Monitoring and Management of Water Use in the Basin of the Transboundary River Seim

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Abstract. Environmental safety issues are of great importance. The problems associated with the monitoring and management of water use in the basins of transboundary rivers are especially acute. The relevance of the research topic and the degree of its scientific development give grounds for formulating a scientific problem as the need to study the state of the transboundary river Seim, flowing through the territory of the Russian Federation and Ukraine, in the context of observing and ensuring international principles of sustainable development of water resources. The study of the issue of improving the ecological state of the Seim River was carried out based on the use of complex monitoring and an expert survey. The authors proposed an approach to organizing a water management system in the basin of the transboundary river Seim and developed measures to improve the state of surface waters.

1. Introduction

One of the most important components in the issue of sustainable development is the problem of water resources. The problem of monitoring the state of rivers and water consumption is given close attention not only at the state level but also in the international arena. The result of the conference in Rio de Janeiro in June 1992 was the Declaration, proclaiming the obligations of states on the basic principles of achieving sustainable development. Among them are those that relate to water management, monitoring of the state of transboundary rivers, and international principles of sustainable development of water resources. Achieving the sustainability of water use requires not only a transformation in the water management system but the development of a new systemic approach to solving the stated problem. The authors of the article monitored the state of the Seim River at four points, which made it possible to identify the environmental damage that the economic activities of the population and enterprises of the Kursk region inflict on the river. As a method of collecting expert assessments, a questionnaire was used, in which 34 people took part. The results of the study made it possible to propose measures to ensure sustainable water use and improve the condition of surface waters in the basin of the transboundary river Seim.
2. Relevance, scientific significance of the issue with a brief review of the literature

Research on monitoring the state of transboundary rivers was carried out by such scientists as G. N. Gaifulina, M. S. Sharopaeva, M. S. Spiridonova [9], V. V. Ivanov, М. V. Tretyakov [10], S. L. Khairullina [11], E. V. Korf [12], G. Ch. Donbaeva [6]. The peculiarities of water resources management of transboundary rivers were studied by V. I. Danilov-Danilyan [5], E. A. Nysanbekova, A. A. Alzhanova, P. T. Bayneeva [17], DD Dzhumadurdyev [7], NB Abdushaxidov [1], M. M. Amanov [2], G. A. Kumie [13].

Aspects of protection of water resources are considered both in the domestic (S. A. Lopatin [14], D. O. Sivakov [24], Yu. V. Treskova, A. S. Biekenova [25], A. F. Nikiforov, A. S. Kutergin, VS Semenishchev, SV Nikiforov [16]) and foreign (K. Sadoff, T. Greiber, M. Smith, G. Bergkamp [22], G. White [27]) literature.

In the works of V. A. Gaidarenko [8], N. K. Savelyeva [23], M.V. Neparko, N. E. Akimov [28], A. A. Zykov [17], the directions of development of international transboundary cooperation are analyzed.

However, despite the increase in the number of publications on this issue, studies that would mutually link the issues of monitoring and management of water use in the basins of transboundary rivers have not been developed, and there is no single integrated approach to water resources management.

3. Statement of the research problem

The relevance of the research topic and the degree of its scientific elaboration give grounds for formulating a scientific problem as the need to study the state of the transboundary river Seim, flowing through the territory of the Russian Federation and Ukraine, in the context of observing and ensuring international principles of sustainable development of water resources.

4. Theoretical and methodological foundations of monitoring and water use management

Environmental monitoring is a complex system for observing the state of the environment, assessing and forecasting this state under the influence of anthropogenic factors [19]. In many regions of the Russian Federation and Ukraine, there is currently a significant anthropogenic impact on water resources [4]. The volume of wastewater discharged into rivers and reservoirs reaches colossal values. As a result, surface waters are polluted with oil products, ammonium nitrogen, phenol, synthetic surface-active substances (surfactants), compounds of copper, iron, zinc, manganese, and cadmium. With insufficient geological protection of aquifers, groundwater pollution with sulfates, nitrogen compounds, phenols, iron, and heavy metals is observed in places [18]. In this regard, the development and implementation of water protection measures are required, but their implementation should be preceded by a comprehensive assessment of the anthropogenic load on water resources. The river basin should be considered as a paragenetic system, where the interaction of conjugated interdependent elements connected by a unidirectional flow of matter and energy is noted [3].

As a result of the joint use of transboundary water bodies between countries, controversial issues arise regarding the assessment of the consequences of the impact. This circumstance is due, as a rule, to the absence of generally accepted methodologies for such assessments. Since a modern water use strategy should be based on the principles of maintaining the state of the drainage basin ecosystem, an ecosystem approach should be applied to water use management. It assumes the achievement of the main goal of water supply and protection of water resources, provided that a stable ecological state is maintained not only for water sources, ut also for the natural environment of the basin as a whole [26]. However, at present, this approach to water resources management has not been formed either in Russia or in Ukraine. The tendency of separate planning and management of ecological-socio-economic aspects of water management continues to persist [11].
5. Assessment of the ecological state of the transboundary river Seim

The assessment of the ecological state of the transboundary river Seim was carried out at four points, which made it possible to identify the environmental damage caused to the river Seim directly from the economic activities of the population and enterprises of the Kursk region. The first point is the Seim River section, 5 km above the city of Kursk; the last one is the section of the Seim River in the Tetkino settlement, on the outskirts of which the state border of Russia and Ukraine passes. To process the data obtained, statistical methods were used that allow showing the quantitative dependence of the content of pollutants in the form of tables. The monitoring results were supplemented by an expert survey conducted in 2020. A questionnaire survey was used as a method for collecting expert assessments. The total number of experts is 34 people aged 25 to 50. The percentage of women and men was 77% to 23%, respectively.

The Seim River is a left tributary of the Desna (Black Sea basin). The source of the river is located on the southwestern slopes of the Central Russian Upland. The width of the river bed during the summer low-water period in the upper reaches ranges from 10 to 30 meters, in the middle - from 40 to 80 meters, and in the lower reaches - from 80 to 100 meters. The depth of the river varies from 2 to 3 meters, decreasing to 1.0 meters in the rifts and increasing to 6 meters in the reach areas and the lower reaches, sometimes up to 15 meters. River feeding predominantly snow, formed also by groundwater. The total area of the river basin is 27,500 km², of which 20,350 km² area in the Kursk region. The river valleys are wide, erosional, worked out by chalk deposits. The main rocks of this region are chalk and limestone. The relief is hilly, strongly dissected by beams and ravines. The Seim's river system has more than 914 tributaries. The Dnieper basin, to which the Seim River with its tributaries belongs, occupies about 80% of the area and is located to the west of the main watershed.

The authors of the article determined the hydrogen index and specific electrical conductivity of the Seim River. The results are shown in Table 1.

| Table 1. Hydrogen index and specific electrical conductivity of the Seim river. |
|---------------------------------------------------------------|
| The Seim River section is 5 km above the city of Kursk within the boundaries of the village. Lebyazhye | The section of the Seim river in Tetkino settlement, 2 km below the city, below the sewage discharge of the PUVKH (northern district) | The section of the Seim river in Tetkino settlement, 0.5 km downstream of the wastewater discharge from the Popov-Reclining sugar factory |
| pH | Electrical conductivity | pH | Electrical conductivity | pH | Electrical conductivity | pH | Electrical conductivity |
| January, winter low water | 7.83 | 702 | 8.03 | 750 | 7.90 | 760 | 8.01 | 798 |
| March, spring flood | 7.95 | 755 | 7.83 | 720 | 8.00 | 780 | 8.05 | 800 |
| April, spring low water | 7.75 | 700 | 7.82 | 705 | 7.80 | 638 | 7.76 | 670 |
| August, summer low water | 7.90 | 743 | 8.02 | 730 | 7.80 | 639 | 7.96 | 654 |
| November, before freezing | 7.72 | 663 | 7.80 | 680 | 7.82 | 642 | 7.90 | 638 |

Based on the data given in the table, it can be concluded that the water of this water body belongs to a weakly alkaline medium since the minimum pH value is 7.60. In such an environment, marine fish feel...
comfortable, since pH changes little in the water of the seas (from 7.5 to 8.5). Freshwaters, in contrast to sea waters, are characterized by pH instability. It depends on many factors, such as the chemical composition of the reservoir, photosynthetic activity of plants, especially during the period of "blooming" of water. Thus, most freshwater fish have adapted to tolerate significant changes in pH.

Within the framework of the monitoring of the Seim River, biological (BOD) and chemical (COD) oxygen consumption was determined, which are complex characteristics of water pollution by organic substances. The results are shown in Table 2.

| Table 2. Mass concentrations of BOD5 and COD obtained as a result of analyzes. |
|--------------------------------|--------------------------------|--------------------------------|--------------------------------|
|                               | The Seim River section         | Seim river section             | The section of the Seim river section, |
|                               | 5 km above the city of Kursk    | 2 km below the city, below the sewage discharge of the PUVKH within the boundaries of the village. | Tetkino settlement, above the post within the village. |
|                               | within the Lebyazhye city       | within the Popov-Reclining settlement, (northern district) | downstream of the wastewater discharge from the sugar factory |
| BOD5                          | January, winter low water       | March, spring flood             | April, spring low water |
| COD                           | 2.12                           | 1.85                           | 2.16                           |
|                               | 14.2                           | 14.5                           | 20.4                           |
| COD                           | 2.78                           | 2.13                           | 2.13                           |
|                               | 22.7                           | 23.7                           | 16.8                           |
| BOD5                          | 1.19                           | 1.43                           | 2.25                           |
| COD                           | 12.0                           | 1.23                           | 2.07                           |
|                               | 24.4                           | 19.4                           | 15.1                           |
| COD                           | 2.0 mg / l                     | 15.0 mg / l                    |                                 |

Based on the data given in Table 2, it can be concluded that, in terms of chemical oxygen consumption, an excess of MPC is observed in 89% of the samples taken. The greatest number of cases of excess was revealed in the phases of spring and summer low water and before freeze-up. The excess of the MPC for BOD5 is observed in 29% of the samples, with the largest number of cases of excess recorded in the spring dry season. For biochemical oxygen consumption for 5 days, the MPC value was set - 2.0 mg / l, for chemical oxygen consumption - 15.0 mg / l. Wastewater COD can reach hundreds of milligrams per cubic decimeter.

The authors of the article determined the mass concentrations of copper, zinc, and iron compounds in the transboundary river Seim. It was revealed that copper compounds exceed the MPC in 83% of the samples taken, zinc compounds - in 77%, and iron compounds - in 57%. The results of the study are shown in Table 3.
Table 3. Mass concentrations of copper, zinc, and iron compounds in the Seim river.

|                  | The Seim River section is 5 km above the city of Kursk within the boundaries of the village. Lebyazhye | Seim river section 2 km below the city, below the sewage discharge of the PUVKH | The section of the Seim river in Tetkino settlement, above the post within the village. Popov-Reclining (northern district) | Seim river section, 0.5 km downstream of the wastewater discharge from the sugar factory |
|------------------|--------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------|
| **January, winter low water** |                                                                                 |                                                                                  |                                                                                                          |                                                                                            |
| Copper           | 1.2                                                                               | 1.6                                                                             | 2.6                                                        | 2.8                                                                                          |
| Zinc             | 1.2                                                                               | 1.2                                                                             | 2.1                                                        | 2.1                                                                                          |
| Iron             | 0.062                                                                              | 0.067                                                                           | 0.105                                                      | 0.116                                                                                      |
| **March, spring flood** |                                                                                 |                                                                                  |                                                                                                          |                                                                                            |
| Copper           | 1.2                                                                               | 1.2                                                                             | 0.0                                                        | 0.0                                                                                          |
| Zinc             | 0.0                                                                               | 1.1                                                                             | 1.1                                                        | 1.2                                                                                          |
| Iron             | 0.125                                                                              | 0.188                                                                           | 0.105                                                      | 0.107                                                                                      |
| **April, spring low water** |                                                                                 |                                                                                  |                                                                                                          |                                                                                            |
| Copper           | 1.0                                                                               | 1.0                                                                             | 1.2                                                        | 1.1                                                                                          |
| Zinc             | 1.1                                                                               | 1.0                                                                             | 1.3                                                        | 1.0                                                                                          |
| Iron             | 0.125                                                                              | 0.145                                                                           | 0.036                                                      | 0.040                                                                                      |
| **August, summer low water** |                                                                                 |                                                                                  |                                                                                                          |                                                                                            |
| Copper           | 1.0                                                                               | 1.1                                                                             | 1.3                                                        | 1.2                                                                                          |
| Zinc             | 1.5                                                                               | 1.4                                                                             | 1.2                                                        | 1.5                                                                                          |
| Iron             | 0.064                                                                              | 0.067                                                                           | 0.115                                                      | 0.102                                                                                      |
| **November, before freezing** |                                                                                 |                                                                                  |                                                                                                          |                                                                                            |
| Copper           | 1.3                                                                               | 1.4                                                                             | 1.6                                                        | 1.4                                                                                          |
| Zinc             | 1.2                                                                               | 1.2                                                                             | 1.1                                                        | 1.1                                                                                          |
| Iron             | 0.082                                                                              | 0.085                                                                           | 0.105                                                      | 0.102                                                                                      |

In addition to instrumental monitoring, a survey of experts was conducted. They were asked to answer questions directly related to the problem of the ecological state of the Seim River. According to the majority of experts, the quality of water in the Seim River has remained unchanged lately (41.2%). 29.4% believe that the deterioration was insignificant. Also, the respondents were asked about the degree of pollution of this river. 62% of the experts were in favor of the high degree of pollution. Then they were asked to answer the question: "Which of the enterprises of the Kursk region is the most environmentally hazardous for the Seim River?" The most dangerous enterprises are MUE Vodokanal of the city of Kursk and LLC Kurskhhimvolokno (44% and 41%, respectively). Less dangerous, according to experts, are OJSC Kursk City Improvement Enterprise (26%), OGUP Kursk Fish Farming Plant (23%).

6. Organization of a water management system and development of measures to improve the state of surface waters of the transboundary river Seim

In the opinion of the authors of the article, the basin system of water consumption management of the transboundary river Seim must be based on a set of legal, methodological, organizational, metrological and technical measures. This is necessary to preserve not only water supplies but also to improve their quality.

The principle of territoriality can act as one of the principles of information support for management [20]. Zoning of the Seim river basin in terms of environmental and economic indicators should be carried out taking into account the hierarchical levels of management. It is also necessary to take into account the ecological vulnerability of the waters of the basin per the specific natural conditions of their formation.
The current state of the ecological system of the Seim River cannot be called stable, since the anthropogenic impact is quite large. Measures to improve the surface waters of the Seim rivers should include measures that will preserve water bodies in the state in which they currently exist. These activities include the fight against poaching, the protection of places of mass fish spawning [21]. It is important to combat illegal logging on the banks of water bodies, as well as pollution of water bodies with toxic substances and heavy metals.

Since at present it is not possible to completely abandon human intervention, measures are needed for the ecological rehabilitation of the Seim River. Environmental remediation includes:
1. Implementation of design and survey work (description of the object: field research of adjacent territories, mapping, drawing up a report; laboratory research: sampling and analysis of samples; recommendations on the technical and biological stages of the rehabilitation of reservoirs).
2. Cleaning the reservoir bed from contaminated sediments.
3. Pond waterproofing project, bottom reinforcement.
4. Accumulation and treatment of drainage and stormwater feeding reservoirs.
5. Reclamation of catchment areas.
6. Bank protection project, anti-landslide, and anti-erosion measures.
7. Population of reservoirs with aquatic organisms, planting of aquatic vegetation.
8. Improvement of floodplain areas, landscaping, landscape design of coastal and recreational areas.

7. Conclusions

To achieve the sustainability of water use requires not only a transformation in the water management system but the development of a new systemic approach based on a set of legal, methodological, organizational, metrological, and technical measures. The monitoring of the state of the Seim River showed that the current state of the ecological system of this river cannot be called stable due to excessive anthropogenic influence. Since it is not possible to refuse human intervention in the aquatic ecosystem, the authors have developed measures for the ecological rehabilitation of the Seim River.

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