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Study of changes in the availability of drinking water supply due to surface water pollution in the Dnipropetrovsk region during the period of war

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ABSTRACT

This study aimed to determine the qualitative and quantitative changes in surface water pollution during the period of martial law in Ukraine. A retrospective and modern analysis of water quality in the water bodies of the Dnipropetrovsk region was conducted, as this is where the surface runoff is formed that is used for field irrigation and drinking water supply in the southern regions of Ukraine. On the basis of the research, the pollutants related to military actions were identified, specifically phosphates and ammonium, which are direct results of the explosion of various types of shells, and chlorides and sulfates, which are indirect results of the war and entered the water after the dam of the Kakhovka HPP was blown up. The results obtained indicate a direct impact of military actions and an increase in the pollution of rivers and canals, which may lead to the water becoming completely unsuitable for drinking water supply in the future.

Keywords: drinking water, pollution, impact of war, industrial enterprises, polluting elements.

INTRODUCTION

Ukraine naturally has a low level of water security, which is confirmed by studies from various international organizations such as UNESCO (UNESCO, 2015), FAO Aquastat (FAO Aquastat, 2020), and the National Institute for Strategic Studies (National Institute for Strategic Studies, 2020). The lowest level of water security is characteristic of the Dnipropetrovsk, Donetsk, Kherson, Mykolaiv, and Odesa regions, and the Autonomous Republic of Crimea. In the Donetsk, Dnipropetrovsk, and Mykolaiv regions, groundwater is also actively involved in water supply (Bubnova et al., 2023). The regions with the lowest water security have a much higher level of water consumption than other areas. Therefore, the preservation of water resources and their economic use is highly relevant for eastern and southern Ukraine.

Unfortunately, as a result of the start of large-scale military actions in February 2022, the ecological state of Ukraine's territory has sharply deteriorated. Although water consumption has decreased in most regions with active combat or regular shelling due to the cessation of industrial activity, there is also an increase in water consumption for liquidating the consequences of shelling, particularly for firefighting. This created a need to study the impact of military actions on the state of water resources.

An analysis of groundwater quality changes in Ukraine (Lyutyi et al., 2021) showed a significant deterioration since 1960. The deterioration of water quality is also recorded in Ukraine's rivers, especially those used for drinking water supply (Alyokhina, 2021; Yatsyk et al., 2018). This change in the quality of Ukraine's water resources is linked to the large-scale discharge of industrial wastewater and mine water into surface water bodies, and the active use of fertilizers in agriculture.

Since 2022, new pollutants related to military actions have been added to the existing contamination. The study (Hapich et al., 2024) noted that Ukraine has lost approximately a third of its water reserves in two years of military action. It is proposed to use groundwater for water consumption (Sudakov et al, 2025), but groundwater is also negatively affected by the war, accumulating even more heavy metal pollution (1495 mg/L) than surface water (349 mg/L) (Shukla et al., 2023).

The impact on water resources manifests through the use of bombs, rockets, chemical weapons, military equipment, etc. (Broomandi et al., 2020; Shaforost et al., 2024).

As the authors of the study (Wiretu and Abdela, 2025) noted, the impact of war on the aquatic environment is the most prolonged and widespread, as it also has consequences for soils, flora, fauna, and people due to trinitrotoluene (TNT) and hexogen that enter the water from exploded and unexploded ordnance. This is confirmed by the studies from the U.S. Environmental Protection Agency (EPA, 2011), which stated that TNT enters groundwater and surface water through soil and air, has high solubility and mobility, and therefore poses a danger to people that persists for decades. When it enters water, TNT forms a dangerous product called trinitrobenzene (Wiretu and Abdela, 2025). Thus, both TNT and hexogen, which are used in munitions, are toxic to humans, and their ability to accumulate in bottom sediments creates a long-term danger. In addition to chemical contamination, surface and groundwater also suffer from biological, toxic, and oil pollution (Filho et al., 2024).

On the basis of the results of bottom sediment samples from the Karlivka and Kleban-Byk reservoirs in 2017, an increased content of non-radioactive strontium, mercury, cadmium, vanadium, and barium was found compared to similar samples from 2008, and in water samples, the content of ammonium nitrogen, nitrate nitrogen, copper, and petroleum products exceeded the pre-war values by 1.1–1.3 times (OSCE, 2017). However, in 2022, in the Seversky Donets River basin, mercury concentrations were 8.4 times higher, and ammonium nitrogen and nitrites were 2.4 and 2.8 times higher than the long-term pre-war values (Shumilova et al., 2023). Thus, with the increased intensity of military actions, river pollution has also increased. A several-fold increase in the content of nitrogen compounds has been recorded in the surface waters of the Kharkiv region as a result of military actions (Bezsonnyi et al., 2022). All the listed compounds are components of modern munitions. The elevated content of copper, zinc, lead, and cadmium in water due to military actions makes such water unsuitable for consumption (Bildirici et al., 2022).

In studies, the zone of impact on rivers is usually limited to the line of military contact and a 50-kilometer zone from it (The Conflict and Environment Observatory and Zoï Environment Network, 2024). However, it should be noted that Ukraine suffers from constant shelling with ballistic and cruise missiles, aerial bombs, UAVs, etc., which designates almost the entire country's territory as a place where water resources are potentially harmed. In the territory with active combat and in the non-government-controlled territory, it is impossible to conduct monitoring, which negatively affects the entire monitoring system, as the assessment is based on probable, rather than reliable data (Hook and Marcantonio, 2022).

The goal was to study and assess surface water pollution during the period of martial law, distinguishing between the pollution from water user discharges and the impact of military actions.

MATERIALS AND METHODS

The research area

In this study, the surface waters of the Dnipropetrovsk region were chosen as the object for the following reasons:

- This is where the runoff for the waters used in the Zaporizhzhia and Kherson regions is formed.
- No active combat took place in the region; only the impact of explosives from shells, rockets, and UAVs was recorded.
- There is access to most of the stationary observation posts for surface water bodies.
- The impact of industrial enterprises on surface water quality is recorded.

Sampling point and period

For the study, the surface water quality monitoring data from January 2018 to September 2025 were used (State Agency of Water Resources of Ukraine, 2025), obtained from 23 observation posts on the Saksahan, Inhulets, and Dnipro rivers (Figure 1).

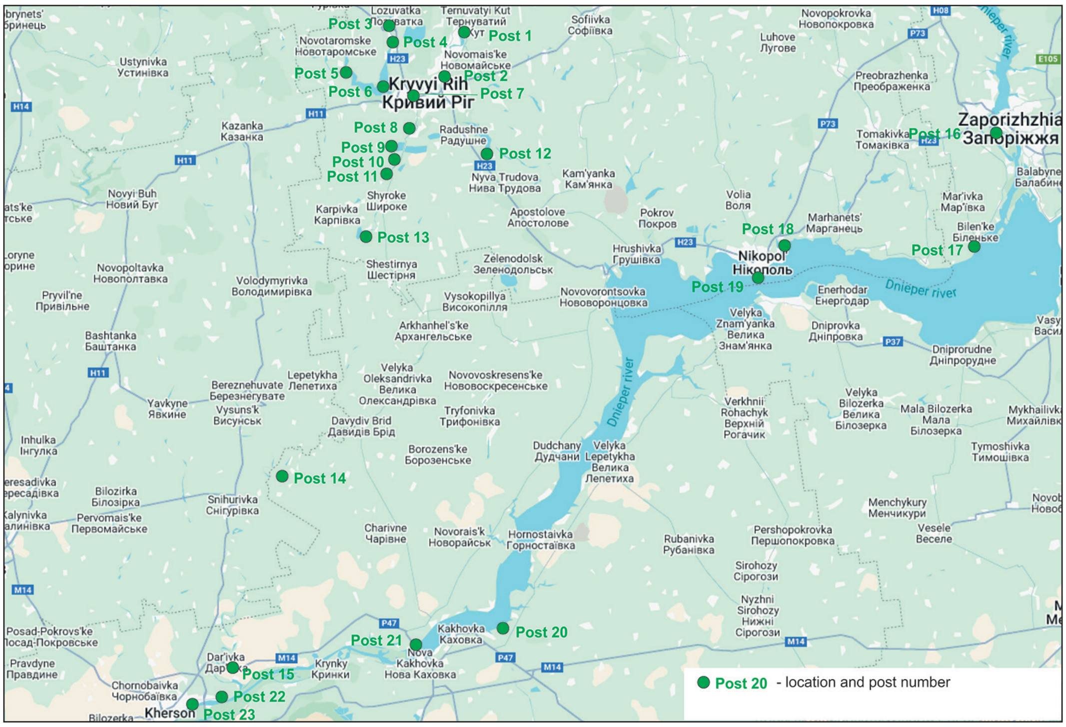

Figure 1. Location of surface water quality monitoring stations

Prior to 2022, there were significantly more observation posts along the Dnieper River from Zaporizhzhia to Kherson. However, they were lost when the Kakhovka Hydroelectric Power Plant dam was destroyed. Nevertheless, Ukraine is establishing new observation posts in line with European legislation, meaning that some of those studied were established after 2022.

From the existing posts, those located downstream from the city of Kryvyi Rih to the confluence of the Inhulets River with the Dnipro River and downstream from the city of Zaporizhzhia on the Dnipro River were selected. It should be noted that the waters of both the Dnipro and Inhulets rivers are used for drinking water supply and for agricultural purposes (field irrigation), so their water quality is essential. At most monitoring posts, the following parameters are controlled: content of NH_4^+, suspended solids, NO_3^-, NO_2^-, SO_4^{2-}, PO_4^{3-}, Cl^-, BOD_5 and dissolved oxygen.

To avoid the scale of comparison, only the main pollutants (NH_4^+, SO_4^{2-}, PO_4^{3-}, Cl^-) were considered. The research results are grouped by location and presented in Figures 2–4, which show the maximum permissible concentrations (MPCs) for each pollutant. The values of maximum permissible concentrations are presented in accordance with the Ukrainian national standard (Ministry of Health of Ukraine, 2022). These figures indicate when the content of the corresponding pollutant in a water sample exceeds MPC.

Data analysis methods

Descriptive and graphical methods were employed to analyze the data. During the study period (2018–2025), the data were preliminarily examined for each post, and a description of the changes that occurred was produced. The data was also organized and examined along the river, where posts with high pollutant content and significant changes to these levels were clearly visible. In the next stage of the study, the data were divided into two groups: the pre-war period (2018–2021) and the period of military operations (2022–2025). All available data were incorporated into the study, irrespective of seasonal variation. The most significant limitations pertain to the river water quality records for the period from March 2022 to September 2023, as measurements are missing for several monitoring posts. Consequently, the resulting analysis may involve a certain degree of uncertainty. Statistical methods, namely the t-test, were used to analyze the data of the groups, and box plots were used to visualize the range of values.

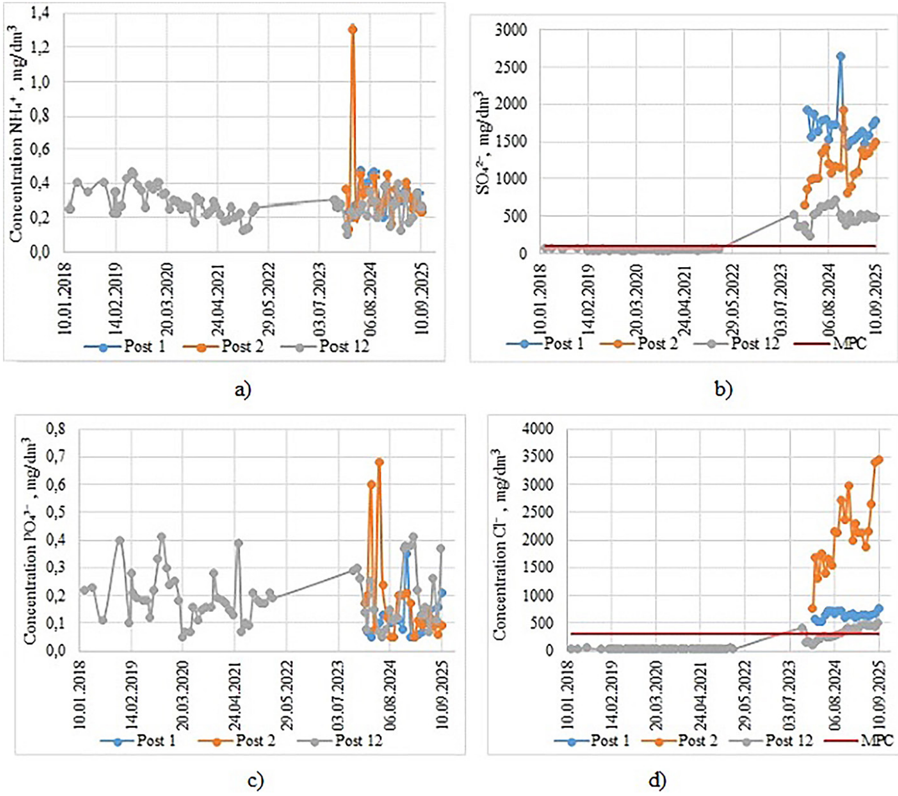

Figure 2. Changes in water quality in the Saksahan River

RESULTS AND DISCUSSION

In the Saksahan River, the most significant changes were observed in the content of NH_4^+, SO_4^{2-}, PO_4^{3-}, Cl^- (Figure 2 a, Figure 2b, Figure 2c, Figure 2d). The content SO_4^{2-} exceeding the MPC starting in February 2022, even in the Dnipro-Kryvyi Rih canal (post 12 in Figure 1), which feeds the Southern reservoir on the Saksahan River.

It should be noted that for all indicators, the water in the Dnipro-Kryvyi Rih Canal is of better quality than the water in the Saksahan River throughout the entire study period. However, since February 2022, the quality has been gradually deteriorating, which may be related to military actions. The Saksahan River flows into the Inhulets River in the southwestern part of the city of Kryvyi Rih. Posts 3–7 are located on the Inhulets River before the confluence with the Saksahan River, and posts 8 and others are located after the confluence. Thus, the deterioration of water quality in the Saksahan River should be reflected in the water quality of the Inhulets River from post 8.

Even before the war, the water quality in the Inhulets River was the worst among the rivers in the Dnipropetrovsk region, as this river is a recipient of the mine and quarry waters from the Kryvyi Rih area, which are discharged into it after settling. As it can be seen from the figures (Figure 3a, Figure 3b, Figure 3c), indicators such as BOD_5 and the content $SO_4^{2-}$and Cl^- in the Inhulets River water significantly exceed MPC. River waters are considered moderately polluted with a BOD_5 value of 2 to 8 mg/dm^3 and heavily polluted with a BOD_5 value greater than 8 mg/dm^3. As can be seen from Figure 6, at post 14, located in the Snihurivka city, BOD_5 was greater than 8 mg/dm^3 in May and August 2023.

The content of SO_4^{2-} (Figure 3b) and Cl^- (Figure 3c) in the Inhulets River is unstable; a significant increase is recorded during the winter-spring period and coincides with the periods of water discharge from the settling pond of mine waters in the Svistunova gully, so the influence of enterprises on this pollution is obvious. However, during the full-scale war, the content of Cl^- and SO_4^{2-} in the Inhulets River has slightly decreased.

Conversely, the content of NH_4^+ and PO_4^{3-} has gradually increased since February 2022 (Figure 3d, Figure 3e), but they do not yet exceed MPCs of 3.0 and 3.5 mg/dm^3, respectively. As it is shown by the data in Figure 3a, 3b, 3c, 3d, 3e, the worst indicators for almost all elements are in the water samples from posts 13 (Andriivka village) and 14 (Snihurivka city).

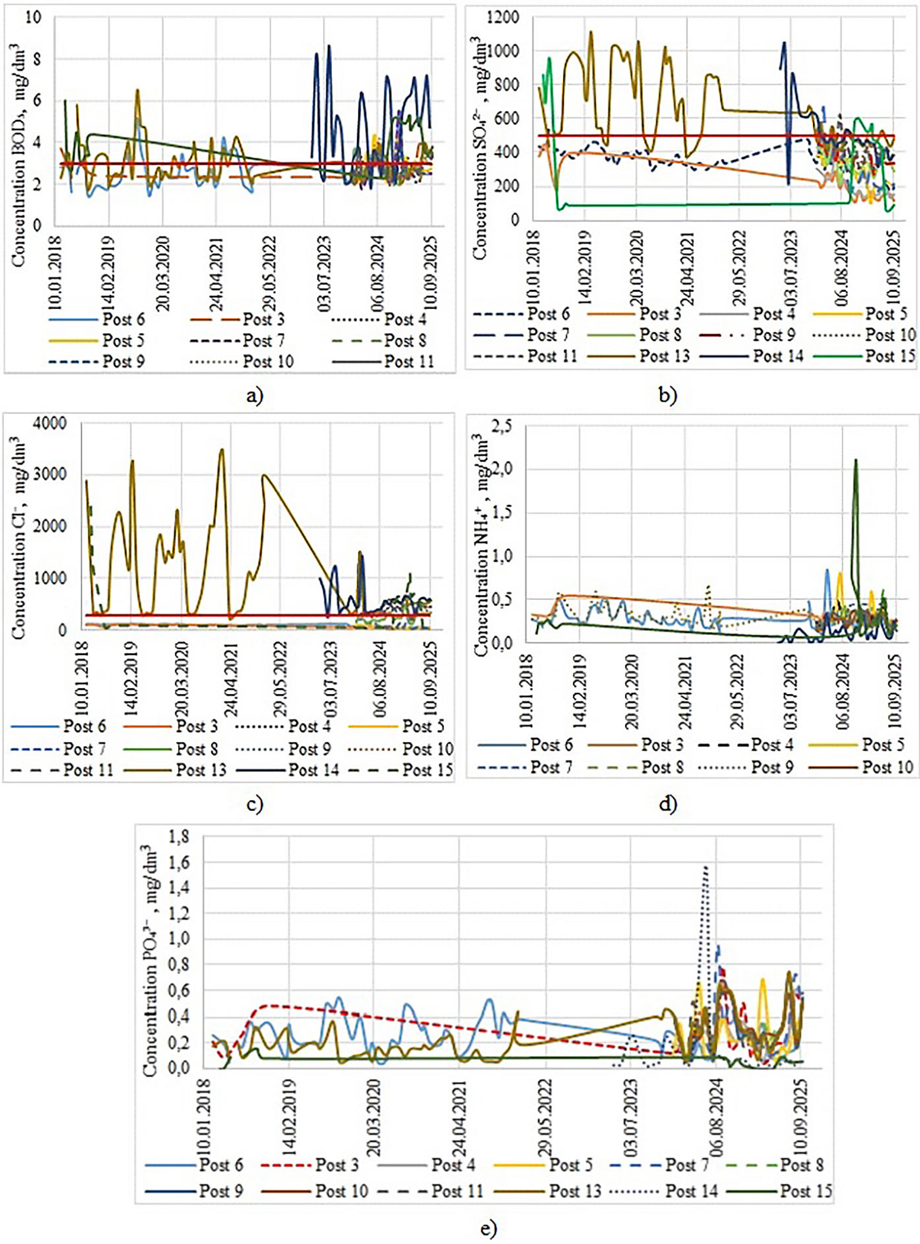

Figure 3. Changes in water quality in the Inhulets River

The Inhulets River flows into the Dnieper near the Sadove village. The last post on the Ingulets River before it flows into the Dnieper is located in the Dar'iivka village (post 15). The post in Sadove village was destroyed when the Kakhovka Hydroelectric Power Plant dam was breached.

On the Dnipro River, the data from posts 16–22 above the confluence with the Inhulets River were analyzed, with post 22 being the last on the Dnipro River before the confluence with the Inhulets River. After the confluence of the Inhulets River, post 23 is located in the Kherson city. Figure 4a, 4b, 4c, 4d show the change in water quality in the Dnipro River.

On the basis of the data presented in Figure 4a, 4b, 4c, 4d, there is a clear gradual increase in the content of pollutants in the Dnipro River water, with the largest increase recorded in early May 2025 to levels exceeding MPC at post 23. Of the three rivers studied, the Inhulets and Saksahan rivers have the worst water quality, and the Dnipro River has the best.

The study showed that the water quality in the rivers is gradually deteriorating, but currently, based on this data, the influence of military actions is not yet obvious. To detect the impact of river pollution, the volumes of wastewater and return water discharge for 2019-2024 were analyzed (Figure 5).

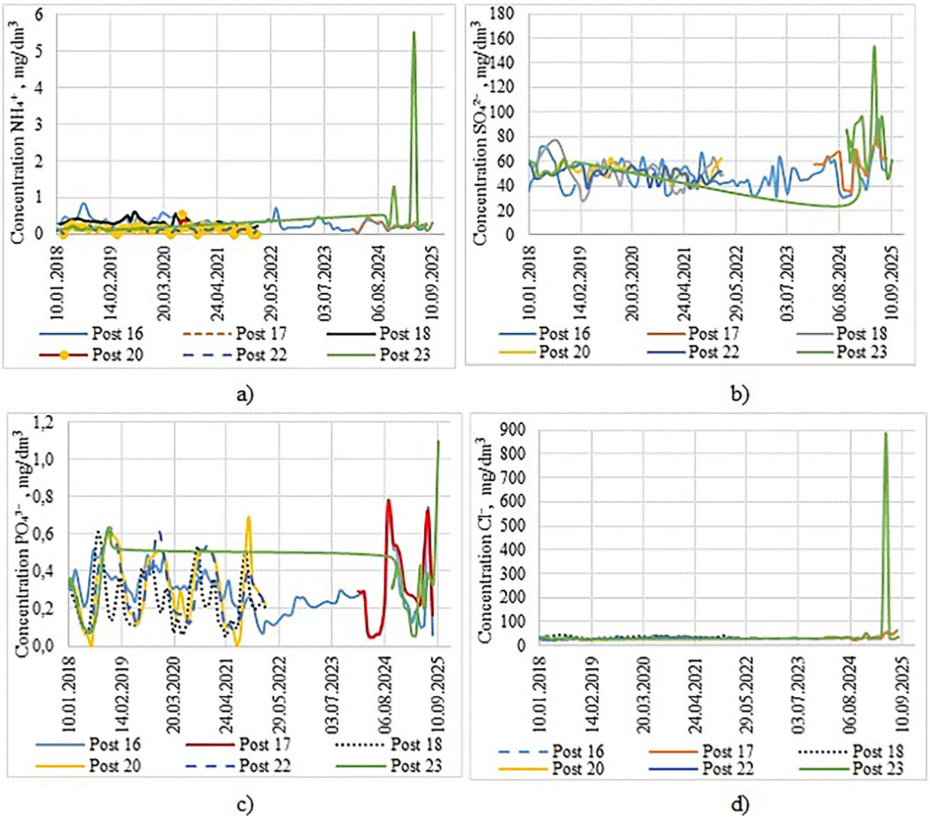

Figure 4. Changes in water quality in the Dnieper River

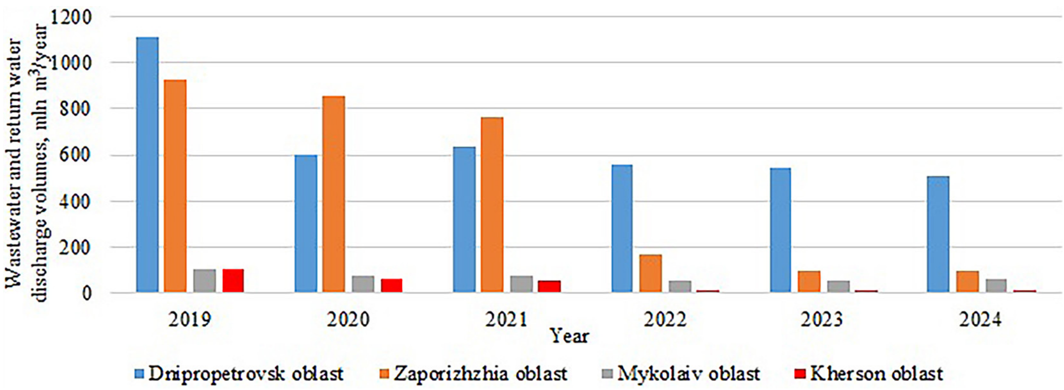

Figure 5. Dynamics of changes in wastewater and return water discharge for 2019–2024 (based on data from the State Agency of Water Resources of Ukraine)

As the data show, water discharge has decreased in all regions. Therefore, the increase in surface water pollution cannot be attributed to industrial enterprises.

Consequently, the distribution of the main pollutants along the river was examined. To this end, mid-June of each year, both before and during the hostilities in the studied area, was selected. Figure 6 shows the graphs for the primary pollutants and their distribution along the Inhulets River, taking into account posts 2 (the confluence of the Saksahan River) and 23 (the confluence with the Dnipro River).

Visually, it is evident that stations 8, 9, 15 and 23 have the highest NH_4^+ content, station 2 has the highest SO_4^{2-} and Cl^- values, and station 14 has the highest PO_4^{3-} values.

To determine the actual change in pollutant content during the period of military operations, a t-test was performed on two data sets: one containing the data from before the military operations (2018–2021) and one containing data from

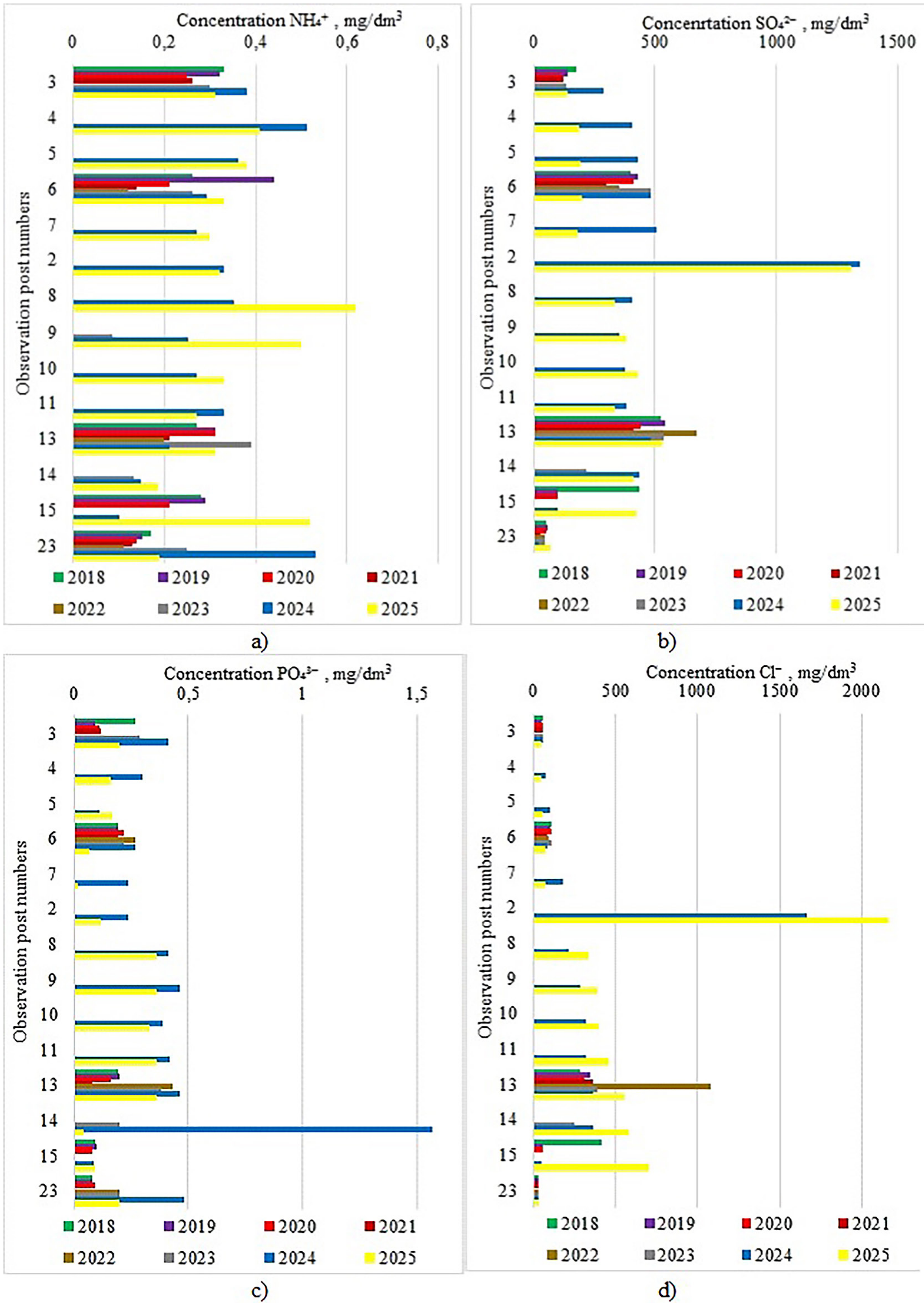

Figure 6. Distribution of pollutant along the Inhulets River for 2018–2025

during the war (2022–2025). The hypothesis assumes that the pollutant indicators are equal and that the data can be used to make accurate measurements. The significance level was set at $\alpha = 0.05$. The results are presented in Table 1. The results show a statistically significant difference at station 6 in terms of SO_4^{2-} and Cl^-; at station 12 – SO_4^{2-} and Cl^- indicators; at station 13 – SO_4^{2-}, PO_4^{3-} and Cl^- indicators; at station 16 – NH_4^+ and PO_4^{3-} indicators. For the sake of clarity, Figures 7–10 illustrate the distribution of data.

As Figures 7–10 show, posts 6 and 12 demonstrate an increase in the range of values. Post 6 shows a slight increase in NH_4^+ content of less

Table 1. Results of the t-test

Post	Indicator	Values for pollutants							
		NH_4^+		SO_4^{2-}		PO_4^{3-}		Cl^-	
		2018–2021	2022–2025	2018–2021	2022–2025	2018–2021	2022–2025	2018–2021	2022–2025
6	Average	0.275	0.287	357.043	298.057	0.268	0.222	108.190	77.195
	Dispersion	0.00553	0.02109	1761.545	10038.20	0.01892	0.01445	78.3840	545.8117
	t-statistic	-0.396647		2.768856		1.288337		6.435089	
	t critical	2.026192		2.032245		2.009575		2.036933	
13	Average	0.314	0.274	722.730	507.974	0.126	0.342	1423.629	685.605
	Dispersion	0.00433	0.00600	57138.27	7059.07	0.00348	0.03209	948889	392783.6
	t-statistic	2.026061		4.321875		-5,83382		3.248883	
	t critical	2.009575		2.039513		2.042272		2.016692	
16	Average	0.392	0.246	50.729	48.218	0.347	0.233	34.012	35.002
	Dispersion	0.01596	0.01606	114.1401	159.4469	0.0064	0.0224	24.2025	61.3295
	t t-statistic	5.327265		0.990533		4.420884		-0.69956	
	t critical	1.98861		1.989686		1.99773		1.993943	
12	Average	0.278	0.255	51.562	457.206	0.182	0.204	39.437	304.073
	Dispersion	0.00450	0.00654	65.57683	27018.896	0.00853	0.01270	15.1096	19381.6
	t-statistic	1.101536		-12.568139		-0.79426		-9.68883	
	t critical	2.010635		2.059539		2.0100635		2.059539	

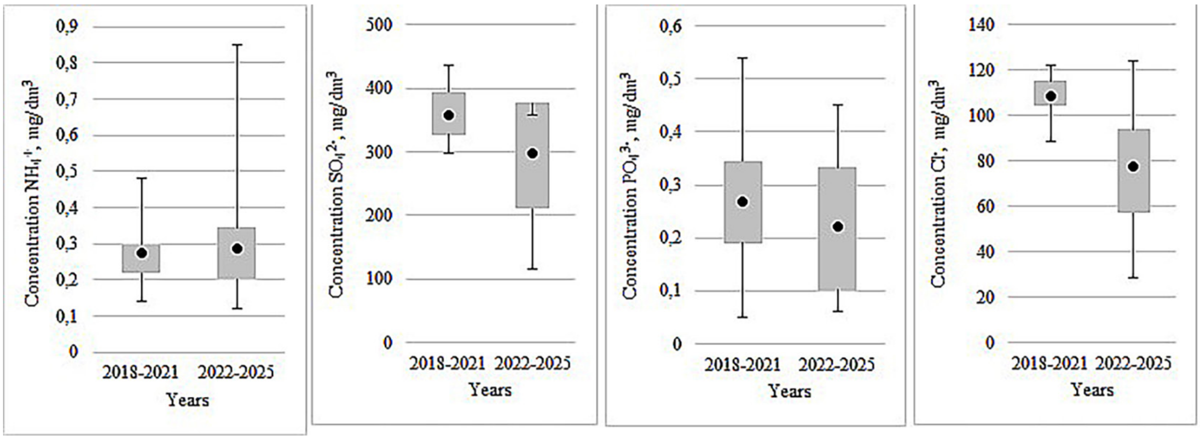

Figure 7. Change in pollutant content. Post 6

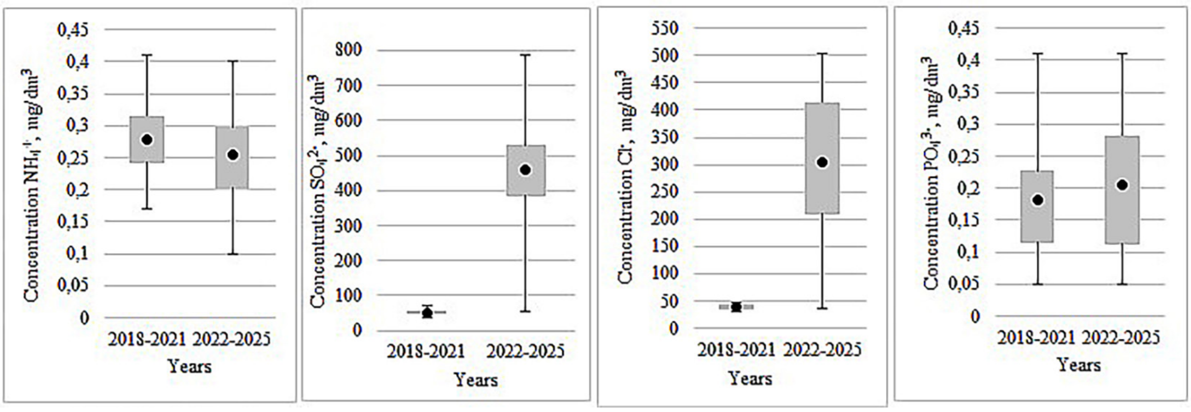

Figure 8. Change in pollutant content. Post 12

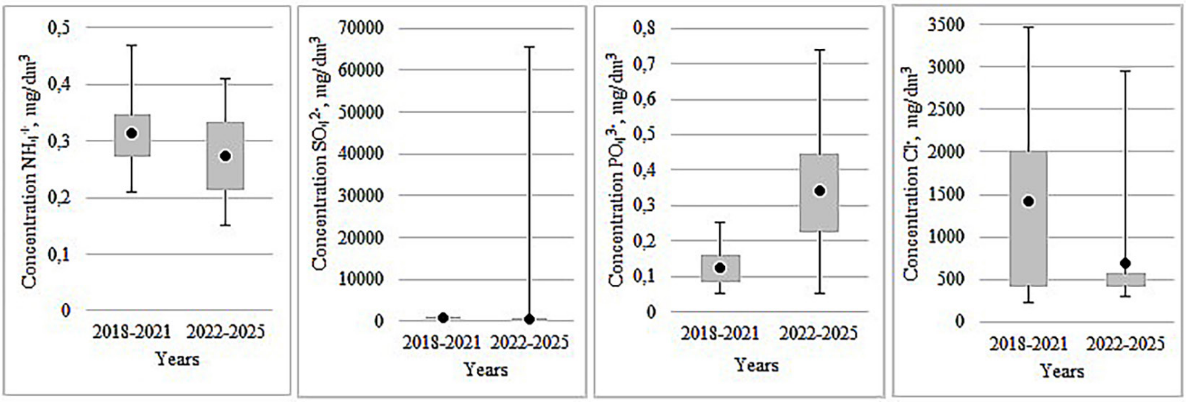

Figure 9. Change in pollutant content. Post 13

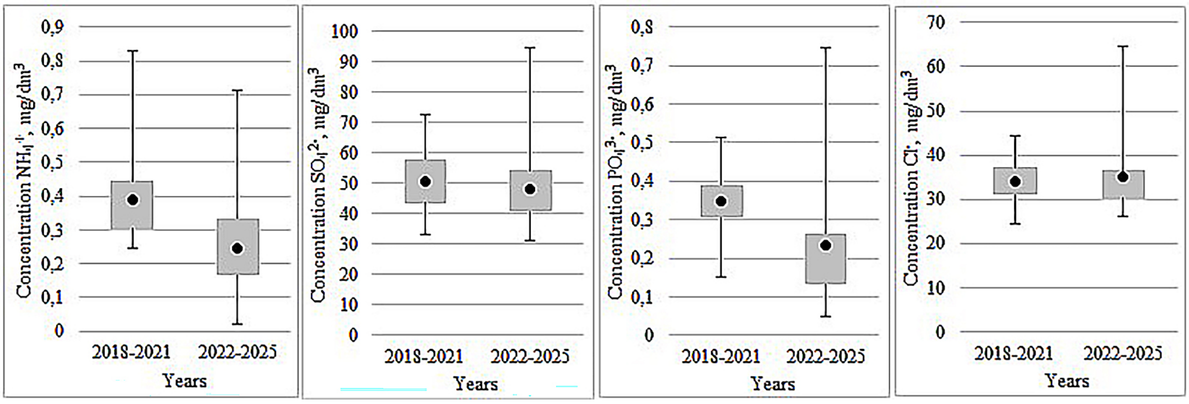

Figure 10. Change in pollutant content. Post 16

than 5%. At station 12, there was a significant increase in the values of SO_4^{2-} (786.7%) and Cl^- (671%), as well as a slight increase in PO_4^{3-} (12.5%). At station 13, a decrease in the content of all pollutants and the range of their values was recorded, except for PO_4^{3-}, which increased by 171.6%. At station 16, a decrease in all pollutants was recorded.

Therefore, reducing wastewater and return water discharge positively impacted the level of river pollution.

To determine the impact of hostilities on the pollutant content in the water, the distance of the observation posts from the line of combat was analyzed (Figure 11). Posts 12 and 13 were within 20–30 km of the combat zone for over six months. Therefore, these posts may be significantly affected by military operations.

The highest values for SO_4^{2-} and Cl^- and their change relative to pre-war values were recorded at post 12 in the water of the Dnipro-Kryvyi Rih Canal, which could have changed the water quality indicators in the Saksahan and Inhulets rivers, respectively. Therefore, it is most likely that Cl^- and SO_4^{2-} entered the canal water after the destruction of the Kakhovka HPP dam and the subsequent large-scale destruction of treatment facilities, other infrastructure, and civilian buildings.

It should be noted that explosions release a number of heavy metals into the air (mercury, lead, copper, iron, and others). Therefore, during the war, simplified water analyses, as proposed by authors (Andrieiev et al., 2022), are inappropriate because they do not reflect the entire ecological situation. During 2025, there were more massive attacks on Ukraine than in previous years, so it is proposed to expand the list of elements for which chemical analyses will be conducted in surface water bodies, especially those used for drinking water supply, to ensure the health safety of the population. It is also proposed that the impact of shell explosions on the level of pollutants in the water, in the event of their entry from the air, be investigated in more detail.

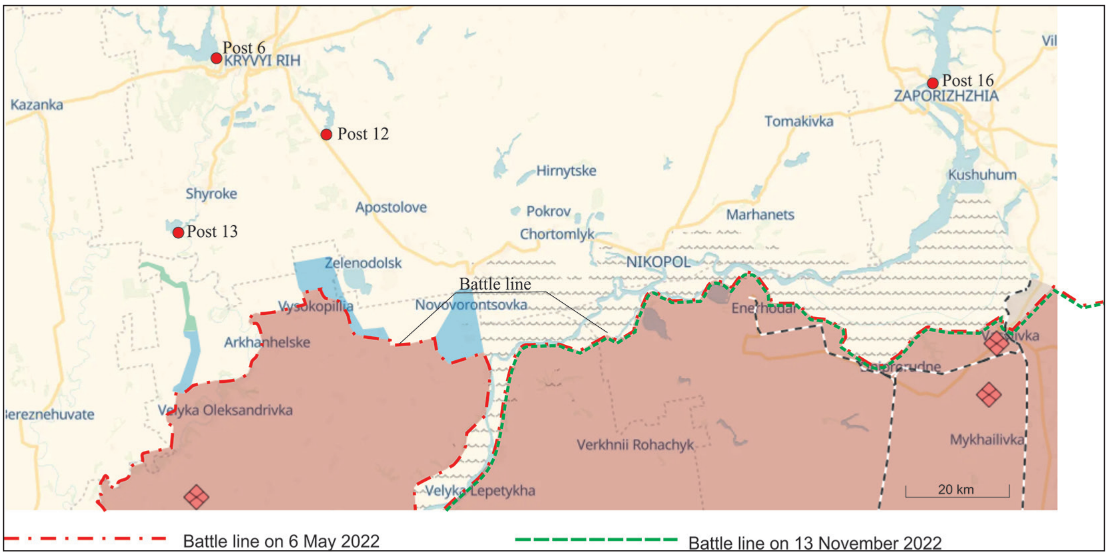

Figure 11. Distance of hostilities from observation posts from May 6, 2022, to November 12, 2022, and from November 13, 2022, to the present (map of the line of contact from https://deepstatemap.live)

CONCLUSIONS

The study was conducted to identify the impact of military actions on the quality of water in rivers used for drinking water supply and for irrigating agricultural land. The data from 23 observation posts for the period 2018–2025 were used for the analysis. The change over time in the content NH_4^+, SO_4^{2-}, PO_4^{3-} and Cl^- (which are the main pollutants in the region) was analyzed for all studied posts, with a distribution based on their location on specific rivers. The dynamics of changes in pollutant content have been established for all objects over the years. An analysis of the dynamics of wastewater and return water discharge from industrial enterprises made it possible to exclude an increase in pollution due to them.

To identify the specific locations where the greatest pollution occurs, water quality was analyzed downstream of the Inhulets and Dnipro rivers. On the Dnipro River, the monitoring data are fragmented, which makes it impossible to identify the pollution sites. On the Inhulets River, it was found that the largest pollutions coincide with areas of active military actions, and in the Dnipro-Kryvyi Rih Canal, which supplies water from the Dnipro River to fill the Southern and Kresivka reservoirs on the Saksahan River.

The T-test revealed an increase in SO_4^{2-}, PO_4^{3-} and Cl^- in the Dnipro-Kryvyi Rih canal water, and an increase in PO_4^{3-} in the Inhulets River. Water pollution in surface water bodies may be associated with shelling and the resulting destruction.

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REFERENCES

1. Alyokhina, T.M. (2021). *Hydrochemical characteristics of surface water bodies of the Kryvyi Rih basin under technogenesis conditions.* In book Study of the ecological condition of post-mining territories in Ukraine on the example of the Kryvyi Rih basin and its surroundings (Dovhiy S.O. ed.) Nika-Center, Kyiv, Ukraine, 31–60. https://itgip.org/wp-content/uploads/2021/12/dosl-postmaining1maket.pdf (in Ukrainian)
2. Andrieiev, V., Hapich, H., Kovalenko, V., Yurchenko, S., Pavlychenko, A. (2022). *Efficiency assessment of water resources management and use by simplified indicators.* Naukovyi Visnyk Natsionalnoho Hirnychoho Universytetu, 5, 148–152. https://doi.org/10.33271/nvngu/2022-5/148
3. Bezsonnyi, V., Plyatsuk, L., Ponomarenko, R., Tretyakov, O. (2022). Assessment of technogenic and ecological safety of a water stream according to risk indicators under the conditions of military danger. *Technogenic and Ecological Safety, 12*, 72–79. https://doi.org/10.52363/2522-1892.2022.2.9
4. Bildirici, M.E., Lousada, S., Yılmaz Genç, S. (2022). Terrorism, freshwater, and environmental pollution: Evidence of Afghanistan, Burkina Faso,

Iraq, Arab Republic of Egypt, Cameroon, Mali, Mozambique, Niger, Nigeria, Somalia, Syrian Arab Republic, and Pakistan. *Water, 14*(17), 2684. https://doi.org/10.3390/w14172684

5. Broomandi, P., Guney, M., Kim, J.R., Karaca, F. (2020). Soil contamination in areas impacted by military activities: A critical review. *Sustainability, 12*(21), 9002. https://doi.org/10.3390/su12219002
6. Bubnova, O.A., Babiy, K.V., Ryumina, D.M., Levchenko, K.S. (2023). Ustification of decisions regarding the water supply to the population in the mining regions in the conditions of local resources insufficiency. *Geo-Technical Mechanics, 167*, 142–152. https://doi.org/10.15407/geotm2023.167.142
7. Conflict and Environment Observatory and Zoï Environment Network (2024). *The environmental consequences of the war against Ukraine.* Preliminary twelve-month assessment (February 2022 – February 2023). Report. https://zoinet.org/product/osce-ukraine-one-year/
8. EPA (2011). *Emerging contaminants – 2,4,6-trinitrotoluene (TNT)*, 1–7. Fact Sheet 505-F-10–0. December 2011. https://clu-in.org/download/techdrct/emerging_contaminant_tnt.pdf
9. FAO Aquastat. *Global Information System on Water and Agriculture,* available at: http://www.fao.org/nr/water/aquastat/data/query/index.html?lang=en.
10. Filho, W.L., Eustachio, J.H.P.P., Fedoruk, M., Lisovska, T. (2024). War in Ukraine: an overview of environmental impacts and consequences for human health. *Front. Sustain. Resour. Manag. Ser. Natural Resources, 3*. https://doi.org/10.3389/fsrma.2024.1423444
11. Hapich, H., Novitskyi, R., Onopriienko, D., Dubov, T. (2024). Water on fire: Losses and the post-war future of ecosystem services from water resources of Ukraine. *Regional Environmental Change, 24*, 154. https://doi.org/10.1007/s10113-024-02320-6
12. Hook, K., Marcantonio, R. (2022). Environmental dimensions of conflict and paralyzed responses: the ongoing case of Ukraine and future implications for urban warfare. *Small Wars & Insurgencies, 34*(8), 1400–1428. https://doi.org/10.1080/09592318.2022.2035098
13. Lyutyi, G.G., Lyuta, N.G., Sanina, I.V. (2021). Assessment of groundwater quality changes in the aquifers of the Dniprovsko-Donetskyi Artesian basin. *Mineral resources of Ukraine, 3*, 20–23 (in Ukrainian).
14. Ministry of Health of Ukraine. (2022). Hygienic standards for water quality of water bodies to meet drinking, household and other needs of the population: Order dated 02.05.2022 No. 721. https://zakon.rada.gov.ua/laws/show/z0524-22/ed20230222#Text (in Ukrainian)
15. National Institute for Strategic Studies. 2020. Information and analytical report on the state of the state's water resources and the features of agricultural production in the context of climate change. http://naas.gov.ua/upload/iblock/78a/Інформаційна%20довідка%204.05.2020-конвертирован.pdf (in Ukrainian)
16. OSCE. (2017). Assessment of environmental damage and priorities for environmental restoration in eastern Ukraine, BAITE, Kyiv, Ukraine.
17. Shaforost, Yu., Pogrebniak, O., Lut, O., Litvin, V., Shevchenko, O. (2024). Chemical military-technogenic load on the soils of military training grounds. *Plant and Soil Science, 15*(2), 67–79. https://doi.org/10.31548/plant2.2024.67
18. Shukla, S., Mbingwa, G., Khanna, S., Dalal, J., Sankhyan, D., Malik, A., Badhwar N. (2023). Environment and health hazards due to military metal pollution: A review. *Environ. Nanotechnol. Monitor. Manag. 20*, 100857. https://doi.org/10.1016/j.enmm.2023.100857
19. Shumilova, O., Tockner, K., Sukhodolov, A., Khilchevskyi, V., Meester, L.D., Stepanenko, S., Trokhymenko, G., Hernandez-Aguero, J.A., Gleik, P. (2023). Impact of the Russia–Ukraine armed conflict on water resources and water infrastructure. *Nat Sustain, 6*, 578–586. https://doi.org/10.1038/s41893-023-01068-x
20. State Agency of Water Resources of Ukraine (2025). Monitoring and ecological assessment of water resources. http://monitoring.davr.gov.ua/Reporting/ViewReports/ViewReport?id=392 (in Ukrainian).
21. Sudakov, A., Pavlychenko, A., Hapich, H., Isakova, M., Shumov, A. (2025). Water supply from groundwater: new solutions for a battered-and-bruised Ukraine. *Water Supply, 25*(3), 617–627. https://doi.org/10.2166/ws.2025.026
22. Tymoshenko, D.O., Kukhar, V.V., Volkova, V.Y., Chub, N.S., Kyrychenko, I.H. (2025). Comparing the environmental performance of steelmaking technologies. *Scientific Journal of Metinvest Polytechnics. Series: Technical Sciences, 3*, 177–183. https://doi.org/10.32782/3041-2080/2025-3-23
23. UNESCO. (2015). Facing the challenges: case studies and indicators, *UNESCO's contributions to the United Nations world water development report*. 2015. http://Unesdoc.unesco.org/images/0023/002321/232179E.pdf
24. Wiretu, Yo.D., Abdela, U. (2025). Impact of war on the environmental: ecocide. Front. Environ. Sci., *Sec. Environmental Policy and Governance, 13*. https://doi.org/10.3389/fenvs.2025.1539520
25. Yatsyk, A.V., Pasheniuk, I.A., Gopchak, I.V., Basiuk, T.O. (2018). Water-ecological problems of rivers of Western Polissia of Ukraine (on an instance of water-collecting area Horyn). *Bulletin of Agricultural Science, 10*, 61–65. https://doi.org/10.31073/agrovisnyk201810-09