Ecological and technological quotas anthropogenic load in basin of the Velikaya River

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Abstract. An algorithm is proposed for environmental and technological standardization anthropogenic load on water bodies basins. An indicator has been developed to assess the level of environmental friendliness of technologies used in production. This indicator, proposed for early levels of environmental impact and the subsequent distribution of permissible loads between enterprises it is within the basins of the normative norm of admissible influence. This approach is implemented in the distribution of permissible load within the water basin of the Velikaya River.

Significant changes took place in the water protection legislation of the Russian Federation regarding permissible loads on water bodies in 2019. The rationing is based on a principle - technological rationing, in which the basic criteria for evaluating enterprises are applied best available technology (BAT). Now, enterprises are assigned one of four categories of negative impact on the environment (NIE) [1, 2].

So, enterprises of the first category should carry out their activities taking into account the best available technology (BAT) and establish technological standards that are taken into account when developing a comprehensive environmental permit (CEP). Enterprises of the second category, if they have information and technical guides (ITG), can also conduct their activities in accordance with the requirements of BAT and take them into account when developing a declaration of negative impact. Along with these changes in the legislation, the principle of basin regulation of the anthropogenic load on water bodies remains, which is enshrined in the norm of admissible influence (NAI) [3 – 5].

The current standardization methodology does not allow to distribute load norms for all water users with their combined impact within a single basin or water management site. There is no clear definition of criteria for technological standardization and assessment of the level of environmental friendliness of enterprises - water users within the boundaries of the water management site.

In the work on the example of the Velikaya river basin, enterprises are identified by the degree of compliance with BAT. The Velikaya River is a river in the Pskov region. It belongs to the basin of the Narva River (through the Pskov-Chudskoe Lake) and, in general, to the Baltic Sea basin.

The main stages of the proposed algorithm of environmental-technological rationing of discharges within the framework of the basin approach, taking into account the level of environmental friendliness (LEF) of technologies of enterprises - water users are (figure 1):
• determination of background characteristics by indicators and parameters of a water body under various hydrological regimes;
• development of the GIS project structure within the boundaries of the water management sections of the water basin;
• determination of the main sources of negative impact on the water basin using environmental and technological assessment of enterprises - water users with subsequent ranking according to a given criterions;
• zoning of the basin of a water body and determination of the boundaries of the design areas with a change in the class of water quality;
• grounded models for normalizing the load on the water body and building a linear scheme;
• simulation modeling for a group of water users using the «GIMS-river» geoinformation complex for allocation of quotas and individual norms of permissible discharge, and justification of discharge parameters that are optimal according to environmental and technological criteria.

Figure 1. Generalized structure of environmental-technological regulation of discharges.

According to figure 1, at the first stage, the collection and synthesis of initial information is carried out. The following data were used as initial data: state water register; reporting on forms 2-TP (vodkhoz); cartographic material for the Velikaya River basin; information on the posts of hydrological and hydrochemical control, including information on the quality of natural water.

Based on the results of processing the initial data, the background characteristics of the main indicators of the basin water bodies were determined. The indicators for which excess standards for maximum permissible concentrations (MPC) are exceeded are the following: COD (1.6 MPC), copper (3.2 MPC), manganese (2.6 MPC) and petroleum products (1.5 MPC). The main indicators in assessing the degree of water pollution are copper and manganese; their total grade points (S) are 8.3
and 8.2. As a result of calculations of water the Velikaya river are characterized as polluted (UKIZV – 2.54, 3 class, category «a»).

At the next stage, a GIS project of the Velikaya river basin was developed, containing the following data layers:

- hydrochemical posts (a point layer containing information on the placement of hydrochemical control posts on water bodies and the results of this control);
- hydrological posts (a point layer containing information about the placement of hydrological observation posts and the parameters monitored on them);
- hydrology (linear and polygonal layers, including watercourses and reservoirs with the main parameters of the objects);
- water management enterprises (the exact location of local enterprises) - water resources and data on discharge volume, qualitative and quantitative composition of wastewater);
- boundaries of water management sites (polygonal layer with the boundaries of water management sites and their intended).

The implementation of the GIS project is carried out in the widespread ArcGIS application software from ESRI [6, 7] shown in figure 2.

![Figure 2. GIS project of the Velikaya river basin.](image)

According to the analysis of the source data, 84 enterprises were identified in the river basin. Great, which carry out the discharge of wastewater. According to the results of ranking for individual and integral masses of pollutant discharges, 16 main enterprises were identified. The technologies of these enterprises were evaluated according to the level of environmental friendliness (LEF).

Assessment of the level of environmental friendliness of the basin enterprises was carried out according to the proposed formula [8]:

...
\[ L\text{EF} = \left( \sum_{i=1}^{n} \alpha_i \right)^{-1} \sum_{i=1}^{n} \alpha_i k_i, \] 

(1)

\( n \) – the number of indicators considered;
\( k_i \) – score indicator;
\( \alpha_i \) – the coefficient of significance of the summed indicator of the considered parameters.

When calculating the following indicators were taken into account: technological standards; design indicators of environmental equipment; specific norms for water consumption and sanitation; coefficients taking into account the use of water (water recycling coefficient \( k_{\text{rec}} \); water reuse coefficient \( k_{\text{reuse}} \); coefficient of irretrievable consumption and fresh water loss \( k_{\text{con}} \); coefficient of water use taken from the source \( k_{\text{use}} \)).

The score for the indicated indicators is formed depending on the ratio of the indicator value to the standard value corresponding to the BAT, or on a normalized scale [8].

The coefficient of significance of indicators for each industry is determined on the basis of expert analysis.

Enterprises are classified by the effectiveness of introducing environmental technologies into five categories, depending on the level of environmental friendliness (table 1).

**Table 1.** Relation of the LEF indicator with environmental and technological production observers [8].

| LEF | Classification of enterprises by the effectiveness of the implementation of environmental technologies | Technology implementation |
|-----|-------------------------------------------------------------|-----------------------------|
| ≥4  | Highly efficient                                           | Development strategy can be accepted as the best. |
|     |                                                              | The technology satisfies BAT and the impact on the aquatic ecosystem. |
|     |                                                              | The technology satisfies several indicators. |
| 3.5 – 4 | Efficient                                                 | The aquatic ecosystem does not degrade due to assimilation |
|     |                                                              | Technology satisfies one or more indicators. |
| 2.5 – 3.5 | Medium Effective                                           | Water ecosystem through assimilation does not degrade |
|     |                                                              | The technology does not satisfy one or several indicators and the impact on the aquatic ecosystem in the future may lead to a decrease in the class of water quality |
| 1 – 2.5 | Little Effective                                            | It is necessary to change the development strategy of the enterprise. Water quality does not meet environmental requirements and the water ecosystem is degrading |
| ≤1  | Ineffective                                                 | |

According to the results of calculating the level of environmental friendliness of enterprises located in the Velikaya river basin.

An excellent diagram was constructed comparing the LEF values (figure 3).
Based on the calculations, the following were assigned to highly efficient enterprises: Krasnogorodsky District Municipal Enterprise of Housing and Communal Services (ME HCS), ME HCS of Pushkinogorsky District No. 2, agricultural cooperative (ACC) Issa Pushkinogorsky District.

Then, according to the given structure of environmental and technological standardization, the calculation of the norms of admissible dump discharges for the enterprises under consideration was made taking into account the LEF. Table 2 shows the results of the calculation of NAD and a comparison with the actual mass of discharge of pollutants.

![Figure 3. Values of the level of environmental friendliness of enterprises.](image)

Table 2. Comparison of actual masses of discharge and NAD.

| Business name                                      | biological oxygen consumption (BOC<sub>nat</sub>) | N<sub>over</sub> | Suspended solid |
|---------------------------------------------------|-----------------------------------------------|-----------------|-----------------|
|                                                    | NAD, M<sub>fact</sub>, tons/year             | NAD, M<sub>fact</sub>, tons/year | NAD, M<sub>fact</sub>, tons/year |
| Ostrovsky «Vodokanal»                             | 39.93, 48.48                                 | 16.07, 17.31    | 4170.01, 9080   |
| Company «Poultry farm «Ostrovskaya»                | 767.24, 790                                  | 308.83, 406.24  | 4012.61, 4956   |
| Company «Pushkinogorsk butter and cheese factory» (settlement Krasnogorodsk) | 49.67, 56.56                                 | 20.00, 182.82   | 5187.47, 7671   |
| Krasnogorodsky District ME HCS                    | 15, 15                                      | 32.9, 32.9      | 1250, 1250      |
| Company «Pushkinogorsk butter and cheese factory» (Selikhnovo village) | 27.31, 42.2                                 | 10.99, 56.46    | 2852.25, 3677   |
| ME HCS of Pushkinogorsky District No. 1          | 0.28, 15.65                                  | 0.11, 0.98      | 29.08, 35.22    |
| ME HCS of Pushkinogorsky                         | 115.45, 115.45                               | 45.56, 45.56    | 1460, 1460      |
For three highly efficient enterprises as standards for allowable discharges actual masses of pollutant discharges were accepted, as the technologies used on them meet modern technological and environmental requirements.

The rest of the enterprises are environmentally ineffective, therefore, the environmental and technological standards for permissible discharges set for them are significantly lower than the actual discharges, which should stimulate the introduction of water protection measures on them.

The proposed methodology of environmental and technological standardization depends on the standards of permissible discharge, permissible load, and criteria for the level of environmental friendliness of enterprises – water users. The developed methods make it possible to evaluate the technologies used at enterprises – water users in the Velikaya River basin, to adjust the standards for permissible discharges of enterprises taking into account environmental and technological criteria.

The proposed methods and algorithms make it possible to increase the efficiency of production by choosing the best available technologies, and increase the competitiveness of production and enterprises in general.

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