to obtain an objective assessment of the functioning of the considered NTE «NE-AO-P» as a research method that gives an opportunity to obtain an objective assessment for the functioning of the considered "AO".

«**Systems approach**», as a classroom research and design methodology NTE «NE-AO-P» is conditioned, on the one hand, by the need to introduce «AO» based on the vital needs

for the use of water resources into the natural environment, and on the other hand, the need to ensure **environmental safety** within the basin geosystem, where the quantitative and qualitative indicators of water resources are formed and where «P» is located.

«**Systems approach**» as a scientific method of research and design NTE «NE-AO-P» is conditioned as a method of thinking that complements traditional methods by creating new approaches to explaining and proving the processes of interconnection, interaction and relationship «AO» and living «P», for example, providing **environmental safety** in the «AO» influence zones.

«**Systems approach**» as a method of analyzing the processes of interconnection, interaction and relationship «AO» as a part of NTE «NE-AO-P» makes it possible to combine the analysis of the system from the standpoint of physics, ecology, biology, economics, social sphere and consider the organization as a whole in order to achieve the greatest efficiency of the considered NTE «NE-AO-P», which functions within the spatial limits of the basin geosystem.

Forecast of qualitative and quantitative changes in «NE» under «AO» influence was performed using «**Systems approach**» when analyzing the functional work NTE «NE-AO-P».

Depending on the environmental problems to be solved in the established zones of «AO» influence to assess the level of changes in natural processes, the relationship, interaction and relationship between natural (biotic and abiotic) elements under the influence «AO» was held by ISEM [7, 8, 9]. Based on the results of monitoring studies of existing «AO» within the basin geosystems of the Kuban, Terek, and lower Don rivers, it was found that the differentiation ISEM it is recommended to perform according to natural environments in the zones of influence «AO», and the social conditions of life «P» attributed to «NE».

Quantitative indicators of influence zones on the earth's surface of the catchment area ($F_{Б.Г.}$, km²) basin geosystems of the Kuban, Terek, and lower Don rivers are given in Table 1.

Table 1. Hierarchical system of quantitative indicators of the sizes of basin geosystems within which «AO» influence zones are located

N o .	Area under study, km ²	Volumetric size, km ³
1	$F_{1.z} \leq 10$	$W_{1.z} \leq 103$
2	$10 < F_{1.z} \leq 500$	$103 < W_{1.z} \leq 500$
3	$500 < F_{1.z} \leq 1000$	$6500 < W_{1.z} \leq 1.3 \cdot 10^3$
4	$1000 < F_{1.z} \leq 10 \cdot 10^3$	$1.3 \cdot 10^3 < W_{1.z} \leq 1.3 \cdot 10^4$
5	$10 \cdot 10^3 < F_{1.z} \leq 10 \cdot 10^4$	$1.3 \cdot 10^4 < W_{1.z} \leq 1.3 \cdot 10^5$
6	$10 \cdot 10^4 < F_{1.z} \leq 5 \cdot 10^5$	$1.3 \cdot 10^5 < W_{1.z} \leq 6.5 \cdot 10^5$
7	$5 \cdot 10^5 < F_{1.z} \leq 10 \cdot 10^5$	$6.5 \cdot 10^5 < W_{1.z} \leq 1.3 \cdot 10^6$
8	$10 \cdot 10^5 < F_{1.z} \leq 5 \cdot 10^6$	$1.3 \cdot 10^6 < W_{1.z} \leq 6.5 \cdot 10^6$

Based on the systemic mechanism of external control to ensure the preservation and development of the basin geosystem under consideration, to ensure the preservation of its own **ecological state** within the spatial limits of the «AO» influence zones determined by space-time moving streams MEI. The movement of these flows occurs as a result of natural processes of interconnection, interaction and interrelation between natural biotic and abiotic elements in the composition of the environment. «NE», and unnatural man-made processes interconnections, interactions and relationships «AO» with «NE» in the «AO» influence zones.

For quantitative and qualitative assessment of expected changes **ecological state** in established zones of influence «AO» within the spatial limits of the basin geosystem based on the results ISEM substantiated the classification types of monitoring observations of the nature and intensity of MEI traffic flows (Fig. 2) Thus, environmental monitoring of the upper layers of the lithosphere includes determining the dynamics of changes in the geological environment associated with the activation of exogenous geological processes (EGP), flowing in the form of mechanical and physicochemical interaction with the hydrosphere of the river network, the atmosphere during construction and further operation «AO». To assess the dynamics of changes and tendencies of their development in the soil cover with underlying rocks, as a systemic element in the component «NE» under influence of «AO» monitoring studies of the soil and vegetation cover, faunistic, radiation, acoustic and electromagnetic interactions, as well as assessments of water and wind erosion of the soil cover were carried out (Fig. 2). To the most negative consequences of «AO» exposure the withdrawal from natural and agricultural turnover of land for «AO» placement, intensification of water and wind erosion. As a result of long-term observations (2005-2015), it was found that an indicator of negative changes in the soil cover is a change in the composition of the vegetation cover and, as a consequence, changes in the populations of the animal world.

The practical use of water resources in a particular branch of economic activity, as a necessity, is associated with intra-basin regulation or inter-basin redistribution of water flow (surface, underground) with the subsequent selection of estimated water flow rates ($Q \text{ m}^3/\text{s}$) in the technological systems of irrigation, water supply of urban households and economic facilities, the generation of electricity for HPP, HEPS, APS, PSHS and other vital needs, which introduces certain changes in the natural processes of the movement of streams MEI into the spatial limits of the basin geosystem, where water resources are formed. Therefore, to ensure **environmental safety**, as a consequence of the ongoing changes in the considered space and time **ecological state**, is necessary to use ISEM during «AO» construction and subsequent operation, in which the main species should be: hydrological, hydrobiological and ichthyological, hydro-chemical, channel processes and reformation of coastal zones, soil-vegetation of the riverbed floodplain, bacteriological and parasitological, faunistic coastal zones (Fig. 2) [5, 6, 31, 20].

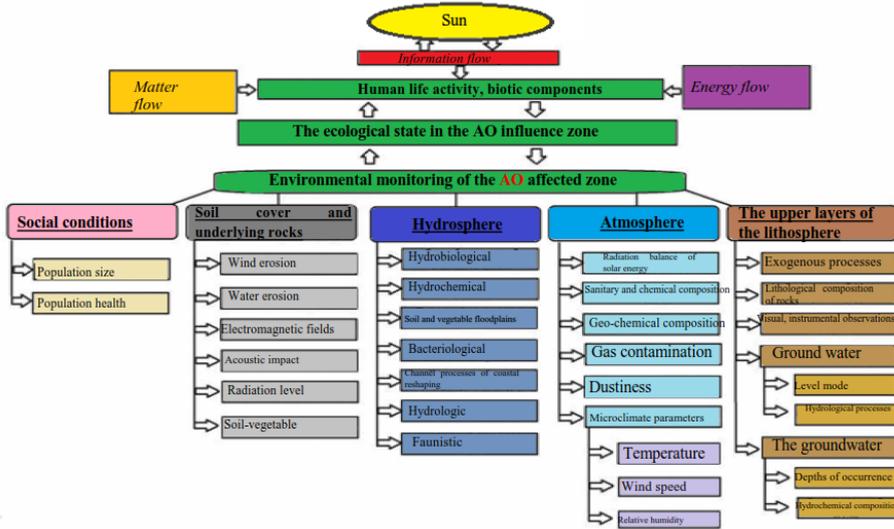


Fig. 2. Classification scheme of complex system environmental monitoring of "Activity Objects" as a part of NTE «NE– AO–P»

To assess the changes in the ecological state in the surface layers of the atmosphere in the «AO» influence zones, as the practice of construction and operation of water facilities in the regions has shown SFD and NCFD, It is recommended to carry out the following types of environmental monitoring - temperature, relative air humidity, speed of air masses over the water surface of reservoirs, water-transporting open channels of local dustiness and pollution during the «AO» construction period, geochemical and sanitary-chemical and radiation balance of solar energy entering the catchment area of the river hydrographic network (Fig. 2) [5, 6, 7].

Under the integral indicator of the ecological state in the considered spatial limits of the «AO» influence zones it is recommended to accept social conditions determined by the quality of life and health of the residents - «P». Thus, the intensity of environmental problems, using the example of the basin geosystem of the upper Kuban river, was expressed in the following points: satisfactory - 1 point; tense - 2 points; critical - 3 points; crisis (zones of ecological emergency) - 4 points; catastrophic (zone of ecological disaster) - 5 points.

2 Conclusion

1. TTF development class NTE «NE-AO-P» based on the categorical basic concept «System» integrable into the categories «Behaviour» and «Structure», is found to be dependent on the category understanding «Systems approach», as a research method for impact assessment «AO» for «NE» and population «P».

2. Based on the ISEM research results of the existing «AO» and «AO» under construction within the basin geosystems of the Kuban, Terek and Lower Don rivers, a classification characteristic of the necessary monitoring species for an objective assessment of changes in «NE» with provision **environmental safety** in the «AO» influence zones has been developed.

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