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IMPROVEMENT OF THE METHODOLOGY FOR COMPREHENSIVE ASSESSMENT OF THE ECOLOGICAL STATUS OF SURFACE WATER BODIES

The principle of international water management in transboundary river basins is that water-related issues should be addressed at the basin level as a whole, with the aim of preventing critical changes within the basin by any single country acting unilaterally. The principles of water resources management in the European Union include the precautionary principle, a high level of protection, preventive measures, the «polluter pays» principle, international cooperation, etc. [1, 2]. The Rhine River is a good example of compliance with these principles. It flows through nine countries and has a total length of 1,320 kilometers. The International Commission for the Protection of the Rhine (ICPR) was established to protect the Rhine. The Rhine 2020 program includes the following provisions: reducing damage by 25% by 2020; improving flood awareness and warning systems; maintaining and strengthening dams (27 hydroelectric power plants have been built along the river); and compiling flood risk maps (for spatial planners). Based on this program, «Rhine 2040» was created in February 2020 [4]. The goal of the program is to create and implement a process for managing the Rhine River basin in response to the effects of climate change. «Rhine 2040» aims to ensure the self-cleaning capacity of water, increase biodiversity, and facilitate the exchange of approaches, methods, experience, and scientific research on adaptation to climate change.

Water resources management within Ukraine's river basin is carried out in accordance with the basin management principle under the Water Code of Ukraine. To ensure effective management of the environmental safety of water resources, basin councils were established on the basis of Article 13³ of the Water Code of Ukraine [3].

The main tasks of the basin council include: providing proposals and ensuring the interests of enterprises, institutions, and organizations in the field of water use and protection, as well as taking measures to restore water resources within the sub-basin; promoting integrated water resources management within the sub-basin; to promote cooperation between central and local executive authorities, local self-government bodies, enterprises, institutions, organizations, international organizations, and experts (by agreement) to ensure the «good» ecological and chemical status of surface water bodies, the «good» chemical and quantitative status of groundwater, and the «good» ecological potential of artificial and significantly modified surface water bodies within the sub-basin [4]

To implement the basin principle of water resource management, it is important and necessary to develop a river basin management plan for each river basin separately in accordance with Article 13 of the European Union Water Framework Directive [5, 6]. In December 2023, a draft plan was developed for the Dnieper river basin for 2025–2030 [7]. Separate councils were established for the Dnieper sub-basins. Currently, the Desna and Upper Dnipro Basin Council, the Middle Dnipro Basin Council, the Lower Dnipro Basin Council, and the Pripjat Basin Council are in operation. The regulations on basin councils are approved by the State Agency of Water Resources of Ukraine. The State Agency of Water Resources of Ukraine, together with the State Service of Geology and Subsoil of Ukraine, central and local executive authorities, and local self-government bodies, in accordance with Article 5 of the Resolution of the Cabinet of Ministers of Ukraine No. 336 of May 18, 2017, «On Approval of the Procedure for Developing a River Basin Management Plan» [8], develop a river basin management plan. The document is updated no later than three years before the end of the current plan.

The aim of the study is to improve the reliability of assessing the ecological status of surface water bodies by taking into account the impact of upstream tributaries located below within the sub-basin on changes in the ecological status of Ukraine's main waterway.

During previous studies [9–10], the impact of pollutants from tributaries geographically located upstream of the main river on downstream tributaries was proven based on isolines constructed using the publicly available geographic information system software QGIS (Quantum GIS – <https://www.qgis.org/>) and a mathematical model was developed to predict changes in the ecological status of surface water bodies within the sub-basin, which allows predicting the impact of upstream tributaries on the main river downstream within the sub-basin, and take this into account when forecasting changes in

the ecological status of the main water artery, which allows it to be used when forecasting the possibility of natural and man-made emergencies and their consequences.

The basis of the proposed algorithm of management actions for the implementation of the basin principle of water resources management is an integrated approach to assessing the ecological status of a sub-basin of a surface water body by taking into account the impact of the left tributaries of the Dnieper River on the ecological status of the main water artery. The algorithm involves the following steps: collection and processing of data by each participating structure; determination of the predicted impact of upstream tributaries on the main river downstream within the sub-basin, which is a key factor in improving the assessment of the ecological status of surface water bodies; identification of pollution sources, development and implementation of measures to prevent and eliminate negative consequences. To forecast the ecological status of surface water bodies within the sub-basin, a mathematical model for forecasting their ecological status should be used, taking into account the impact of upstream tributaries on downstream tributaries, the reliability and adequacy of which has been proven by research.

When deciding on the necessary measures to respond to pollution of a downstream surface water body due to the impact of a water body located upstream, it is recommended to proceed as follows. It is assumed that, based on information about potential or existing pollution of a water body, structural units should use all available means of communication to convey information about the situation as quickly as possible to each organization involved in monitoring the environmental status of water bodies: basin water resource management authorities, territorial divisions of the State Emergency Service, the State Environmental Inspection, and local executive authorities.

The algorithm of management actions for implementing the basin principle of water resources management is presented in Figure 1.

These structures, either independently or in cooperation with another organization (the polluting enterprise), must immediately take the necessary measures to investigate and clarify the situation, eliminate the consequences, and control the situation that has arisen at the water facility. Organizations responsible for developing and monitoring the implementation of response measures, and enterprises that carry out the prescribed measures, must organize continuous monitoring of the situation in order to determine the effectiveness of the measures developed. Organizations responsible for developing and monitoring the implementation of response measures, and enterprises that carry out the instructions provided, must organize constant monitoring of the situation in order to establish

the effectiveness of the measures developed and, in accordance with the established procedure, promptly notify all interested structures with information about the environmental status of the water body, the concentrations of pollutants in it and in the enterprise's wastewater, in particular the expected concentration values from geographically higher rivers, the actions taken and their results in preventing or eliminating pollution. When MPCs are exceeded, the information is immediately forwarded to the territorial bodies of the State Emergency Service to determine the scale of the situation and assess the threat to the life of the population in a certain territory, which in turn promptly convey the information to the population and local authorities.

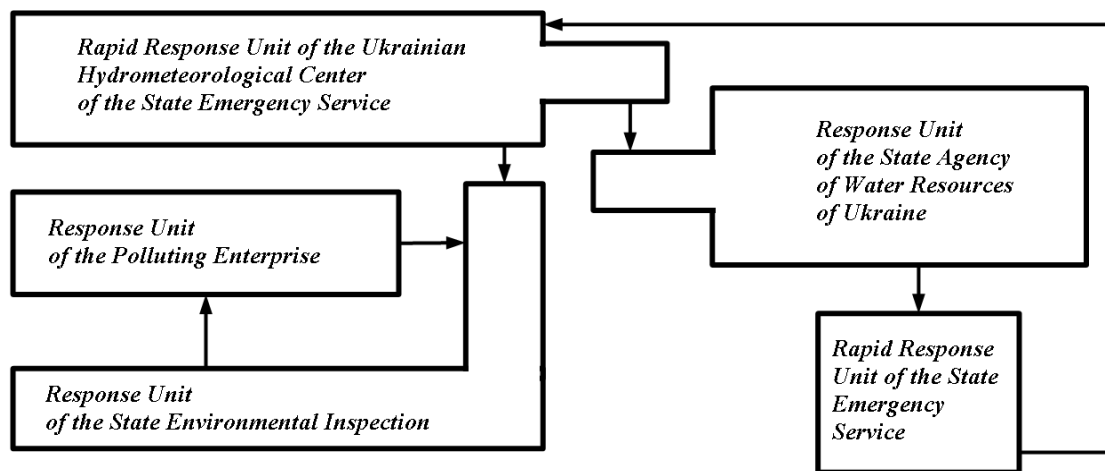


Figure 1 – Algorithm of management actions for implementing the basin principle of water resources management

Observation and control points must be combined with hydrological stations or areas that provide hydrological data. In accordance with the Regulations on the Ukrainian Hydrometeorological Center of the State Emergency Service of Ukraine dated April 2, 2024, the territorial body of the Ukrainian Hydrometeorological Center regularly collects and processes data on substance concentrations obtained from observation posts at water bodies. In order to improve the assessment of the ecological status of surface water bodies and to respond promptly to natural and man-made emergencies, the territorial body of the Ukrainian Hydrometeorological Center, based on the identified patterns of influence of the geographically higher left tributary of the Dnieper on the lower one due to internal flow, must regularly determine the expected value of the concentration of the substance from the higher tributary at the observation post of the lower tributary and compare it with the actual data on the concentrations of substances.

The criterion for determining the occurrence of a pollution threat is the environmental risk coefficient (K), which determines the degree of approximation of the concentration of the i-th substance to its MPC and is calculated using formula (1)

$$K = \frac{C_i}{\Gamma_{ДК_i}}, \quad (1)$$

Among the components of observations, it is essential to take into account visual monitoring of the condition of the water body. One of the most significant signs of a dangerous situation at a water body is the mass death of fish and other aquatic organisms, the release of bottom gas bubbles, the appearance of increased turbidity, foreign coloring, odor, water blooms, foam, film, and other phenomena that deviate from the normal state of the water body.

The Basin Council is the legislator for all water issues in the basin. The functions of basin councils include, in particular, considering proposals for draft river basin management plans and promoting coordinated action to improve the ecological status of sub-basins. Therefore, the proposed improvement of the methodology for identifying the main sources of deterioration of the ecological status of surface water bodies, by taking into account the mutual influence of tributaries within the sub-basin and on the ecological status of the main waterway, should be considered at a meeting of the Basin Council.

The proposed algorithm involves structures that are subordinate to various ministries. The Cabinet The proposed algorithm involves structures that are subordinate to various ministries. The Cabinet of Ministers of Ukraine is the highest executive authority in Ukraine, which exercises state administration and ensures the implementation of legislation. Therefore, a decision of the Cabinet of Ministers of Ukraine should be developed and approved, which will allow the application of the provided algorithm, with the aim of introducing management decisions aimed at reducing the negative anthropogenic load on surface water bodies for the implementation of the basin principle of water resources management.

Conclusions

Recommendations have been developed to improve the methodology for assessing the ecological status of surface water bodies, based on an algorithm of management actions, using a mathematical model to predict changes in the ecological status of the main waterway within the basin, taking into account the mutual influence of the left tributaries of the Dnipro sub-basins for rapid response to natural and man-made emergencies.

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