Mon23-089

Hydrochemical determination of the Teteriv River and the Kamianka River eutrophication potential

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SUMMARY

River ecosystems are heavily influenced by a number of natural and anthropogenic factors that are changing rapidly. The channel regime and general condition of medium and small rivers are now less dependent on natural factors and more on economic activities in the catchment area, which flow through urbanized areas. Urbanization processes can lead to increased river eutrophication. Urbanization can lead to changes in river flow due to water

extraction, channelization, or the creation of barriers like dams and weirs. Altered flow can impact sediment and nutrient distribution and transport. Urbanized areas have a higher percentage of impervious surfaces (e.g., roads, buildings, and pavements) compared to natural landscapes. This can result in faster and greater volumes of surface runoff after rainfall. This runoff can carry a variety of pollutants into rivers, including nutrients that drive eutrophication. Even with modern wastewater treatment, urban sewage systems can sometimes release

nutrient-rich water, especially during overflow events. Moreover, in some developing areas, wastewater treatment might be insufficient or nonexistent, leading to the direct discharge of phosphates, nitrates, and organic matter into rivers. Eutrophication effects, like murky water, reduced fish populations, and unpleasant odors, can degrade the recreational value of rivers and lakes, leading to potential economic losses.

The aim of the investigation was to determine the eutrophication potential of the Teteriv and Kamianka rivers based on hydrochemical monitoring indicators.

Determining the eutrophication potential of small rivers can help raise community awareness about the environmental impacts of their lifestyle choices, including the use of fertilizers, detergents, and waste disposal practices.

Introduction

Determining the eutrophication potential of a small river array is critical, especially in the context of growing urbanization (*Kotsiuba, 2022*). As urban areas grow, so do the amount of pollutants released into nearby water bodies. Poor water quality can have serious implications for public health and may also contribute to the decline of local ecosystems (*Gandziura, 2008*). High nutrient levels due to eutrophication can lead to algal blooms, some of which can produce toxins harmful to aquatic life and humans. Eutrophication leads to oxygen depletion, which can result in the large-scale death of fish and other aquatic organisms, thereby disrupting the food chain and overall ecosystem health. Eutrophication can make water treatment more complicated and expensive, raising the cost for communities and potentially affecting the quality of drinking water. Understanding the eutrophication potential can help in resource allocation and in planning wastewater treatment facilities or other mitigation measures. Information on the eutrophication potential can influence urban planning decisions, including zoning laws, land use planning, and urban drainage system designs (*Smith, 2003*). In summary, understanding the eutrophication potential of a small river array in the context of growing urbanization is important for both ecological and human health, economic well-being, and long-term sustainability planning. Monitoring and mitigating eutrophication should be an integral parts of urban environmental management strategies (*Schindler, 2012*).

The aim of the investigation was to determine the eutrophication potential of the Teteriv and Kamianka rivers based on hydrochemical monitoring indicators.

To achieve this goal, the following tasks were set:

1) Determine the indicator values of the aquatic environment that are sensitive to eutrophication conditions, namely nitrate content, phosphate content, biochemical oxygen demand (BOD), and dissolved oxygen concentration in hydrochemical samples using standard hydrochemical methods.

2) To analyze the long-term dynamics of the studied hydrochemical parameters.

3) To determine the eutrophication potential of the Teteriv and Kamianka rivers.

Method and Theory

Nitrate content determination in hydrochemical samples. The colorimetric method for determining nitrate content in water involves a reaction that produces a color proportional to the concentration of nitrate present. By measuring the intensity of this color, usually using a spectrophotometer, the nitrate concentration can be quantified. The colorimetric method is widely employed due to its simplicity, sensitivity, and capability to produce rapid results. However, accuracy depends on the proper preparation of reagents, calibration standards, and care during the procedure (*Maksymenko, 2022*). Determination of the phosphate content in hydrochemical samples. The molybdate method is a widely used colorimetric technique for determining the phosphate content of water samples. In this method, a soluble molybdate ion reacts with phosphate ions to form a colored complex, typically blue or yellow, whose intensity can be measured to determine the phosphate concentration. The molybdate method is popular because it is relatively quick, simple, and sensitive. However, the accuracy of the method depends on the quality of the reagents, the calibration curve, and the spectrophotometer, as well as the absence of interfering substances in the water samples (*Maksymenko, 2022*). Biochemical Oxygen Demand (BOD) is a widely used metric for determining the organic pollution level in water and wastewater, particularly in freshwater systems. Dissolved oxygen (DO) concentration plays a pivotal role in determining the eutrophication potential of water bodies. DO refer to the concentration of oxygen that is present in water. Eutrophication is the enrichment of nutrients (like nitrogen and phosphorus) in a water body, leading to the increased growth of algae and plants. As these organisms die and decay, bacteria decompose them, consuming dissolved oxygen in the process. A decrease in DO can have significant negative effects on aquatic life and indicates an increasing eutrophication potential (*Maksymenko, 2022*).

Results

In many freshwater systems, phosphorus is the limiting nutrient, meaning its availability determines the rate of growth for primary producers. High phosphate levels and resulting algal blooms can complicate water treatment processes, making it harder and more expensive to produce clean drinking water (*Gandziura, 2023*). The dynamics of phosphate content in the Teteriv River are variable (Fig. 1).

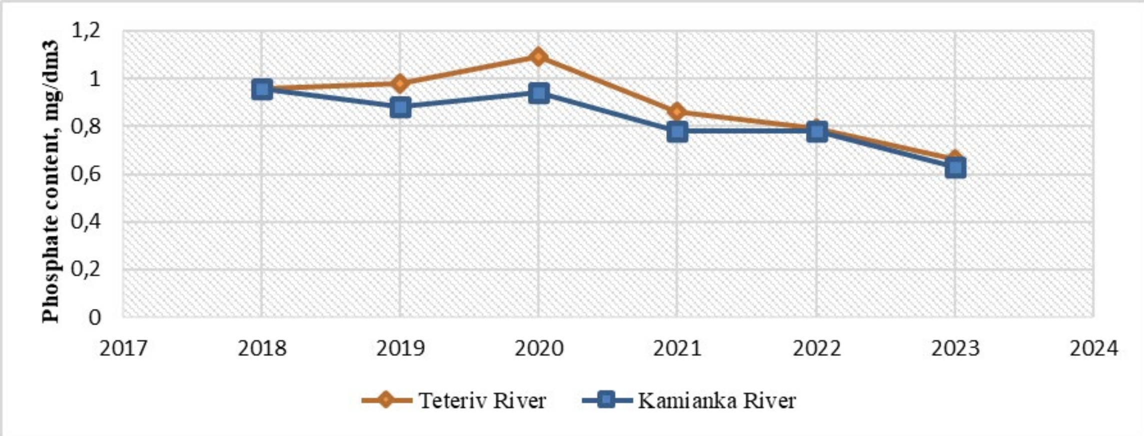

Figure 1 *Phosphate content dynamics of the Teteriv River and the Kamianka River water surfaces*

Since 2018, there has been an increase, with a peak in 2020 (1.09 mg/dm3), followed by a gradual decrease after 2020. The correlation index was 0.91, and the approximation reliability was 0.8316. As for the phosphate content in the Kamianka River, the trend is similar to that in the Teteriv River (a peak of 0.94 mg/dm3 was observed in 2020, and a downward trend is observed thereafter). The correlation index was 0.80. The approximation reliability is 0.6470. While phosphorus is often considered the primary limiting nutrient in freshwater systems, nitrates (forms of nitrogen) can also significantly influence eutrophication, especially where they are abundant. Analyzing the dynamics of nitrate content in the water environment of the studied rivers (Fig. 2), we can observe an increase in both water bodies.

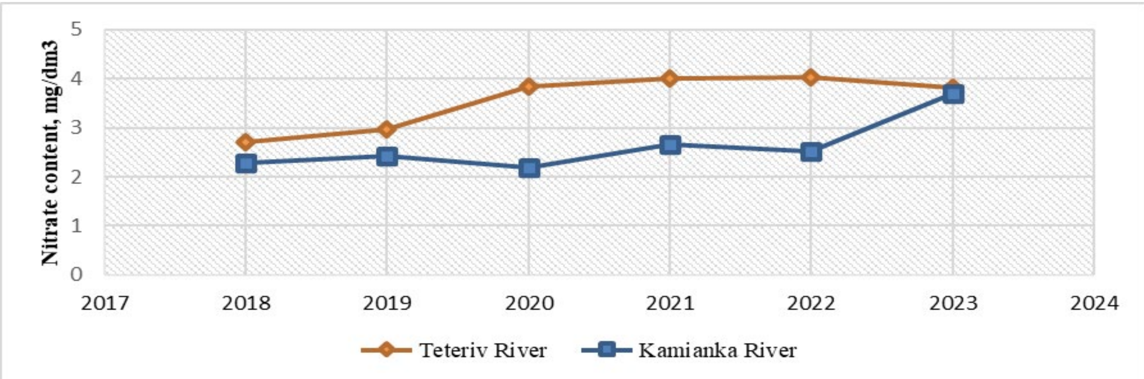

Figure 2 *Nitrate content dynamics of the water surfaces of the Teteriv River and the Kamianka River*

The nitrate content of the Teteriv River is increasing, as evidenced by the graphical display of the dynamics. The correlation index was 0.83. It is also quite high. The approximation reliability is 0.6864. As for the Kamianka River, it varies, with moderate fluctuations from 2018 to 2022 and an increase in 2023. The correlation index was 0.77. It is also quite high. The reliability of the approximation is 0.5873. It is essential to interpret BOD_5 data in the context of other water quality parameters and the specific circumstances of the water body or system being studied. The dynamics of BOD 5 in the Teteriv River have a downward vector (tab. 1).
Over the past 5 years, BOD_5 values in the Teteriv River have ranged from 3.91 to 4.5 mgO_2/dm^3, with a peak in 2021 and a minimum in the first half of 2023. A reduced BOD_5 typically suggests that there is less biodegradable organic matter in the water. Regarding the Kamianka River, a tributary of the Teteriv River, BOD_5 values ranged from 3.83 to 4.1 mgO_2 /dm^3 with a peak in 2019 and a minimum in the first half of 2023.

Table 1 *Biochemical oxygen demand dynamics in the aquatic environment of the monitored rivers*

BOD_5, mgO_2/dm^3	Hydrochemical sampling year					
	2018	2019	2020	2021	2022	2023
Teteriv River	4,15	4,19	4,16	4,50	4,02	3,91
Kamianka River	4,04	4,10	4,08	4,09	3,93	3,83

The downward trend of BOD_5 in the Kamianka River is similar to the Teteriv River, but the dynamic range is much narrower. Oxygen is essential for the survival of most aquatic organisms. When these levels drop due to eutrophic conditions, it can lead to reduced biodiversity and, in extreme cases, mass die-offs. Absolutely, the dynamics of dissolved oxygen (DO) concentration in the aquatic environment plays a vital role in understanding river eutrophication. The DO dynamics in the Teteriv River have an upward trend (tab. 2).

Table 2 *Dissolved oxygen concentration dynamics in the water surfaces of the monitored rivers*

DO, mg/dm^3	Hydrochemical sampling year					
	2018	2019	2020	2021	2022	2023
Teteriv River	9,0	9,2	9,2	8,9	9,7	10,0
Kamianka River	8,6	8,6	9,0	9,0	9,1	9,6

Over the past 5 years, DO values in the Teteriv River have ranged from 8.9 to 10 mg/dm^3, with a peak in 2023 and a minimum in 2021. As for the Kamianka River, DO values ranged from 8.6 to 9.0 mg/dm^3, with a peak in 2023 and a minimum in 2018–2019. The downward trend in DO in the Kamianka River is similar to that in the Teteriv River. When BOD_5 decreases in the water environment of a river and DO concentration increases, it typically suggests an improvement in the quality of the river water.

Conclusions

1. The nitrate content of the Teteriv River and Kamianka River is increasing, as evidenced by the graphical display of the dynamics. The dynamics of phosphate content in the Teteriv River variable. As for the phosphate content in the Kamianka River, the trend is similar.
2. Over the past 5 years, the BOD_5 value in the studied rivers has been on a downward trend, while the DO indicator has been increasing. Overall, a decrease in BOD_5 combined with an increase in DO typically suggests a healthier river environment, which is beneficial for aquatic life and human use.
3. The results of the hydrochemical monitoring of the water environment of the Teteriv River and the Kamianka River indicate positive dynamics and a decrease in eutrophication.

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