DOI: https://doi.org/10.26565/1992-4259-2025-33-04
UDK 338.49: 656.2: 504.5

L. A. HOROSHKOVA, DSc (Economy), Prof.,
Professor of the *Department of Ecology*
e-mail: goroshkova69@gmail.com ORCID ID: https://orcid.org/0000-0002-7142-4308
National university of Kyiv Mohyla academy
2, Skovorody, Str., Kyiv, 04070, Ukraine

O. I. MENSHOV, DSc (Geology), Senior Researcher,
Department of Geoinformatics
e-mail: menshov@knu.ua ORCID ID: https://orcid.org/0000-0001-7280-8453
Taras Shevchenko National University of Kyiv
60, Volodymyrska, Str., Kyiv, 01033, Ukraine

A. N. NEKOS, DSc (Geography), Prof.,
Professor of the Department of Environmental Monitoring and Nature Conservation
e-mail: alnekos999@gmail.com ORCID ID:https://orcid.org/0000-0003-1852-0234
V. N. Karazin Kharkiv National University,
4, Svobody Sq,, Kharkiv, 61022, Ukraine

Y. D. KORNIICHUK[1,2], Master's Degree,
e-mail: yuliia.korniichuk@ukma.edu.ua ORCID ID: https://orcid.org/0009-0008-0742-3213
[1]*Taras Shevchenko National University of Kyiv*,
60, Volodymyrska, Str., 01033 Kyiv, Ukraine
[2]*V.N. Karazin Kharkiv National University*,
4, Svobody, Sq., Kharkiv, 61022, Ukraine

K. V. KHADUSKINA, Bachelor
e-mail: kateryna.khaduskina@student.karazin.ua ORCID ID: https://orcid.org/0009-0008-8558-8937
V.N. Karazin Kharkiv National University,
4 Svobody Sq., Kharkiv, 61022, Ukraine

ANTHROPOGENIC IMPACT OF THE WAR ON THE CONDITION OF SURFACE WATERS OF THE RIVERS KAZENNYI TORETS AND KRYVYI TORETS WITHIN THE CITY OF DRUZHKIVKA

Purpose. To provide a comprehensive ecological assessment of the surface waters state of the Kryviy Torets and Kazenny Torets rivers in the city of Druzhkivka in order to determine the main anthropogenic factors of influence, in particular the consequences of war.

Methods. System analysis, statistical processing methods, analysis of retrospective dynamics, and forecasting of future trends.

Results. An analysis of water condition indicators was carried out for the monitoring posts – Kryvyi Torets River and Kazennyi Torets River. Organic pollution (BOD_5 and dissolved oxygen) in both rivers throughout the entire observation period there was a systematic excess of BOD_5 over the MPC. The concentration of dissolved oxygen repeatedly dropped below the standard, which indicates a threat to aquatic biota and disruption of self-purification processes. Nitrites constantly and significantly exceeded the standard, especially in 2005–2008. Periodic significant maxima of phosphate-ion content were recorded, which indicates eutrophication processes and the inflow of phosphates from detergents and fertilizers. Water mineralization (sulfate and chloride ions) is high, especially in 2006–2008 and 2011–2013. Since 2014, stabilization has been observed, but at a high level. Using the Forecast Sheet resource forecasting carried out, which showed good convergence of forecast and actual values. No positive dynamics in water quality were recorded — in 2024–2025 most indicators exceed the MPC.

Conclusions. The rivers Kazennyi Torets and Kryvyi Torets are in a state of persistent organic and chemical pollution. The overall ecological condition remains unsatisfactory, and in 2024–2025 the situation has even worsened. Overall, the war has significantly deepened the ecological problems of these rivers. They require a comprehensive approach to restoration: modernization of treatment facilities, rehabilitation of aquatic ecosystems, and restoration of the monitoring system. Without this, there is a threat of further degradation of the region's water resources, which will have long-term consequences for the environment and human health.

KEYWORDS: *Kryvyi Torets River, Kazennyi Torets River, surface waters, ecological monitoring, phosphates, ammonium, sulfates, chlorides, dissolved oxygen, BOD$_5$, nitrates, nitrites, anthropogenic impact, consequences of war*

Як цитувати: Horoshkova L. A., Menshov O. I., Nekos A. N., Korniichuk Y. D., Khaduskina K. V. Anthropogenic impact of the war on the condition of surface waters of the rivers Kazennyi Torets and Kryvyi Torets within the city of Druzhkivka. *Вісник Харківського національного університету імені В. Н. Каразіна. Серія «Екологія»*. 2025. Вип. 33. С. 49-69. https://doi.org/10.26565/1992-4259-2025-33-04

In cites: Horoshkova, L. A., Menshov, O. I., Nekos, A. N., Korniichuk, Y. D., & Khaduskina, K. V. (2025). Anthropogenic impact of the war on the condition of surface waters of the rivers Kazennyi Torets and Kryvyi Torets within the city of Druzhkivka. *Visnyk of V.N. Karazin Kharkiv National University. Series Ecology*, (33), 49-69. https://doi.org/10.26565/1992-4259-2025-33-04

Introduction

Under the conditions of a prolonged military conflict in eastern Ukraine, the problem of ecological monitoring of the condition of surface waters of rivers becomes more significant. Due to hostilities taking place in the territories of river basins of the eastern regions, monitoring of water quality is significantly complicated or impossible. An example of this problem is the basin of the Siverskyi Donets River, which flows through the territories of three regions (Luhansk, Kharkiv, Donetsk). Hostilities in the eastern regions of Ukraine have a significant impact on the ecological state of surface waters of rivers. The largest in terms of catchment area in eastern Ukraine is the Siverskyi Donets River. During martial law, it undergoes substantial military impact. Under the influence of long-term constant military impact, the condition of surface waters has significantly deteriorated. From detonation and fragments of ammunition, toxic compounds enter the soil (water vapor, hydrocyanic acid vapors, carbon monoxide, nitrogen, carbon dioxide, etc.) [1]. With surface runoff and in the process of infiltration into the soil with meltwater and precipitation, pollutants enter groundwater, and from there into surface waters [1].

In addition, during hostilities, wastewater treatment facilities are destroyed, and as a result of the absence of water purification there is uncontrolled pollution of surface waters. In conditions of hostilities, the priority issues are the assessment of military impact and the determination of the ecological state of surface waters. Apart from industrial and agricultural pollution, the main impact now comes from hostilities. The problem of obtaining environmentally safe water resources for the local population of frontline regions is becoming increasingly urgent and important. In such conditions, access to drinking water is significantly limited or may be completely unavailable. Military impact on water supply and water treatment facilities affects the availability and quality of water purification [2].

Objects and Research Methods

Given the relevance of the problem, the objects of research were chosen to be the rivers of Donetsk region: the Kazennyi Torets (right tributary of the Siverskyi Donets River) and the Kryvyi Torets (left tributary of the Kazennyi Torets River) within the city of Druzhkivka. The city is located in the Kramatorsk district of Donetsk region, in the zone of active hostilities. During hostilities, the access of the local population to water resources is limited, water supply is carried out in limited quantities according to a set schedule. Under such conditions, the issue of finding alternative sources of water supply arises acutely.

Since the data of the Basin Water Monitoring Laboratory of the Siverskyi Donets BUVR for the observation posts of the Kazennyi Torets and Kryvyi Torets rivers are available from 2003 to 2019, we carried out forecasting of the corresponding indicators until 2025. For forecasting, Excel tools were selected. The first of these is the tool of data approximation by creating a trendline on a chart, which shows the general tendency of the data, using various regression methods such as linear, logarithmic, polynomial, or exponential. Smoothing is achieved by adding a moving average line, which averages data values over a given period to show a smoother dependence and hide short-term fluctuations. In Excel, the least squares algorithm is used to build the trendline, which finds the best approximation of the data to a straight line or another trend model by minimizing the sum of squared deviations of the actual points from the trendline. Excel allows choosing different types of trends, each of which uses the corresponding mathematical algorithm to determine the best curve for your data. The accuracy of the model is checked using the coefficient of determination (R-squared), which shows how well the trendline fits the data.

Also, for forecasting the studied indicators for the period until 2025, we used another Excel tool – Forecast Sheet. It creates a table and chart with forecasted values using exponential smoothing algorithms. The forecast makes it possible to predict future values based on existing data (taking into account the time component) using the AAA version of the exponential smoothing (ETS) algorithm.

In general, exponential smoothing is a time series forecasting method that is used to analyze and predict data where each subsequent value in the series takes into account the previous values with gradually decreasing weight, which decreases according to the exponential law. That is, it uses average values to predict future values, reducing the influence of fluctuations and highlighting the general trend. Exponential smoothing takes into account all previous values of the time series, but gives greater weight to the most recent observations, since their influence on future values is considered more significant. This is achieved using a special smoothing coefficient (α), which determines the rate of decrease in the weight of previous values. The higher the value of α, the greater the weight given to the most recent data, and the lower, the more the weight is distributed over the entire series.

FORECAST.ETS.CONFINT makes it possible to calculate the confidence interval for the forecast value. A 95% confidence interval means that 95% of future data points are likely to fall within this interval. The boundaries of the confidence interval are the binding of the lower and upper probability.

Results and Discussion

The problem of ecological assessment of surface water quality under modern conditions is relevant, and this topic has been developed by many authors. In the works of Horoshkova L.A., Menshov O.I., and others, the problem of anthropogenic impact and military actions on the condition of surface waters of the Dnipro River in Zaporizhzhia was considered using modeling methods [6]. An ecological assessment and forecast were also conducted for the Danube River [7]. Issues of monitoring ecological safety by oxygen indicators were addressed by Bessonnyi V.L., Ponomarenko R.V., Tretyakov O.V., and others [8]. The dynamics of changes in dissolved oxygen in a mathematical model using retrospective data for forecasting the oxygen regime were studied in the work of Bessonnyi V.L., Tretyakov O.V., Kravchuk A.M., Statsenko Yu.F. [9]. For the rivers of the Western Bug, an ecological assessment of the water condition was carried out based on the microphyte index by Nekos A.N., Boyaryn M.V., and others [10–14].

In order to assess the anthropogenic load, including that of the war, on the condition of surface waters of the Kryvyi Torets and Kazennyi Torets rivers in Druzhkivka, an analysis of water condition indicators was conducted for the monitoring posts: Post № 1 – Kryvyi Torets River, 1 km, Karlivska dam, technical water intake (48.616667, 37.533333), and Post № 2 – Kazennyi Torets River, 55 km, Druzhkivka, below the confluence, below the city technical water intake (48.648694, 37.516667). Figure 1 shows the monitoring points of the studied rivers as recorded by the Water Monitoring Laboratory of the Siverskyi Donets BUVR. The research was conducted for the following indicators: biochemical oxygen demand for 5 days (BOD_5) and dissolved oxygen, phosphate ions and ammonium ions, nitrite ions and nitrate ions, sulfate ions and chloride ions.

Figure 2 presents the dynamics of changes in dissolved oxygen and BOD_5 in water samples from the Kryvyi Torets River (Post № 1) according to retrospective data for the period 2005–2019 at the observation post (Post № 1 in Fig. 1). Monitoring observations were conducted. All recorded concentrations of dissolved oxygen and BOD_5 during the defined period did not meet the maximum permissible concentrations (MPC of dissolved oxygen – 4 mgO_2/dm^3 and BOD_5 – 3 mgO_2/dm^3).

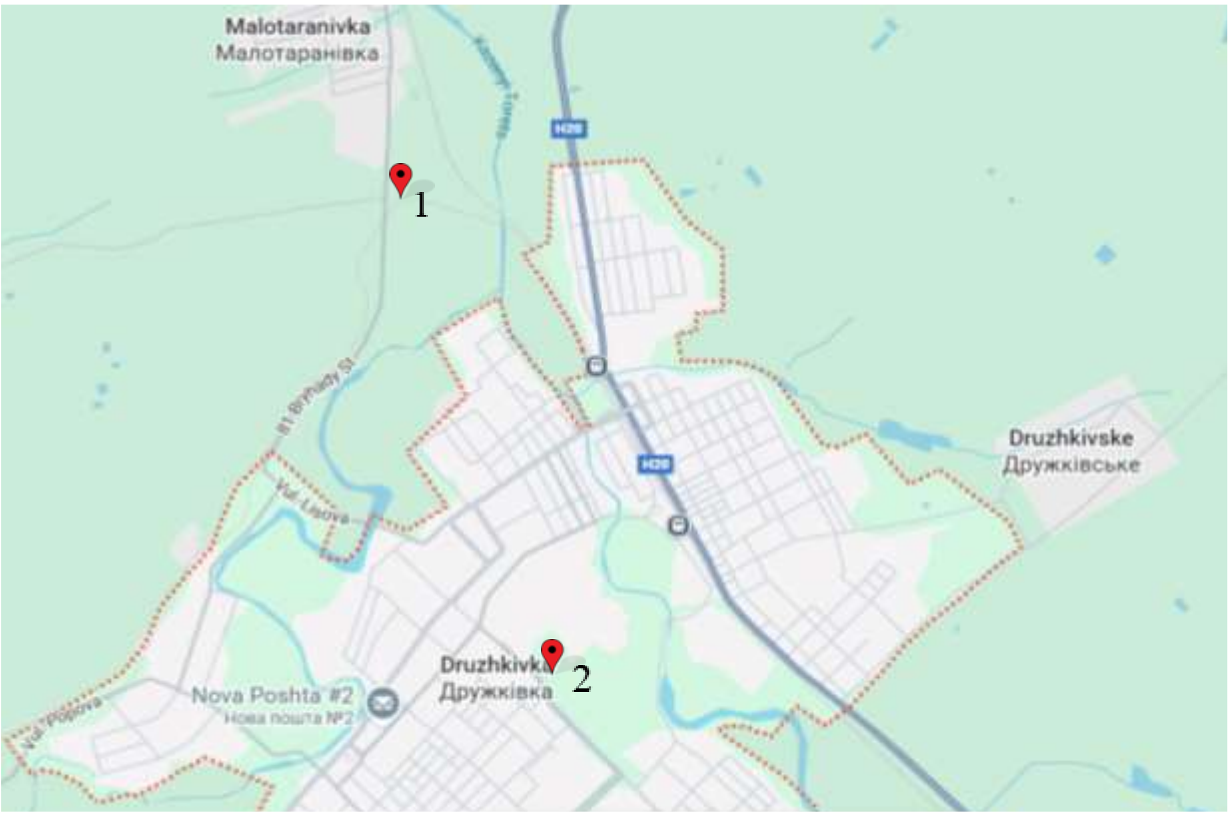


Fig. 1 - Location of Post 1 of the Kryvyi Torets River and Post 2 of the Kazennyi Torets River

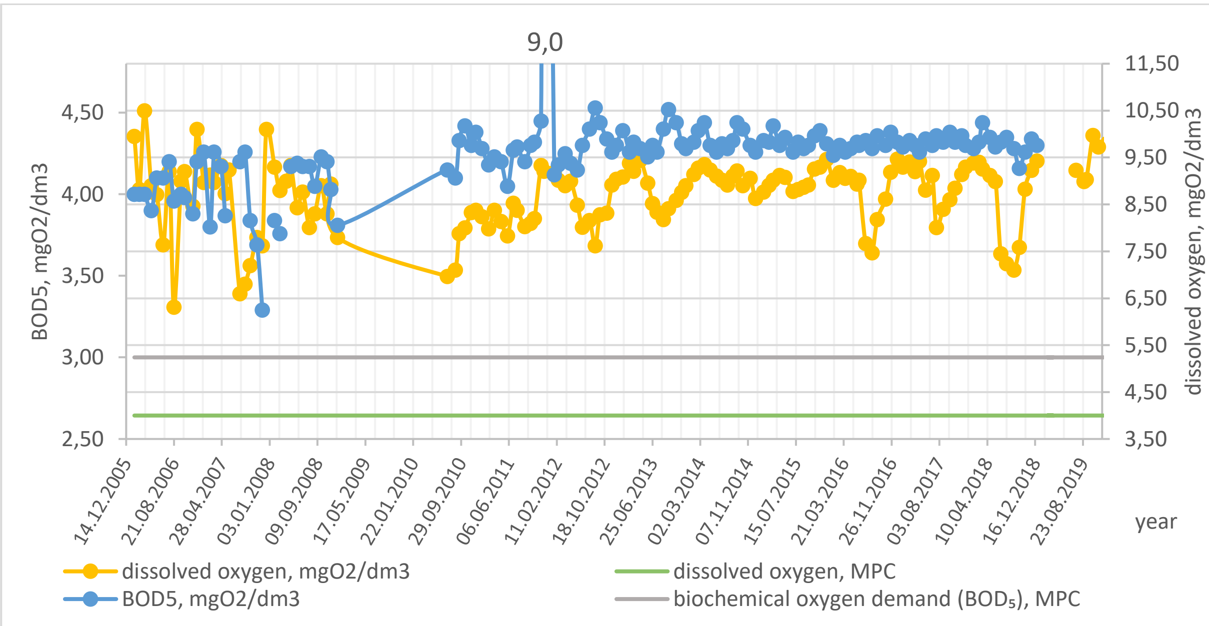


Fig. 2 – Dynamics of dissolved oxygen and biochemical oxygen demand (BOD_5) in the waters of the Kryvyi Torets River in 2005–2019

The values of the studied indicators showed significant fluctuations in the period 2005–2009. The value of dissolved oxygen

The values of the studied indicators showed significant fluctuations in the period 2005–2009. The value of dissolved oxygen tended to increase up to the highest during the monitoring period – 10.50 mgO_2/dm^3 in 2006. A gradual decrease to the lowest value for the fourteen-year period was observed in 2006 and amounted to 6.31 mgO_2/dm^3.

In the period 2010–2014, the fluctuations of dissolved oxygen with increases and decreases varied from 6.97 to 9.50 mgO_2/dm^3. In 2015–2019, the dissolved oxygen indicator tended to decrease with subsequent return to average values; sharp increases were not observed, the lowest value in this period was 7.10 mgO_2/dm^3.

During the period from 2006 to 2014, BOD_5 indicators fluctuated significantly; the lowest value during the period was observed in 2007 and amounted to 3.29 mgO_2/dm^3, and the highest value was in 2011 – 9.21 mgO_2/dm^3. In the period from 2014 to 2019, BOD_5 values showed only minor fluctuations.

Ddata showing the changes in the concentrations of phosphate ions and ammonium ions in water samples from the Kryvyi Torets River Fig. 3 presents. From 2005 to 2008, ammonium ion values fluctuated considerably and reached the maximum highest value in 2008 – 1.21 mg/dm^3, while the minimum values were recorded in 2006 and 2007 – 0.26 mg/dm^3. In the period from 2010 to 2015, the concentrations of ammonium ions had a general tendency to increase with periods of sharp decrease; during this interval, the highest values of the fourteen-year period were observed in 2013 and 2015 – 1.72 mg/dm^3. The period from 2015 to 2019 was characterized by a general decreasing.

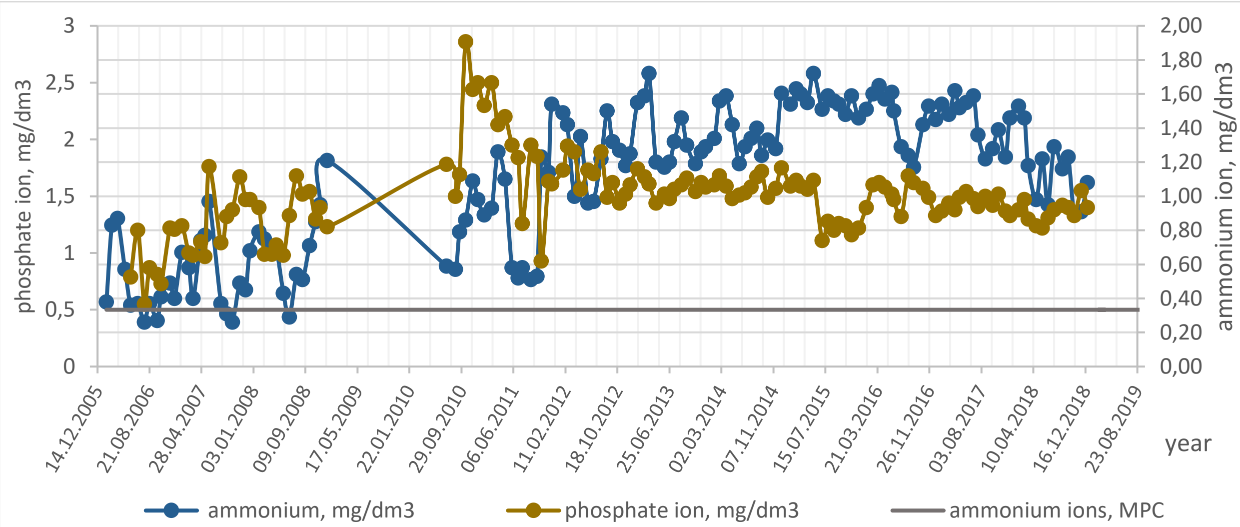


Fig. 3 – Dynamics of phosphate ion and ammonium ion concentrations in the waters of the Kryvyi Torets River during 2005–2019 compared with the maximum permissible concentrations (MPC)

trend with intermittent sharp increases in ammonium ion concentrations The dynamics of phosphate ion concentrations show a tendency for gradual increase during the monitoring period of 2005–2008, reaching the maximum value in 2007 – 1.76 mg/dm^3. Also, from 2005 to 2008, the minimum value for the fourteen-year period was recorded. In the interval of 2010–2011, a sharp increase in phosphate ion concentrations was characteristic, reaching the highest value for the fourteen-year period in 2010 – 2.86 mg/dm^3, followed by a gradual decrease to 0.93 mg/dm^3 in 2011. From 2012 to 2015, no sharp fluctuations were observed. In 2015, there was a sharp drop from 1.64 mg/dm^3 to 1.11 mg/dm^3, after which concentrations did not show significant fluctuations until the end of the year. Since 2016, phosphate ion concentration indicators have shown a tendency for short-term increases to 1.62 mg/dm^3 and 1.68 mg/dm^3; after this period, significant fluctuations were absent.

Figure 4 presents the dynamics of changes in chloride ion and sulfate ion indicators in water samples from the Kryvyi Torets River. From 2005 to 2009, chloride ion concentrations had a general tendency to increase with periods of decrease; in this interval of the fourteen-year observation period, the lowest value was recorded in 2006 – 234.30 mg/dm^3. In the period from 2010 to 2018, fluctuations in chloride ion concentrations were minor, within the

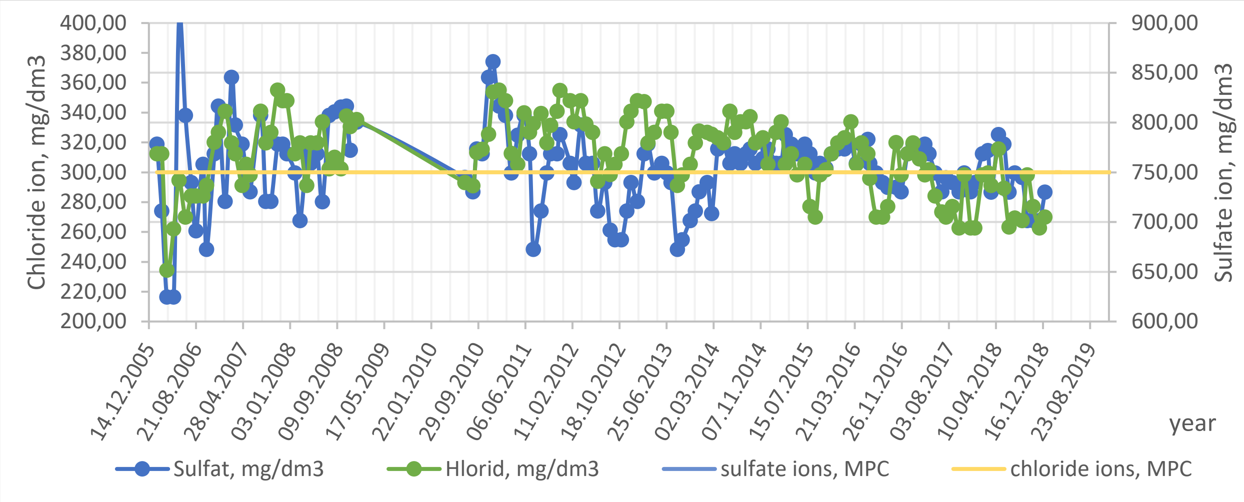


Fig. 4 – Dynamics of changes in sulfate and chloride ion concentrations in the Kryvyi Torets River in 2005–2019

range of 262.70–355 mg/dm³. Most of the graph of chloride ion concentration values lies outside the MPC.

From 2005 to 2008, sulfate ion concentrations tended to increase with periods of sharp decrease in values; in this interval, the highest value was recorded in 2006 – 902.90 mg/dm³, and in the same year the lowest – 624.40 mg/dm³. The observation period from 2010 to 2014 was characterized by fluctuations in sulfate ion concentrations; the lowest values were found in 2011 and 2013 – 672.40 mg/dm³, while the highest was in 2010 – 861.10 mg/dm³. During 2015–2018, no significant fluctuations in sulfate ion concentration indicators occurred.

Figure 5 demonstrates the change in nitrate and nitrite concentration indicators in water samples from the Kryvyi Torets River. Nitrate concentrations during the fourteen-year observation period did not exceed the established MPC of 40 mg/dm³.

The dynamics of nitrite concentrations are inversely proportional to nitrates. During the fourteen-year period, all nitrite concentration indicators did not meet the MPC, which was 0.08 mg/dm³, reaching the highest value in 2007 – 1.90 mg/dm³, while the lowest in the same year was 0.18 mg/dm³.

Nitrogen compounds, in particular nitrates (NO_3^-) and nitrites (NO_2^-), are important indicators of water quality, reflecting the level of organic pollution and the efficiency of nitrification and denitrification

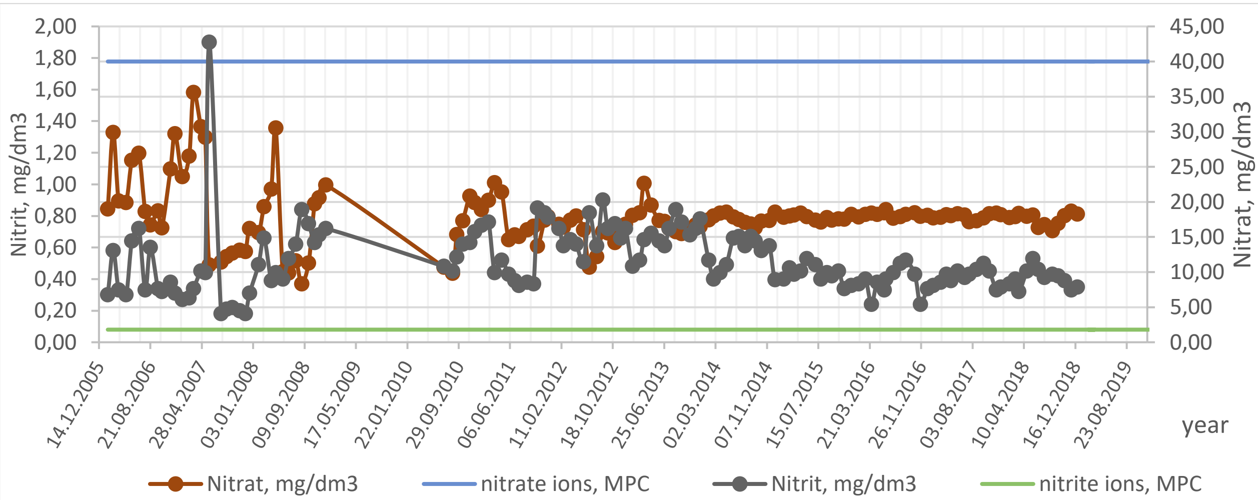


Fig. 5 – Dynamics of changes in nitrate and nitrite ion concentrations in the surface waters of the Kazennyi Torets River in 2005–2019 compared with the maximum permissible concentrations (MPC)

processes. Monitoring their concentrations makes it possible to detect technogenic impact, in particular the inflow of insufficiently treated wastewater. The graph shows the long-term dynamics of changes in the content of nitrate and nitrite ions in the Kazennyi Torets River, which is a left tributary of the Siverskyi Donets, taking into account comparison with the maximum permissible concentrations (Fig. 5).

Figure 5 presents the dynamics of changes in nitrate ion concentrations (right axis, orange line) and nitrite ion concentrations (left axis, gray line) in the waters of the Kazennyi Torets River during 2005–2019. The values are compared with the maximum permissible concentrations (MPC), which for nitrites are 0.02 mg/dm³ (green line), and for nitrates – 45 mg/dm³ (blue line).

Regarding nitrites, in 2005–2008 an extremely high level of nitrite pollution was observed – with frequent exceedances of 1.0 mg/dm³, and in some cases up to 1.9 mg/dm³, which is more than 90 times higher than the MPC. This indicates a significant organic load during this period, probably due to the inflow of insufficiently treated domestic or industrial wastewater. Starting from 2009, the level of nitrite ions decreases and stabilizes within 0.3–0.6 mg/dm³. Although this still significantly exceeds the standard (by 15–30 times), the fluctuations decreased significantly, which may indicate some improvement in the state of wastewater treatment.

Regarding nitrates, nitrate ion concentrations were less variable and generally did not exceed the maximum permissible level of 45 mg/dm³. Most of the observed values were within 15–22 mg/dm³, which indicates background pollution typical for areas with developed agriculture or urban infrastructure. After 2011, the concentrations became even more stable.

Significant and prolonged exceedance of the MPC for nitrites indicates high toxicity of the aquatic environment in certain years, since nitrites are extremely harmful to aquatic biota. The absence of nitrate exceedances does not exclude risks for the ecosystem, as the combination of high nitrite and nitrate contents indicates active transformation of nitrogen compounds, typical for organic pollution. The decrease in nitrite concentrations after 2010 can be associated with the improvement of biological treatment processes or the reduction of load on sewage networks. The obtained data indicate that the Kazennyi Torets River in 2005–2008 was subject to intensive organic pollution, which was manifested in numerous nitrite peaks. Since 2009, a gradual improvement in the hydrochemical state has been observed. At the same time, the persistent exceedance of the MPC for nitrites requires further research into pollution sources and strengthening of control over the region's water treatment infrastructure.

The parameters of biochemical oxygen demand (BOD_5) and dissolved oxygen (DO) are key indicators of organic pollution and the aeration state of aquatic ecosystems. The graph presents the change of these indicators in the waters of the Kazennyi Torets River in the period from 2002 to 2019, which makes it possible to assess the dynamics of organic load and the ability of the reservoir for self-purification (Fig. 6).

The level of dissolved oxygen (DO) in most cases fluctuates within 7.5–10.0 mgO_2/dm^3, which indicates satisfactory conditions for oxygen saturation of the waters.

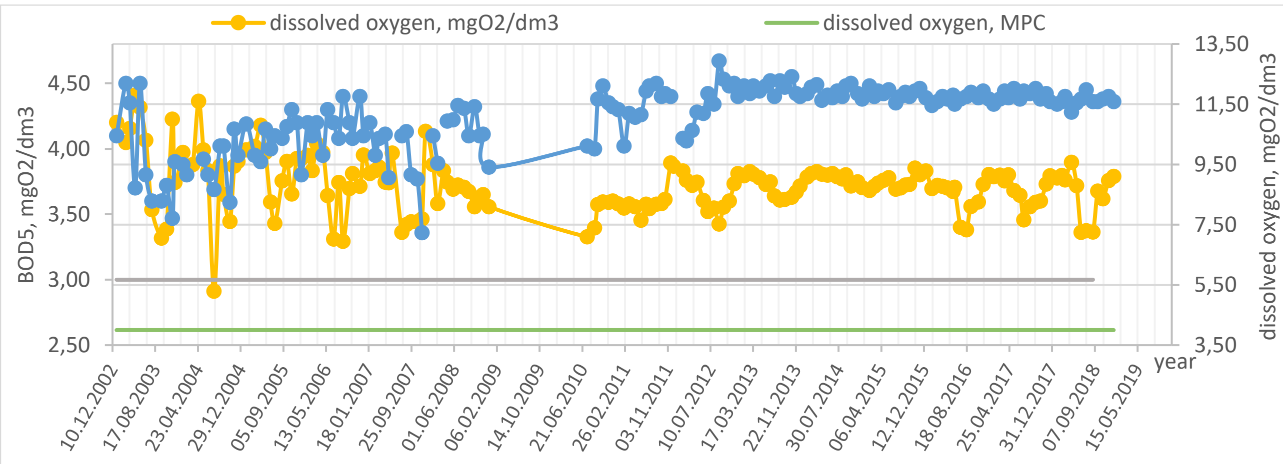


Fig. 6 – Dynamics of biochemical oxygen demand (BOD_5) and dissolved oxygen concentration in the waters of the Kazennyi Torets River (2002–2019)

However, in some years, especially during the periods 2004–2006 and 2011–2013, a decrease of DO to the level of 6.5–7.0 mgO_2/dm^3 was observed, which may be related to increased organic pollution or changes in hydrological conditions. Biochemical oxygen demand (BOD_5) was mainly within the range of 4.0–4.5 mgO_2/dm^3, which is close to the maximum permissible concentration (MPC) of 3 mgO_2/dm^3. The indicators repeatedly exceeded this level, especially during the periods 2005–2007 and 2011–2013, which indicates the presence of organic load. In 2011–2013, the greatest decrease in the level of dissolved oxygen was observed simultaneously with an increase in BOD_5– probably due to increased inflow of organic substances, which led to active oxygen consumption by microorganisms. Since 2015, there has been a tendency towards stabilization: the DO level fluctuates within 8.0–9.5 mgO_2/dm^3, and BOD_5 decreased to a more stable level (3.8–4.2 mgO_2/dm^3), which indicates improvement of the aquatic environment condition.

The analysis of the dynamics of dissolved oxygen and BOD_5 in the waters of the Kazennyi Torets River during 2002–2019 indicates periodic increases in organic load, especially in the mid-2000s and early 2010s. However, in the second half of the study period, there is a tendency towards improvement of the ecological condition, which may indicate a decrease in anthropogenic impact or an increase in the effectiveness of treatment measures.

The Kazennyi Torets River, as a tributary of the Siverskyi Donets, is an important element of the Donbas water system and undergoes significant anthropogenic load due to the presence of industrial facilities and settlements. For the purpose of assessing the degree of surface water pollution and analyzing the sources of organic and inorganic load, the concentrations of ammonium ions (NH_4^+) and phosphate ions (PO_4^{3-}) were analyzed during 2002–2019 (Fig. 7).

In the period 2002–2005, the levels of both ions were mainly below the MPC, although isolated spikes of ammonium exceeded 2.5 mg/dm^3. Starting from 2007–2008, a tendency of increasing concentrations of both ions was observed, with a particularly sharp rise in 2010–2012. Peak values of phosphates reached almost 3.0 mg/dm^3, and ammonium ions – 1.8 mg/dm^3, which significantly exceeds sanitary standards.

After 2014, concentrations stabilized, however ammonium remained at a level twice as high as the MPC.

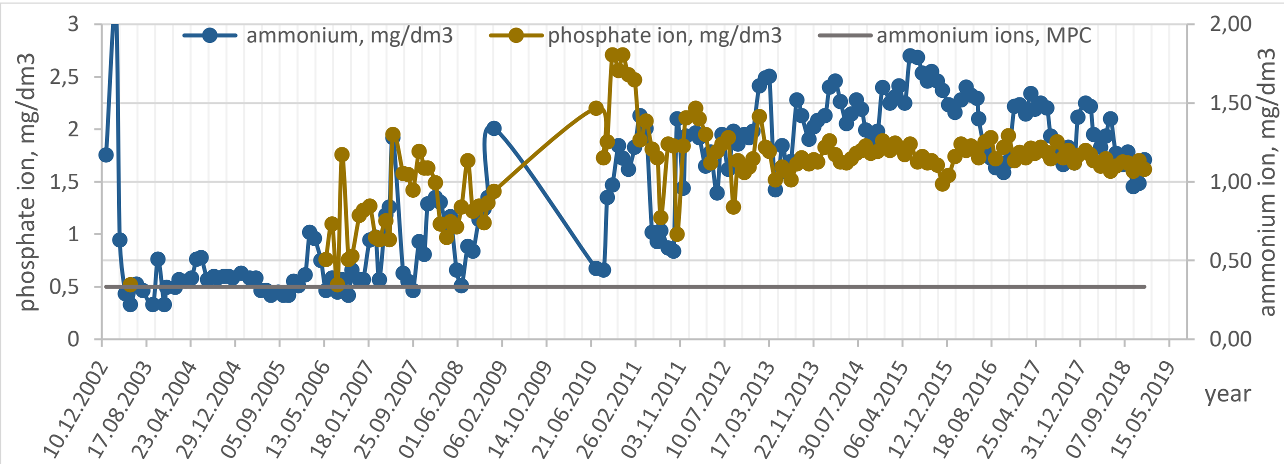


Fig. 7 – Dynamics of changes in ammonium and phosphate ion concentrations in the waters of the Kazennyi Torets River (2002–2019)

Constant exceedance of the MPC for ammonium ions indicates significant organic load, probably caused by insufficient treatment of wastewater and the presence of domestic and industrial pollution sources. High phosphate concentrations may indicate eutrophication caused by excessive application of phosphate fertilizers or the entry of phosphates from detergents. In general, the ecosystem of the Kazennyi Torets shows signs of nutrient overloading, which creates risks for the condition of the aquatic environment and biota.

Sulfate and chloride ions are among the main components of natural water mineralization and serve as important indicators of anthropogenic load. Their concentration is formed under the influence of natural processes (rock leaching, atmospheric precipitation) and economic activity (discharges of industrial and municipal wastewater, use of mineral fertilizers, road reagents, etc.).

For the Kazennyi Torets River, which flows through industrially developed areas, fluctuations in the levels of these ions are typical depending on seasonal factors and technogenic impact. The study of changes in SO_4^{2-} and Cl^- concentrations makes it possible to assess the degree of stability of the hydrochemical regime and the level of anthropogenic pressure on the aquatic ecosystem (Fig. 8).

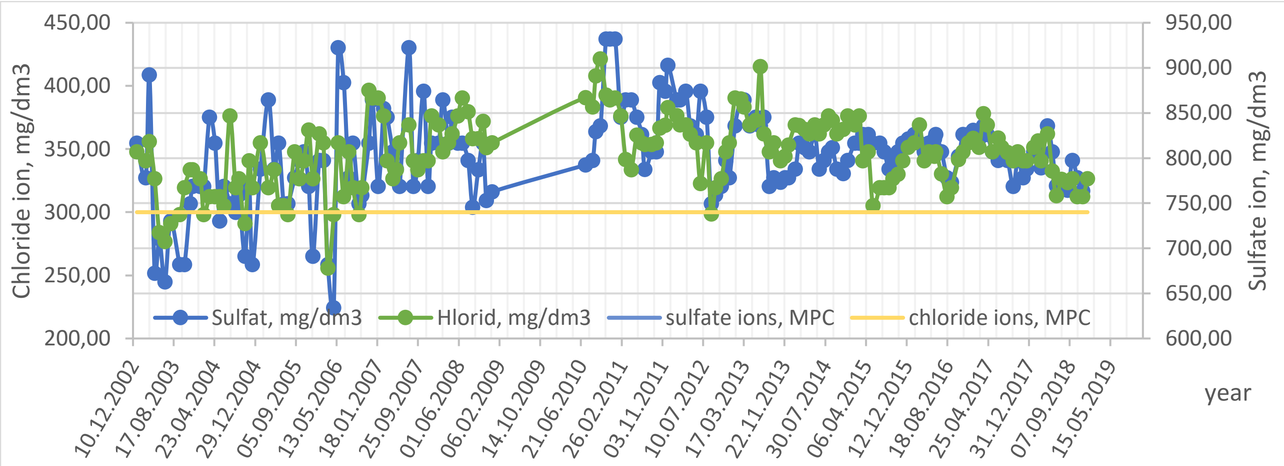


Fig. 8 - Dynamics of changes in sulfate and chloride ion concentrations in the waters of the Kazennyi Torets River (2002–2019)

The graph shows the dynamics of sulfate and chloride ion content in the surface waters of the Kazennyi Torets River during 2002–2019. Sulfate concentrations fluctuated within 600–950 mg/dm³, with periodic peak values that exceeded the average level. Chloride ions were mainly in the range of 200–450 mg/dm³, with a tendency to increase in 2006–2013, after which some stabilization was observed.

In general, both indicators in a number of cases approached or exceeded the normative MPC values, which indicates significant technogenic impact on the river. There is synchrony in the fluctuations of Cl^- and SO_4^{2-}, which points to their common sources of inflow, in particular from industrial and municipal wastewater. The largest peaks were recorded in 2006–2008 and 2011–2013, which may be related to intensive industrial discharges and low river flow during these periods.

Starting from 2014, a relative stabilization of concentrations is observed, but they still remain high and, in some years, exceed permissible standards. This indicates prolonged persistence of anthropogenic load on the aquatic ecosystem and limited capacity of the river for self-purification.

Monitoring of nitrogen-containing compounds (nitrates and nitrites) is an important component of assessing the ecological state of surface waters. Their excessive accumulation may indicate the influence of anthropogenic pollution sources – municipal wastewater, agricultural fertilizers, or industrial discharges. High concentrations of these compounds pose risks of eutrophication and deterioration of water quality, which is especially dangerous for river ecosystems (Fig. 9).

Nitrate ions (brown line), their values fluctuated within 5–25 mg/dm³. In certain years (2003–2008), significant peaks were recorded, approaching the maximum permissible concentration (MPC = 40 mg/dm³). Starting from 2010, a relative stabilization of indicators at the level of about 15–20 mg/dm³ is observed, which is below the normative value, but indicates constant anthropogenic load. Nitrite ions (gray line), fluctuated in the range from 0.1 to 2.0 mg/dm³. In 2007, a sharp increase was observed (over 1.8 mg/dm³), which significantly exceeded the MPC (0.08 mg/dm³). After that, the maximum concentrations decreased, but throughout the entire study period an exceedance of the standard by several times was observed. Comparison with the MPC, the permissible level lines (blue – for nitrates, green – for nitrites) clearly show that the nitrate content in the river mostly remains within the standard, while the concentra-

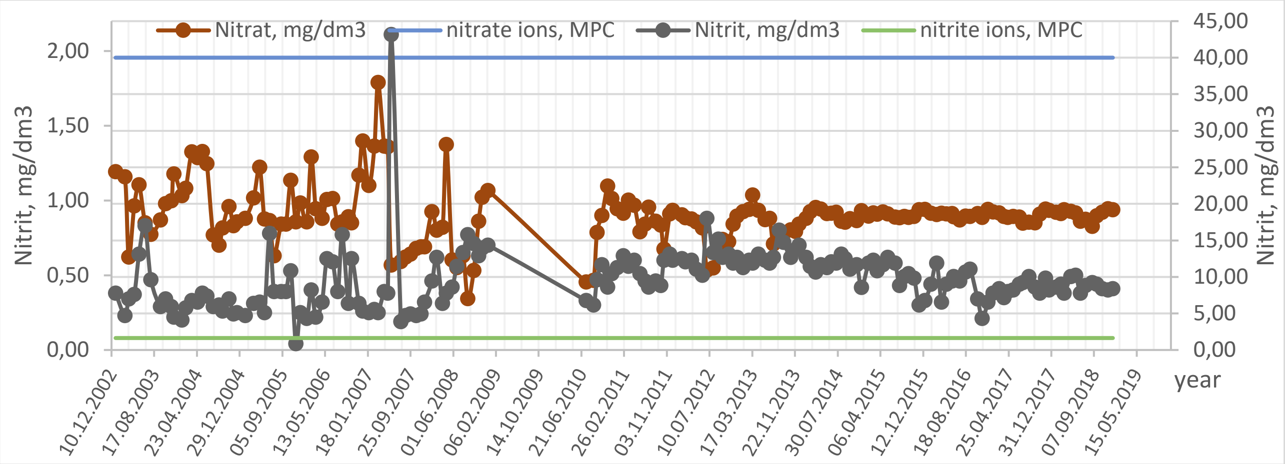


Fig. 9 – Dynamics of nitrate and nitrite ion content in the waters of the Kazennyi Torets River (2002–2019)

tion of nitrites systematically exceeds the limit values The obtained results indicate a consistently high level of nitrite pollution in the waters of the Kazennyi Torets River, which poses a threat to the ecological balance of the aquatic ecosystem. The nitrate content generally corresponds to the standards, however individual peak concentrations may be related to the inflow of agricultural fertilizers and wastewater. The presence of such tendencies indicates the need to strengthen control over the sources of nitrogen-containing compounds, especially in the spring-summer period, when the risk of eutrophication processes increases.

Since the data of the Basin Water Monitoring Laboratory of the Siverskyi Donets BUVR for the observation posts of the Kazennyi Torets River (55 km, Druzhkivka, below the confluence, below the city technical water intake) and the Kryvyi Torets River (1 km, Karlivska dam, technical water intake) are available for 2003–2019, we carried out forecasting of the corresponding indicators up to 2025.

The use of the data approximation tool in Excel by creating a trend line on the chart did not allow achieving acceptable forecasting accuracy. Verification of the accuracy of all models for all indicators, carried out using the coefficient of determination (R-squared), showed that the trend lines do not correspond to the data.

That is why for forecasting the studied indicators for the period up to 2025 we used another Excel tool – Forecast Sheet. Taking into account that for using this function it is necessary to arrange the time scale with a constant step between different points, we determined the average annual values of the indicators.

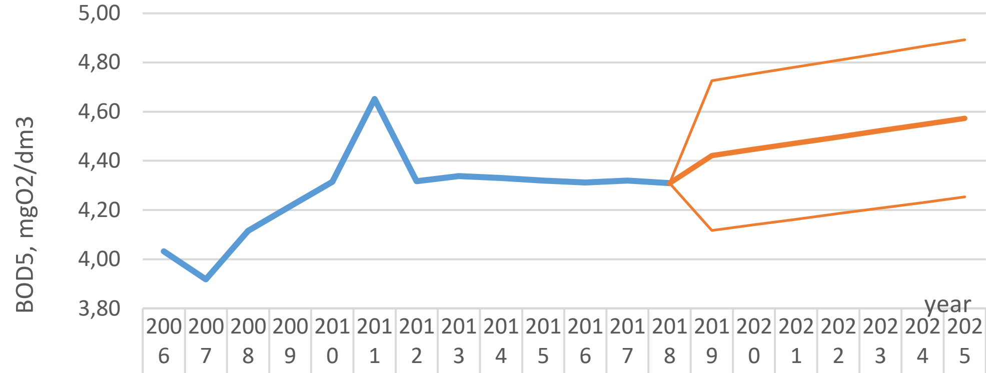
The forecasting results using the Forecast Sheet tool for the Kryvyi Torets River are presented for each studied indicator up to 2025 in Figs. 10–17.

The forecasting results using the Forecast Sheet tool for the Kazennyi Torets River are presented for each studied indicator up to 2025 in Figs. 18–25.

The accuracy of the forecasts was verified using official data as of 26.05.2025 for the corresponding posts of the Kazennyi Torets River (https://ecozagroza.gov.ua/map?id=39546&layer=water_resource) and the Kryvyi Torets River (https://ecozagroza.gov.ua/map?id=39551&layer=water_resource), as well as for the Kryvyi Torets River as of 04.07.2024 (http://monitoring.davr.gov.ua/EcoWaterMon/MapEcoWaterMon/Index). The obtained comparative data are presented in Table 1 and Table 2.

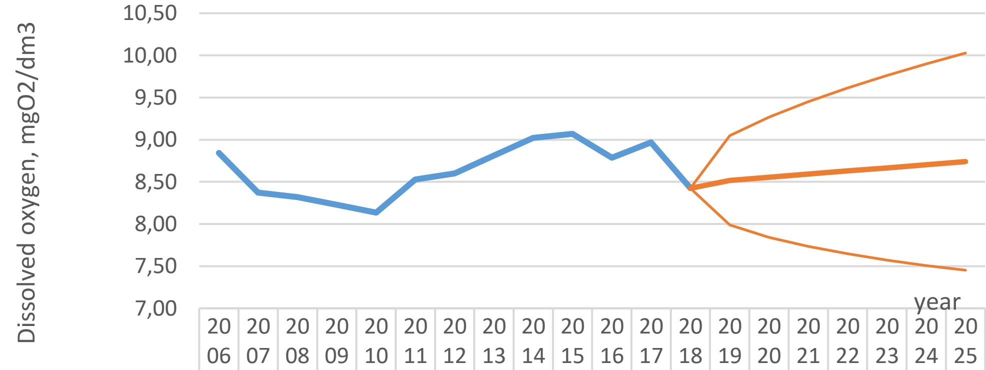
As can be seen, high accuracy was obtained in the coincidence of the actual values of the studied indicators in 2025 with the corresponding average forecast values.

The general trends during the studied years are as follows: the level of BOD_5 increases, the level of dissolved oxygen decreases, the level of phosphate and ammonium ions increases; the content of sulfate and chloride ions, as well as nitrate and nitrite ions, decreases. However, these trends regarding water quality in 2024–2025 are not positive, since the indicator values exceed the MPC.



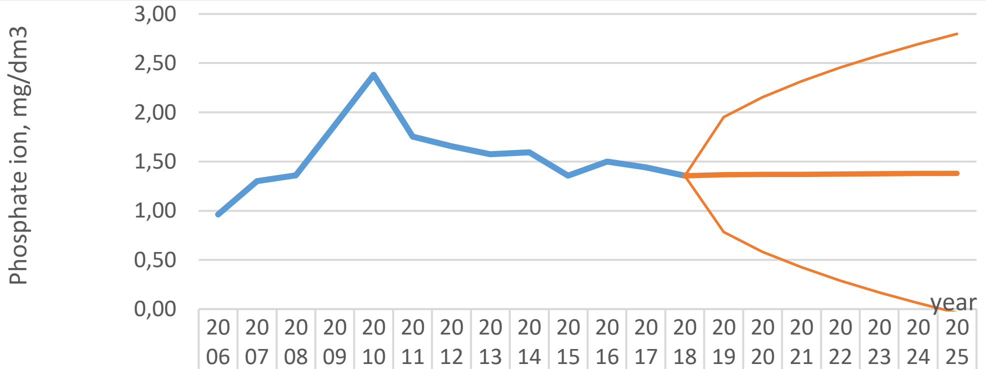
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Value	4,03	3,92	4,12	4,22	4,31	4,65	4,32	4,34	4,33	4,32	4,31	4,32	4,31							
Forecast													4,31	4,42	4,45	4,47	4,50	4,52	4,55	4,57
Low-probability weighting													4,31	4,12	4,14	4,16	4,19	4,21	4,23	4,25
High-probability weighting													4,31	4,73	4,75	4,78	4,81	4,84	4,86	4,89

Fig. 10 – Dynamics of changes in BOD_5 level in the Kryvyi Torets River and its forecasting until 2025



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Value	8,84	8,37	8,32	8,23	8,14	8,53	8,60	8,81	9,02	9,07	8,79	8,97	8,42							
Forecast													8,42	8,52	8,56	8,59	8,63	8,67	8,70	8,74
Low-probability weighting													8,42	7,99	7,84	7,73	7,65	7,57	7,51	7,45
High-probability weighting													8,42	9,05	9,27	9,45	9,61	9,76	9,90	10,0

Fig. 11 – Dynamics of changes in dissolved oxygen level in the Kryvyi Torets River and its forecasting until 2025



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Value	0,96	1,30	1,36	1,87	2,38	1,75	1,65	1,57	1,59	1,36	1,50	1,44	1,36							
Forecast													1,36	1,37	1,37	1,37	1,37	1,38	1,38	1,38
Low-probability weighting													1,36	0,78	0,58	0,42	0,29	0,17	0,06	-0,0
High-probability weighting													1,36	1,95	2,15	2,32	2,46	2,58	2,69	2,80

Fig. 12 – Dynamics of changes in phosphate ion levels in the Kryvyi Torets River and their forecasting until 2025

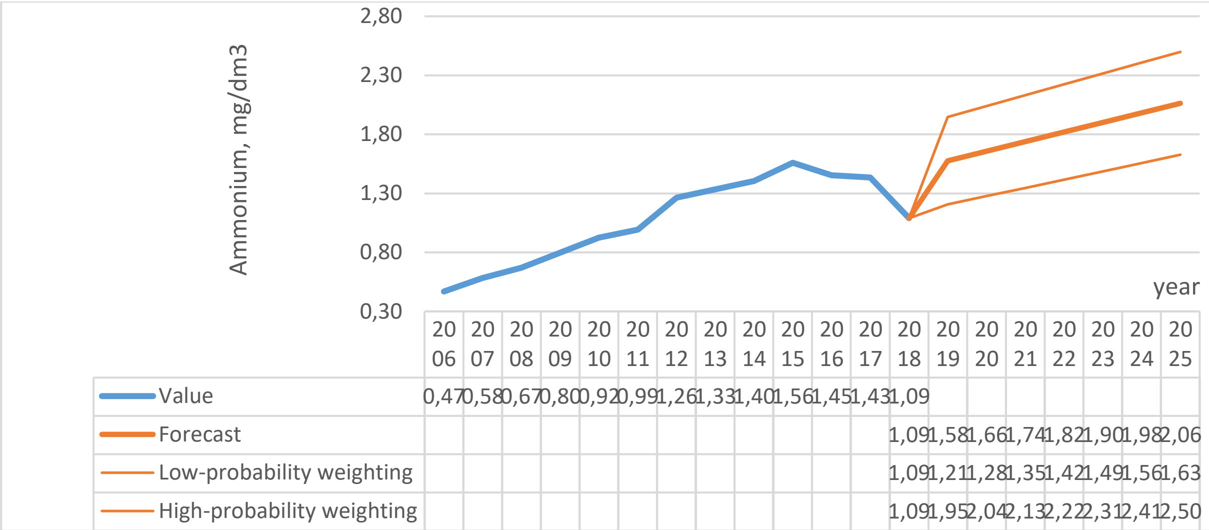


Fig. 13 - Dynamics of changes in ammonium ion levels in the Kryvyi Torets River and their forecasting until 2025

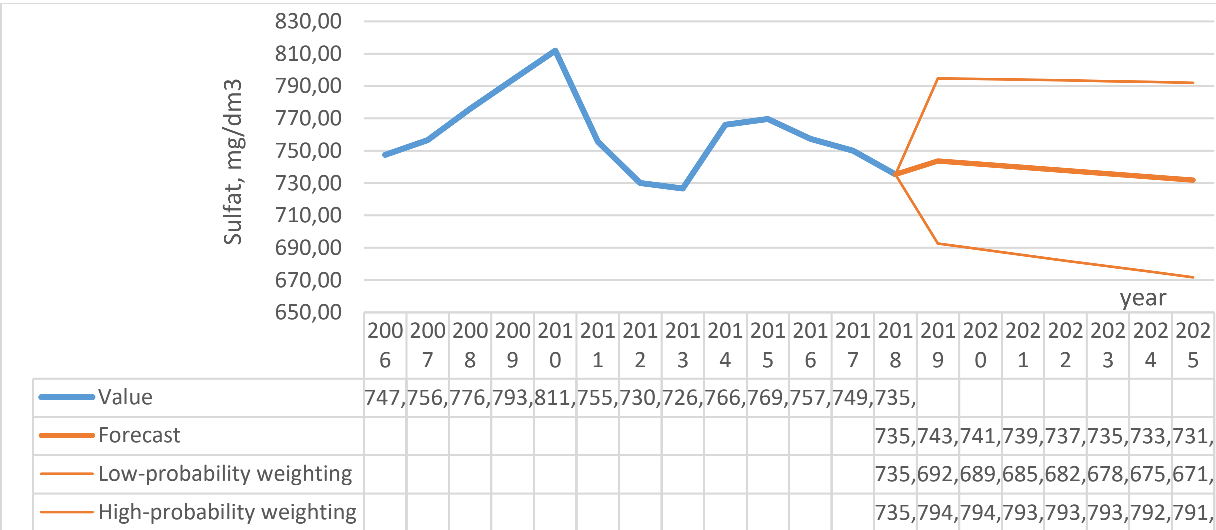


Fig. 14 – Dynamics of changes in sulfate ion levels in the Kryvyi Torets River and their forecasting until 2025

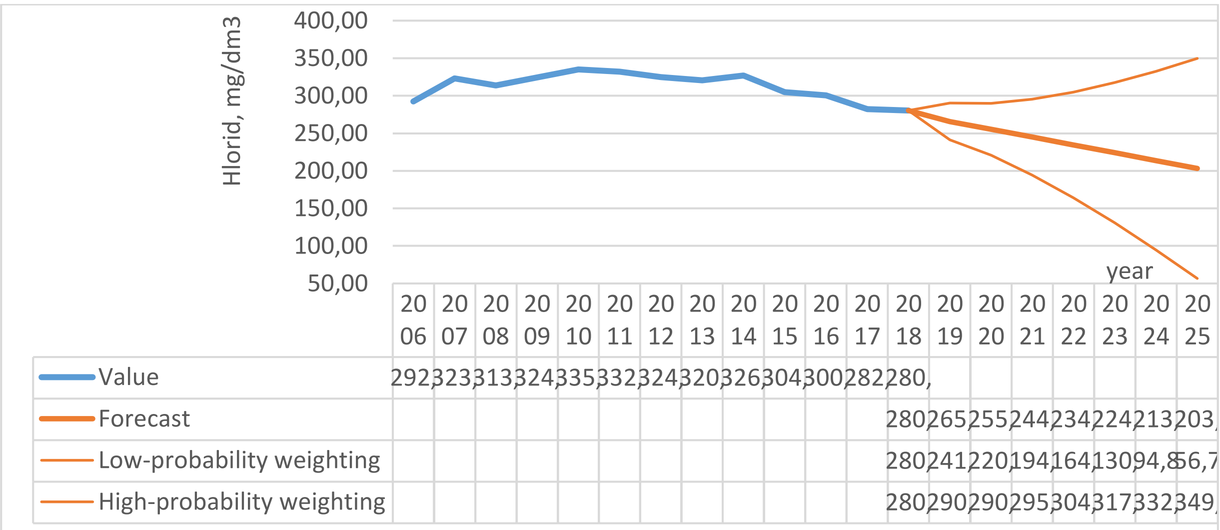
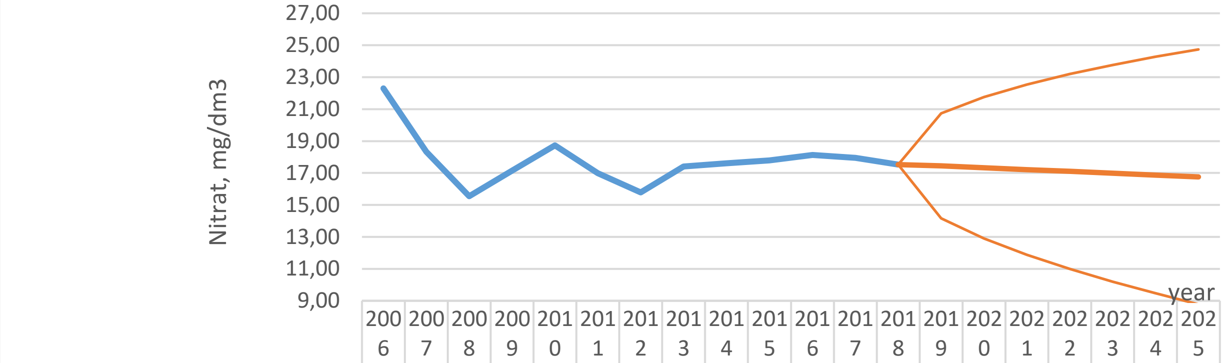
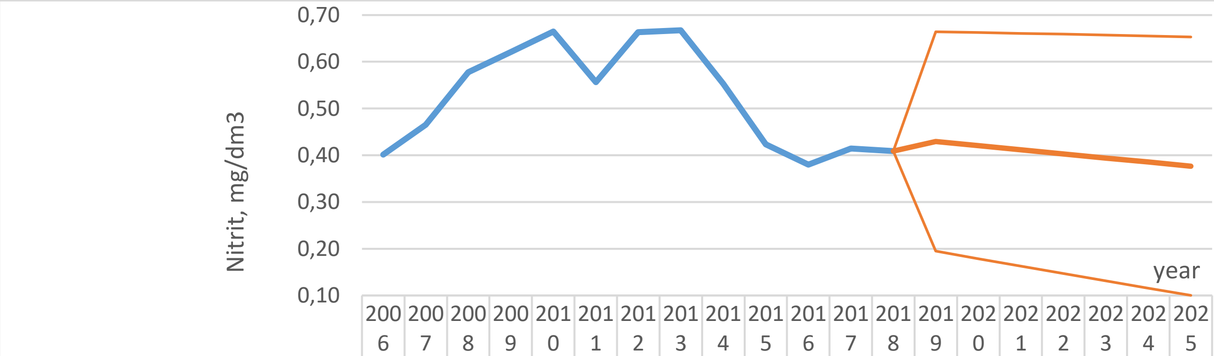


Fig. 15 – Dynamics of changes in chloride ion levels in the Kryvyi Torets River and their forecasting until 2025



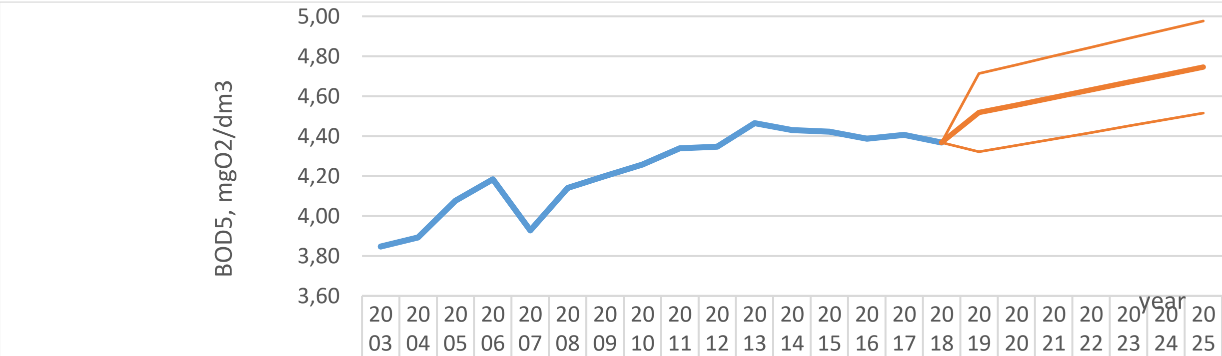
	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Value	22,3	18,3	15,5	17,1	18,7	16,9	15,7	17,4	17,6	17,7	18,1	17,9	17,5							
Forecast													17,5	17,4	17,3	17,2	17,1	16,9	16,8	16,7
Low-probability weighting													17,5	14,1	12,9	11,8	11,0	10,2	9,46	8,77
High-probability weighting													17,5	20,7	21,7	22,5	23,2	23,7	24,2	24,7

Fig. 16 – Dynamics of changes in nitrate ion levels in the Kryvyi Torets River and their forecasting until 2025



	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Value	0,40	0,46	0,58	0,62	0,67	0,56	0,66	0,67	0,55	0,42	0,38	0,41	0,41							
Forecast													0,41	0,43	0,42	0,41	0,40	0,39	0,39	0,38
Low-probability weighting													0,41	0,19	0,18	0,16	0,15	0,13	0,12	0,10
High-probability weighting													0,41	0,66	0,66	0,66	0,66	0,66	0,66	0,65

Fig. 17 – Dynamics of changes in nitrite ion levels in the Kryvyi Torets River and their forecasting until 2025



	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025
Value	3,85	3,89	4,08	4,18	3,93	4,14	4,20	4,26	4,34	4,35	4,47	4,43	4,42	4,39	4,41	4,37							
Forecast																4,37	4,52	4,56	4,59	4,63	4,67	4,71	4,75
Low-probability weighting																4,37	4,32	4,35	4,39	4,42	4,45	4,48	4,52
High-probability weighting																4,37	4,71	4,76	4,80	4,85	4,89	4,93	4,98

Fig. 18 – Dynamics of changes in BOD_5 level in the Kazennyi Torets River and its forecasting until 2025

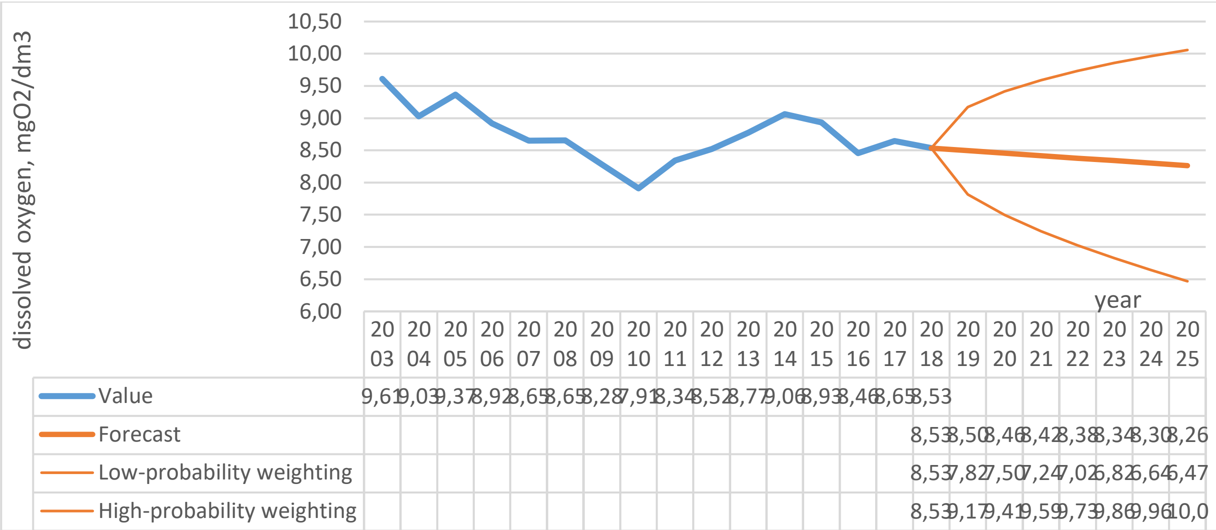


Fig. 19 – Dynamics of changes in dissolved oxygen level in the Kazennyi Torets River and its forecasting until 2025

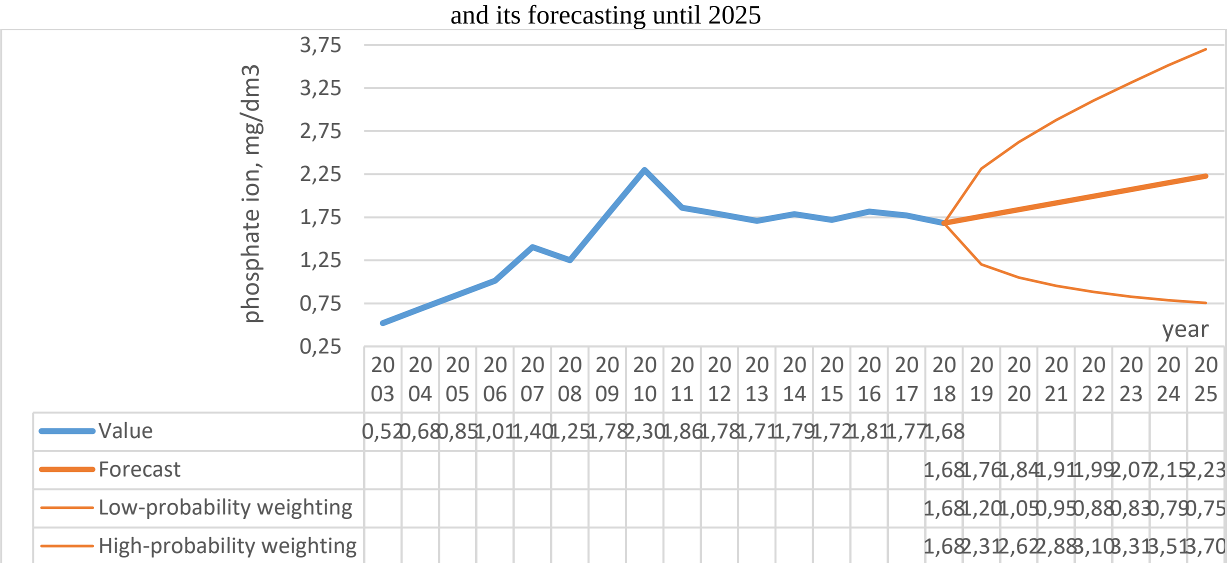


Fig. 20 – Dynamics of changes in phosphate ion levels in the Kazennyi Torets River and their forecasting until 2025

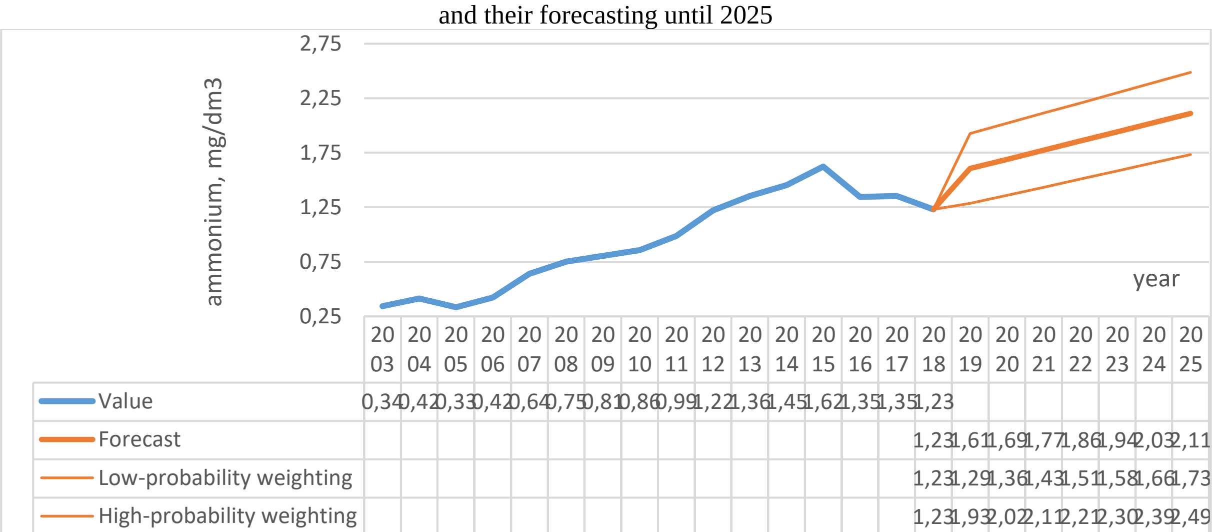


Fig. 21 – Dynamics of changes in ammonium ion levels in the Kazennyi Torets River and their forecasting until 2025

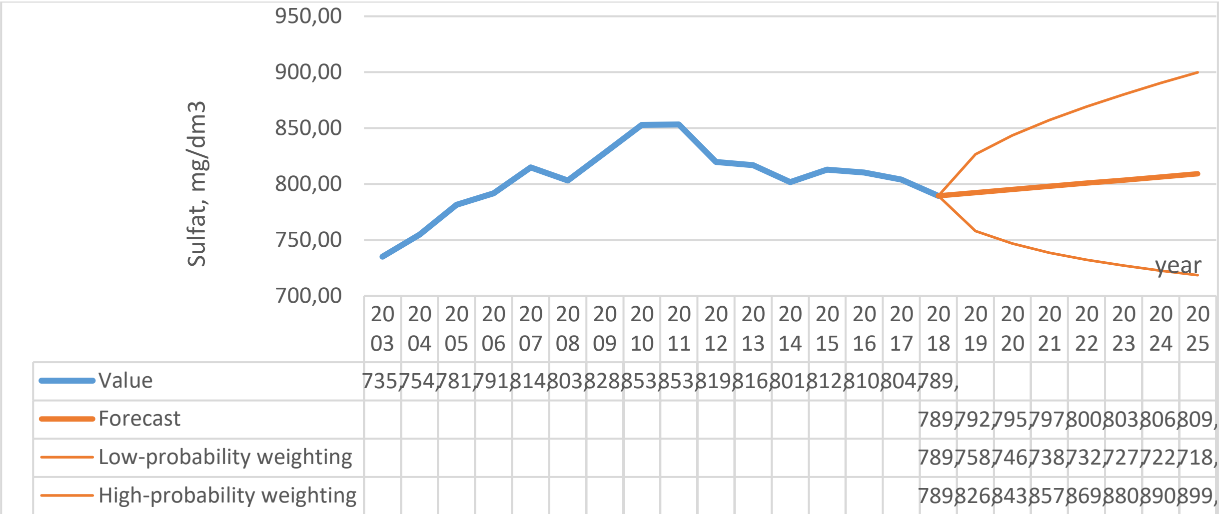


Fig. 22 – Dynamics of changes in sulfate ion levels in the Kazennyi Torets River and their forecasting until 2025

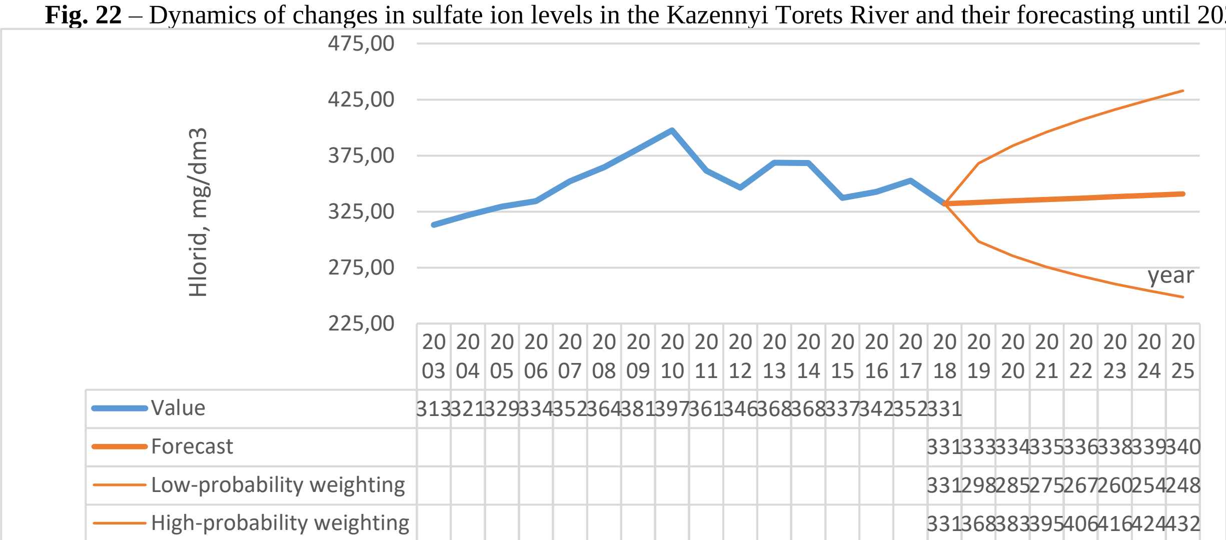


Fig. 23 – Dynamics of changes in chloride ion levels in the Kazennyi Torets River and their forecasting until 2025

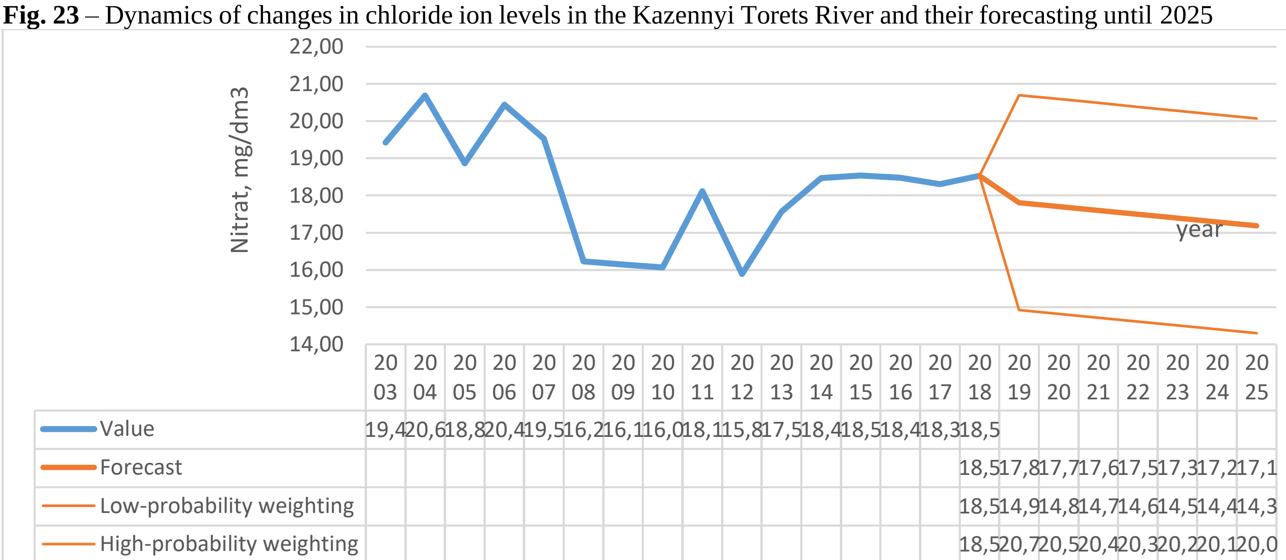


Fig. 24 - Dynamics of changes in nitrate ion levels in the Kazennyi Torets River and their forecasting until 2025

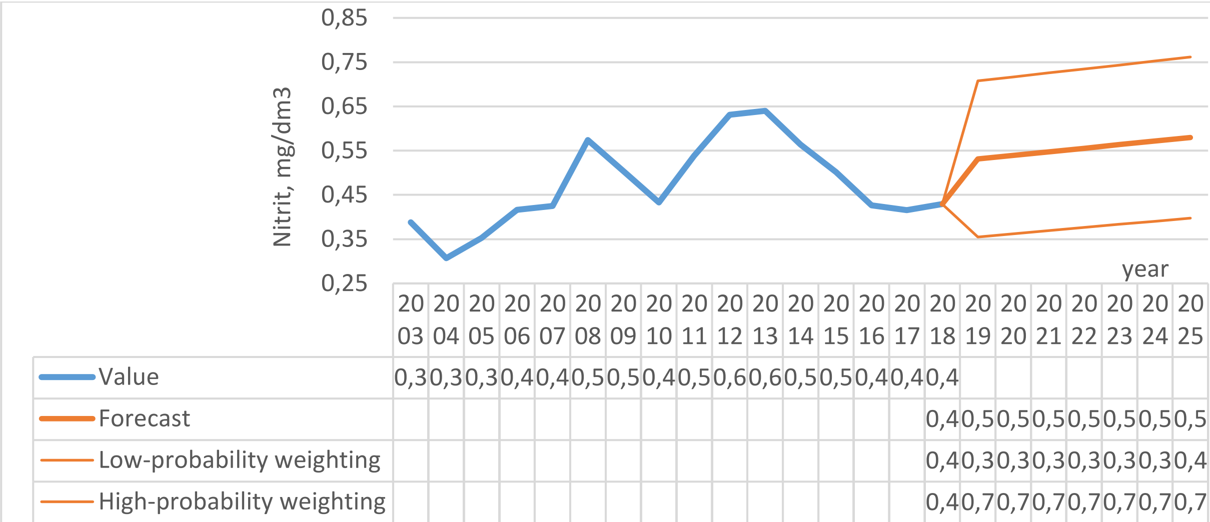


Fig. 25 – Dynamics of changes in nitrite ion levels in the Kazennyi Torets River and their forecasting until 2025

Table 1

Comparative analysis of forecasting results of the surface water condition of the Kryvyi Torets River with BUVR monitoring data

Indicator	BOD5, mgO2/dm3	Dissolved oxygen, mgO2/dm3	Phosphate ion, mg/dm3	Ammonium, mg/dm3	Sulfat, mg/dm3	Hlorid, mg/dm3	Nitrat, mg/dm3	Nitrit, mg/dm3
04.07.2024	4,56	7,38	1,48	1,21	749,30	298,20	***1,95***	0,26
Forecast	**4,55**	8,70	**1,38**	1,98	**733,82**	213,63	**16,87**	**0,39**
Low-probability weighting	4,23	**7,51**	0,06	**1,56**	675,13	94,84	9,46	0,12
High-probability weighting	4,86	9,90	2,69	2,41	792,51	**332,41**	24,28	0,66
26.05.2025	4,42	7,84	1,08	1,08	701,20	383,40	19,78	0,43
Forecast	4,57	8,74	**1,38**	2,06	**731,85**	203,20	**16,76**	**0,38**
Low-probability weighting	**4,25**	**7,45**	0,04	**1,63**	671,42	56,70	8,77	0,10
High-probability weighting	4,89	10,03	0,80	2,50	791,98	**349,70**	24,74	0,65

Thus, according to the data of the State Institution "Donetsk Regional Center for Disease Control and Prevention of the Ministry of Health of Ukraine" [15–17], in the Druzhkivka TG as of May 2024 the water of the Kazennyi Torets River and the Kryvyi Torets River was characterized by the following exceedances of standards:

1) Kazennyi Torets River: sulfates – from 2.9 to 3.51 MPC, chlorides – from 1.71 to 2.46 MPC, BOD_5 – from 1.83 to 2.03 MPC, dissolved oxygen below the norm by 1.12–2.41 times;

2) Kryvyi Torets River: sulfates – from 2.38 to 3.45 MPC, chlorides – from 1.37 to 2.09 MPC, BOD_5 – from 1.8 to 1.86 MPC, dissolved oxygen below the norm by 1.12–2.41 times

Table 2

Comparative analysis of forecasting results of the surface water condition of the Kazennyi Torets River with BUVR monitoring data

Indicator	BOD5, mgO2/dm3	Dissolved oxygen, mgO2/dm3	Phosphate ion, mg/dm3	Ammonium, mg/dm3	Sulfat, mg/dm3	Hlorid, mg/dm3	Nitrat, mg/dm3	Nitrit, mg/dm3
26.05.2025	4,42	7,82	0,33	1,21	797,30	383,40	17,49	0,65
Forecast	4,75	**8,26**	2,23	2,11	**809,26**	**340,75**	**17,19**	**0,58**
Low-probability weighting	**4,52**	6,46	**0,75**	**1,73**	718,66	248,63	14,30	0,40
High-probability weighting	4,98	10,07	3,70	2,49	899,95	432,88	20,07	0,76

In August 2025, in the Kazennyi Torets River the following exceedances were recorded: sulfates – 2.02–2.05 MPC, BOD_5 – 1.5 MPC, chlorides – 1.15 MPC, the actual content of dissolved oxygen was 2.12 and 2.15 mg/dm³ with the normative value ≥4.0 mg/dm³, a decrease of 1.88 and 1.85 mg/dm³, respectively, was recorded. In the Kryvyi Torets River: BOD_5 – 2.33 MPC; sulfates – 2.01–3.93 MPC.

Conclusions

The conducted analysis of the state of surface waters of the Kryvyi Torets and Kazennyi Torets rivers indicates long-term and systematic pollution of the rivers. Organic pollution (BOD_5 and dissolved oxygen) in both rivers was high, throughout the entire observation period there was a systematic exceedance of BOD_5 over the MPC (3 mgO_2/dm^3), which indicates excessive organic load. The concentration of dissolved oxygen repeatedly dropped below the standard (4 mgO_2/dm^3), which indicates a threat to aquatic biota and disruption of self-purification processes. The most critical periods were the mid-2000s and early 2010s. In 2024–2025 a steady decrease in oxygen levels is observed with high BOD_5 values, which confirms an unfavorable ecological state.

As for nitrogen-containing compounds (nitrates, nitrites, ammonium) – the situation is also unfavorable. Nitrates generally did not exceed the MPC, however peak values were recorded, associated with agricultural load. Nitrites constantly and significantly exceeded the standard (by tens of times), especially in 2005–2008, which indicates intensive organic pollution and the inflow of insufficiently treated wastewater. Ammonium ions in most years exceeded permissible values, reaching peaks over 1.7–2.0 mg/dm³. This indicates a stable technogenic load.

Periodic significant maxima of phosphate ion content (up to 3.0 mg/dm³) were noted, which indicates eutrophication processes and the inflow of phosphates from detergents and fertilizers. Mineralization of water (sulfate and chloride ions) is high, the concentrations of both indicators often exceeded the standards, especially in 2006–2008 and 2011–2013. Since 2014 stabilization has been observed, but at a high level, which indicates a constant technogenic influence of industrial and municipal discharges.

In the absence of monitoring data, we carried out forecasting using the Forecast Sheet resource, which showed good convergence of forecast and actual values. The general trends are as follows: BOD_5 indicators increase, DO decreases, the content of ammonium and phosphate ions increases, the content of sulfate, chloride, nitrate and nitrite ions decreases, but their levels still remain elevated. This means that no positive dynamics of water quality was recorded – in 2024–2025 most indicators exceed the MPC.

Thus, the Kazennyi Torets and Kryvyi Torets rivers are in a state of persistent organic and chemical pollution, with dangerously low oxygen levels and exceedances of BOD_5, ammonium, phosphates, sulfates and nitrites. Despite partial stabilization after 2015, the overall ecological state remains unsatisfactory, and in 2024–2025 the situation has even worsened. This requires strengthening control over sources of discharges, modernization of treatment facilities, and the development of a comprehensive program for the ecological rehabilitation of the Siverskyi Donets basin.

Overall, the war has significantly deepened the ecological problems of these rivers. They require a comprehensive approach to restoration: modernization of treatment facilities, rehabilitation of aquatic ecosystems, and restoration of the monitoring system. Without this, there is a threat of further degradation of the region's water resources, which will have long-term consequences for the environment and public health.

Conflict of Interest

The authors declare no conflict of interest regarding the publication of this manuscript. Furthermore, the authors have fully adhered to ethical norms, including avoiding plagiarism, data falsification, and duplicate publication.

Authors Contribution: all authors have contributed equally to this work.

The work does not use artificial intelligence resources.

References

1. Myhal, M. (2024). War and ecology: Why nature becomes a victim of armed conflict. *Institute of Analytics and Advocacy*. Retrieved from https://iaa.org.ua/articles/vijna-ta-ekologiya-chomu-pryroda-staye-zhertvoyu-zbrojnogo-konfliktu/
2. Velychko, S., & Dupliak, O. (2023). Impact of full-scale aggression on water bodies as sources of water supply. *Problems of Water Supply, Sewerage and Hydraulics*, (45), 5–14. https://doi.org/10.32347/2524-0021.2023.45.5-14
3. Ministry of Health of Ukraine. (2022, May 2). *Hygienic standards of water quality in water bodies for drinking, household and other needs of the population* (Order No. 721). Retrieved from https://zakon.rada.gov.ua/laws/show/z0524-22#top
4. Ministry of Health of Ukraine. (2010, May 12). *State sanitary norms and rules. Hygienic requirements for drinking water intended for human consumption (DSanPiN 2.2.4-171-10)*. Retrieved from https://zakon.rada.gov.ua/laws/show/z0452-10#Text
5. Google Earth. (n.d.). Cartographic data: Google, Maxar Technologies, Airbus. Retrieved from https://www.google.com.ua/earth/
6. Horoshkova, L., Menshov, O., Maslov, D., & Horoshkov, S. (2025, April). Environmental assessment of the war impact on the surface waters of the Dnipro River in Zaporizhzhia city. In *XVIII International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment"* (pp. 1–5). European Association of Geoscientists & Engineers. Retrieved from https://eage.in.ua/wp-content/uploads/2025/04/Mon25-052.pdf
7. Horoshkova, L. A., Menshov, O. I., Korniichuk, Y. D., Horoshkov, S. V., & Ryshykov, I. V. (2025). Ecological assessment of surface water conditions of the Danube River. *Bulletin of V. N. Karazin Kharkiv National University Series Ecology*, *32*, 6–22. https://doi.org/10.26565/1992-4259-2025-32-01
8. Bezsonnyi, V., Ponomarenko, R., Tretyakov, O., Kalda, G., & Asotskyi, V. (2021). Monitoring of ecological safety of watercourses by means of oxygen indicators. *Technogenic and Ecological Safety*, *10*(2), 75–83. https://doi.org/10.52363/2522-1892.2021.2.12
9. Bezsonnyi, V. L., Tretyakov, O. V., Kravchuk, A. M., & Statsenko, Yu. F. (2016). Prediction of the oxygen regime of the Siverskyi Donets River by mathematical modeling methods. *Construction, Materials Science, Mechanical Engineering. Series: Life Safety*, (93), 113–119. Retrieved from http://srd.pgasa.dp.ua:8080/xmlui/handle/123456789/3632
10. Nekos, A., Boiaryn, M., Lugowska, M., Tsos, O., & Netrobchuk, I. (2021). Assessment of the ecological state of rivers in the Western Bug basin using the macrophyte index (MIR). *Bulletin of V. N. Karazin Kharkiv National University. Series "Geology. Geography. Ecology"*, (54), 316–328. https://doi.org/10.26565/2410-7360-2021-54-24
11. Bezsonnyi, V., Tretyakov, O., Khalmuradov, B., & Ponomarenko, R. (2017). Examining the dynamics and modeling of oxygen regime of Chervonooskil water reservoir. *Eastern European Journal of Enterprise Technologies, 5/10(89)*, 32–38. Retrieved from http://repositsc.nuczu.edu.ua/handle/123456789/5546
12. Bezsonnyi, V., & Nekos, A. (2022, November 15–18). Modeling of the oxygen regime of the Chervonooskilsky reservoir. In *16th International Conference "Monitoring of Geological Processes and Ecological Condition of the Environment"*. Kyiv, Ukraine. https://doi.org/10.3997/2214-4609.2022580216
13. Bezsonnyi, V. (2022). Selection of indicative indicators of ecological condition of surface source of water supply. *Municipal Economy of Cities (Technical Science), 3(170)*, 26–34. https://doi.org/10.33042/2522-1809-2022-3-170-26-34

14. Horoshkova, L., Zaitsev, V., Ryshykov, I., & Shovkoplias, T. (2025, April). Environmental impacts of dredging operations on the condition of surface waters of the Danube River. In *XVIII International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment"* (pp. 1–5). European Association of Geoscientists & Engineers. Retrieved from https://eage.in.ua/wp-content/uploads/2025/04/Mon25-189.pdf
15. Public Health Center of the Ministry of Health of Ukraine. (2024, June 10). Sanitary-epidemiological situation in Donetsk region as of 10.06.2024. Retrieved from https://dn.cdc.gov.ua/articles/sanitarno-epidemichna-sytuatsiya-v-donetskij-oblasti-stanom-na-10-06-2024/
16. Public Health Center of the Ministry of Health of Ukraine. (2025, September 1). Sanitary-epidemiological situation in Donetsk region as of 01.09.2025. Retrieved from https://dn.cdc.gov.ua/articles/sanitarno-epidemichna-sytuatsiya-v-donetskij-oblasti-stanom-na-01-09-2025/
17. Public Health Center of the Ministry of Health of Ukraine. (2025, August 4). Sanitary-epidemiological situation in Donetsk region as of 04.08.2025. Retrieved from https://dn.cdc.gov.ua/articles/sanitarno-epidemichna-sytuatsiya-v-donetskij-oblasti-stanom-na-04-08-2025/

The article was received by the editors 09.09.2025 The article was revised 21.10.2025
The article is recommended for printing 25.10.2025 This article published 30.12.2025

Л. А. ГОРОШКОВА, д-р екон. наук, проф.,
професор кафедри екології
e-mail: goroshkova69@gmail.com ORCID ID: https://orcid.org/0000-0002-7142-4308
Національний університет «Києво-Могилянська академія»
вул. Сковороди, 2, Київ, 04070, Україна

О. І. МЕНШОВ, д-р геол. наук, ст. наук. співроб.,
Кафедра геоінформатики
e-mail: menshov@knu.ua ORCID ID: https://orcid.org/0000-0001-7280-8453
Київський національний університет імені Тараса Шевченка
вул. Володимирівська. 60, Київ, 01033, Україна

А. Н. НЕКОС, д-р географ. наук, проф.,
професор кафедри екологічного моніторингу та заповідної справи
e-mail: nekos@karazin.ua ORCID ID: https://orcid.org/0000-0003-1852-0234
Харківський національний університет імені В. Н. Каразіна,
майдан Свободи, 4, м. Харків, 61022, Україна

Ю. Д. КОРНІЙЧУК[1, 2], магістр
e-mail: yuliia.korniichuk@ukma.edu.ua ORCID ID: https://orcid.org/0009-0008-0742-3213
[1]*Київський національний університет імені Тараса Шевченка*
вул. Володимирівська. 60, Київ, 01033, Україна
[2]*Харківський національний університет імені В. Н. Каразіна,*
майдан Свободи, 4, м. Харків, 61022, Україна

К. В. ХАДУСКІНА, бакалавр
e-mail: kateryna.khaduskina@student.karazin.ua ORCID ID: https://orcid.org/0009-0008-8558-8937
Харківський національний університет імені В. Н. Каразіна,
майдан Свободи, 4, м. Харків, 61022, Україна

АНТРОПОГЕННИЙ ВПЛИВ ВІЙНИ НА СТАН ПОВЕРХНЕВИХ ВОД РІЧОК КАЗЕННИЙ ТОРЕЦЬ ТА КРИВИЙ ТОРЕЦЬ В МЕЖАХ М. ДРУЖКІВКА

Мета. Надати комплексну екологічну оцінку стану поверхневих вод річок Кривий Торець та Казенний Торець у м. Дружківка з метою визначення основних антропогенних факторів впливу, зокрема наслідків війни.

Методи. Системний аналіз, методи статистичної обробки, аналіз динаміки у ретроспективі та прогнозування майбутніх тенденцій.

Результати. Проведено аналіз показників стану води для постів моніторингу – р. Кривий Торець та р. Казенний Торець. Органічне забруднення (БСК$_5$ та розчинений кисень) в обох річках упродовж усього періоду спостерігалося систематичне перевищення БСК$_5$ над ГДК. Концентрація розчиненого кисню неодноразово опускалася нижче нормативу, що вказує на загрозу для водної біоти та порушення процесів самоочищення. Нітрити постійно та суттєво перевищували норматив особливо у 2005–2008 рр. Відзначено періодичні значні максимуми вмісту фосфат-іонів, що свідчить про евтрофікаційні процеси та надходження фосфатів з миючих засобів і добрив. Мінералізація води (сульфат- та хлорид-іони) є високою особливо у 2006–2008 та 2011–2013 рр. З 2014 р. спостерігається стабілізація, але на високому рівні. Прогнозування з використанням ресурсу Forecast Sheet, яке показало добру збіжність прогнозних та фактичних значень. Позитивної динаміки якості води не зафіксовано – у 2024–2025 рр. більшість показників перевищує ГДК.

Висновки. Річки Казенний Торець і Кривий Торець знаходяться у стані стійкого органічного та хімічного забруднення. Загальний екологічний стан залишається незадовільним, а у 2024–2025 рр. ситуація навіть погіршилася. Загалом, війна значно поглибила екологічні проблеми цих річок. Вони потребують комплексного підходу до відновлення: модернізації очисних споруд, реабілітації водних екосистем та відновлення системи моніторингу. Без цього існує загроза подальшої деградації водних ресурсів регіону, що матиме довгострокові наслідки для довкілля та здоров'я населення.

КЛЮЧОВІ СЛОВА: *річка Кривий Торець, річка Казенний Торець, поверхневі води, екологічний моніторинг, фосфати, амоній, сульфати, хлориди, розчинений кисень, БСК$_5$, натрати, нітрити, антропогенний вплив, наслідки війни*

Конфлікт інтересів

Автори заявляють, що конфлікту інтересів щодо публікації цього рукопису немає. Крім того, автори повністю дотримувались етичних норм, включаючи плагіат, фальсифікацію даних та подвійну публікацію.

Внесок авторів: всі автори зробили рівний внесок у цю роботу

В роботі не використано ресурс штучного інтелекту.

Список використаної літератури

1. Мигаль, М. Війна та екологія: чому природа стає жертвою збройного конфлікту. *Інститут аналітики та адвокації*. 2023. URL: https://iaa.org.ua/articles/vijna-ta-ekologiya-chomu-pryroda-staye-zhertvoyu-zbrojnogo-konfliktu/
2. Величко, С., & Дупляк, О. Вплив повномасштабної агресії на водні об'єкти як джерела водопостачання. *Проблеми водопостачання, водовідведення та гідравліки.* 2023. № 45. С. 5–14. https://doi.org/10.32347/2524-0021.2023.45.5-14
3. Міністерство охорони здоров'я України. *Гігієнічні нормативи якості води водних об'єктів для задоволення питних, господарсько-побутових та інших потреб населення* (Наказ № 721). 2022, 2 травня. URL: https://zakon.rada.gov.ua/laws/show/z0524-22#top
4. Міністерство охорони здоров'я України. *Державні санітарні норми та правила. Гігієнічні вимоги до води питної, призначеної для споживання людиною* (ДСанПіН 2.2.4-171-10). 2010, 12 травня. URL: https://zakon.rada.gov.ua/laws/show/z0452-10#Text
5. Google Earth. Картографічні дані: Google, Maxar Technologies, Airbus. URL: https://www.google.com.ua/earth/
6. Horoshkova L., Menshov O., Maslov D., Horoshkov S. Environmental assessment of the war impact on the surface waters of the Dnipro River in the Zaporizhzhia city. In *XVIII International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment"* (pp. 1–5). European Association of Geoscientists & Engineers. 2025, April. URL: https://eage.in.ua/wp-content/uploads/2025/04/Mon25-052.pdf
7. Horoshkova L. A., Menshov O. I., Korniichuk Y. D., Horoshkov S. V., Ryshykov I. V. Ecological assessment of surface water conditions of the Danube River. *Вісник Харківського національного університету імені В. Н. Каразіна. Серія «Екологія»*. 2025. *32*, 6–22. https://doi.org/10.26565/1992-4259-2025-32-01
8. Bezsonnyi V., Ponomarenko R., Tretyakov O., Kalda, G., Asotskyi V. Monitoring of ecological safety of watercourses by means of oxygen indicators. *Technogenic and Ecological Safety.* 2021. Vol.10. *N* 2. P.75–83. https://doi.org/10.52363/2522-1892.2021.2.12
9. Безсонний В. Л., Третьяков О. В., Кравчук А. М., Стаценко Ю. Ф. Прогнозування кисневого режиму річки Сіверський Донець методами математичного моделювання. *Будування, матеріалознавство, машинобудування. Серія: Безпека життєдіяльності.* 2016. № 93. С. 113–119. URL: http://srd.pgasa.dp.ua:8080/xmlui/handle/123456789/3632

10. Nekos A., Boiaryn M., Lugowska M., Tsos O., Netrobchuk I. Оцінка екологічного стану річок басейну Західного Бугу за індексом макрофітів (MIR). *Вісник Харківського національного університету імені В. Н. Каразіна. Серія «Геологія. Географія. Екологія»*. 2021. Вип. 54. С. 316–328. https://doi.org/10.26565/2410-7360-2021-54-24
11. Bezsonnyi V., Tretyakov O., Khalmuradov B., Ponomarenko R. Examining the dynamics and modeling of oxygen regime of Chervonooskil water reservoir. *Eastern European Journal of Enterprise Technologies,* 2017. *5/10(89)*, 32–38. URL: http://repositsc.nuczu.edu.ua/handle/123456789/5546
12. Bezsonnyi V., Nekos A. Modeling of the oxygen regime of the Chervonooskilsky reservoir. In *Proc. of the XVIth International Conference Monitoring of Geological Processes and Ecological Condition of the Environment*. (2022, November 15–18). Kyiv, Ukraine. https://doi.org/10.3997/2214-4609.2022580216
13. Bezsonnyi V. Selection of indicative indicators of ecological condition of surface source of water supply. *Municipal Economy of Cities (Technical Science), 2022. 3(170)*, 26–34. https://doi.org/10.33042/2522-1809-2022-3-170-26-34
14. Horoshkova, L., Zaitsev, V., Ryshykov, I., & Shovkoplias, T. Environmental impacts of dredging operations on the condition of surface waters of the Danube River. In *Proc. of the XVIII International Scientific Conference "Monitoring of Geological Processes and Ecological Condition of the Environment"* (2025, April). (pp. 1–5). European Association of Geoscientists & Engineers. URL: https://eage.in.ua/wp-content/uploads/2025/04/Mon25-189.pdf
15. Центр громадського здоров'я МОЗ України. (2024, 10 червня). Санітарно-епідемічна ситуація в Донецькій області станом на 10.06.2024. URL: https://dn.cdc.gov.ua/articles/sanitarno-epidemichna-sytuatsiya-v-donetskij-oblasti-stanom-na-10-06-2024/
16. Центр громадського здоров'я МОЗ України. (2025, 1 вересня). Санітарно-епідемічна ситуація в Донецькій області станом на 01.09.2025. URL: https://dn.cdc.gov.ua/articles/sanitarno-epidemichna-sytuatsiya-v-donetskij-oblasti-stanom-na-01-09-2025/
17. Центр громадського здоров'я МОЗ України. (2025, 4 серпня). Санітарно-епідемічна ситуація в Донецькій області станом на 04.08.2025. URL: https://dn.cdc.gov.ua/articles/sanitarno-epidemichna-sytuatsiya-v-donetskij-oblasti-stanom-na-04-08-2025/

Стаття надійшла до редакції 09.09.2025 Переглянуто 21.10.2025
Стаття рекомендована до друку 25.10.2025 Опубліковано 30.12.2025