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CORRELATION ANALYSIS OF THE INFLUENCE OF CLIMATIC AND BIOLOGICAL FACTORS ON HYDROCHEMICAL INDICATORS OF THE GENERAL ECOLOGICAL CONDITION OF THE TRUBIZH RIVER

The article deals with the issue of correlation analysis of the influence of external factors on the hydrochemical composition of the Trubizh River in the conditions of an urbanised environment within the city of Pereyaslav. The aim of the study is to investigate the correlation between climatic and biological factors in order to identify the key factors determining the variation component of hydrochemical parameters. An integrated approach to the analysis was implemented, which included the use of a number of analytical methods and quantitative analysis. The following methods were used to assess the quality of the surface water of the Trubizh River: Winkler's iodometric titration to quantify the dissolved oxygen content, Kubel's permanganate oxidation to analyse the concentration of organic compounds, Mohr's argentometry to determine the level of chloride ions, complexometric titration to assess the total hardness of the water, acid-base titration to analyse the temporary hardness and total acidity, and a qualitative method to determine the concentration of iron. These methods provided comprehensive information on the chemical composition and water quality of the Trubizh River. The analysis of the surface water of the Trubizh River has provided new scientific results that significantly expand the existing knowledge in the field of environmental monitoring of water resources, providing up-to-date data on changes in the chemical composition of the water, which requires measures to optimise the impact of agricultural practices and industrial emissions on the watercourse. It has been found that an increase in the concentration of elements stimulates the active development of phytoplankton, leading to a decrease in the oxygen regime and a deterioration in the conditions for most aquatic organisms. The phenomenon of local "blooming" of the water was recorded, which is an indicator of massive development of phytoplankton on the surface of the reservoir. It was confirmed that the quality of the surface water of the Trubizh River is subject to significant biotic and abiotic factors.

Key words: *hydrochemistry, ecology, environmental monitoring, biotic factors, abiotic factors, surface waters.*

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КОРЕЛЯЦІЙНИЙ АНАЛІЗ ВПЛИВУ КЛІМАТИЧНИХ І БІОЛОГІЧНИХ ЧИННИКІВ НА ГІДРОХІМІЧНІ ПОКАЗНИКИ ЗАГАЛЬНОГО ЕКОЛОГІЧНОГО СТАНУ РІЧКИ ТРУБІЖ

У статті розглядається питання кореляційного аналізу впливу зовнішніх чинників на гідрохімічний склад річки Трубіж, в умовах урбанізованого середовища, в межах міста Переяслав. Метою роботи є дослідження кореляційної залежності між кліматичними та біологічними чинниками, виявлення ключових факторів, що визначають варіаційну складову гідрохімічних показників. Реалізовано комплексний підхід до аналізу, що передбачав застосування низки аналітичних методів, кількісного аналізу. Для оцінки якості поверхневих вод річки Трубіж було використано: йодометричне титрування за Вінклером для кількісного визначення вмісту розчиненого кисню, перманганатна окиснюваність за Кубелем для аналізу концентрацій органічних сполук, аргентометрія за методом Мора для визначення рівня хлорид-іонів, комплексонометричне титрування для оцінки загальної твердості води, кислотно-основне титрування для аналізу тимчасової твердості та загальної кислотності, а також якісний метод для встановлення концентрації заліза. Використання цих методів забезпечило отримання всебічної інформації про хімічний склад і якість води річки Трубіж. У ході проведення аналізу поверхневих вод річки Трубіж отримано нові наукові результати, які суттєво розширюють існуючі знання в галузі екологічного моніторингу водних ресурсів, що дозволило отримати актуальні дані про зміни в хімічному складі води, що зумовлює необхідність вжиття заходів для оптимізації впливу сільськогосподарських практик та промислових викидів на водотік. Встановлено, що підвищення концентрації елементів стимулює активний розвиток фітопланктону, що зумовлює зменшення кисневого режиму та погіршення умов для більшості водних організмів. Зафіксовано явище локалізованого «цвітіння» води, що є індикатором масового розвитку фітопланктону на поверхні водойми. Підтверджено, що якість поверхневих вод річки Трубіж піддається значним біотичним та абіотичним чинникам.
Ключові слова: *гідрохімія, екологія, моніторинг довкілля, біотичні чинники, абіотичні чинники, поверхневі води.*

Relevance. The study of the quality of surface water is one of the key tasks of environmental monitoring in the context of modern anthropogenic pressure. An integrated approach allows us to identify patterns in water quality and assess the impact of biological productivity and climate change on the parameters under study.

Analysis of Recent Research and Publications. An analysis of scientific research in the field of water quality, particularly surface water, shows that researchers are increasingly paying attention to the impact of anthropogenic factors on river ecosystems. In the project "*Assessment of Water Quality in Urban Rivers*" (Msabi N. Masunga, 2018), the author conducted a comprehensive assessment of the quality of surface water in urban rivers, using various physical, chemical, and biological parameters for analysis and comparing the results with established water quality standards. In the article "*Chemical Pollution Imposes Limitations to the Ecological Status of European Surface Waters*" (Posthuma, Zijp, De Zwart, et al., 2020), the authors address the problem of chemical pollution of surface waters within an integrated approach, focusing on the need to develop rules for the prevention, assessment, and management of water quality.

The purpose of this work is to study the correlation between climatic, geochemical, and biological factors and to identify the key factors that determine the variation component of hydrochemical parameters.

The ecological status of Ukraine's small rivers depends not only on the internal processes occurring within the water bodies but also on the total catchment area. These rivers are key and sensitive components of river systems, included in the overall hydrological cycle, and serve as a source of fresh water for various ecosystems and human needs (Zahorodniuk, 2005).

The general characterization of the water body was formed based on an integral analysis aimed at assessing anthropogenic factors affecting the ecological state of water systems. This analysis includes the determination of hydrological, geological, hydrobiological, and hydrochemical indicators within the studied coastline (Khimko, Merezhko, Babko, 2003).

A hydromelioration system with a total area of 33,400 hectares was constructed in the river floodplain. From an environmental perspective, this two-way system is capable of altering the natural hydrological regime and influencing the processes of self-purification and biochemical composition. The upper reaches of the main canal are humidified by transferring water from the Desna River, facilitated by the presence of numerous hydraulic structures (1,125, including 827 control gates).

According to morphometric and hydrological indicators, the total length of the river is 113 km, the drainage area is 4,700 km^2, and the floodplain is 500–600 m wide and reclaimed. The river width is 3.5 km, and the depth is 10 m. The riverbed is slightly sinuous, canalized, and regulated downstream, except for the estuarine areas. Its average width is 15 m, with a slope of 0.25 m/km (Kovalchuk, 1997).

The overall forest cover of the Trubizh River basin is 9.7 %, demonstrating a reduced probability of floods within the water body. The share of plowed land and agricultural activity is 14% and 55.6 %, respectively, indicating significant anthropogenic impact on the basin and forming a potential cause of eutrophication observed at the site, particularly due to the use of agrochemicals and intensive farming methods. Within the water body, the conservation of natural landscapes remains high, fluctuating at 79.9 %, indicating favorable conditions for maintaining biodiversity (Kovalchuk, 1997).

Taking into account the specifics of the study, attention is focused on the indicator of river flow utilization as a means of determining potential abiotic factors of influence. The actual use of river runoff is very high and ranges from 66 %, reflecting the total volume of water withdrawn from the river for various needs. Based on the actual use, we derive the criterion of irreversible water consumption, which is 56.8 % and is very high. The amount of water discharged into the river network with residual impurities as a product of various human activities is 1.7 % (Kravchenko, 2015).

According to the macrophyte indicators common within the studied shoreline, the trophic status of the reservoir is meso-eutrophic. This type of reservoir is characterized by high biological activity and rapid reproduction of aquatic vegetation, which can further accelerate eutrophication.

Based on the identified species diversity of air-water plants, including *Carex riparia, Sagittaria sagittifolia, Typha latifolia*, and *Phragmites australis*, it can be concluded that the reservoir is swampy and partially shallow (Kotsur, Dzhuran, Fedoronchuk, Shevera, 2010).

In the context of hydrochemical monitoring of surface waters conducted in the winter-autumn period of 2024, indicators were obtained that made it possible to assess the risks of eutrophication of the reservoir.

The phenomenon of eutrophication is based on the enrichment of a water body with nutrients, resulting in a rapid increase in the primary production of organic matter due to photosynthesis of algae and macrophytes. There is a direct correlation between the ability of algae to accumulate nutrients and the potential for massive development. Additional accumulation of these elements in the water column can increase as a result of autochthonous and allochthonous processes. The comprehensive study focuses on allochthonous sources of anthropogenic eutrophication by urban type (Romanenko, 2001).

The maximum value of dissolved O_2 is reached in the first quarter of 2024 at the research site № 3, which is due to the lower temperature regime and minimal biological activity of hydrobionts. The measured values at sites № 1 and № 2 indicate a significant level of water saturation. The activation of biological processes and the increase in

Table 1

Ecological and physiological classification by Hams

Type		**Latin species name**
Free-floating unrooted	Neuston species	Lemna minor
Rooted plants	Elodeids	Elodea canadensis
		Potamogeton lucens
	Valisneriidae	Sagittaria sagittifolia
	Nymphaeids	Nuphar lutea
	Lineidae	Phragmites australis
		Typha angustifolia
		Carex riparia

Table 2

Chemical composition of surface waters of the Trubizh River

Indicator	Units of measurement	I quarter 2024 p.	II quarter 2024 p.	III quarter 2024 p.	IV quarter 2024 p.	I quarter 2024 p.	II quarter 2024 p.	III quarter 2024 p.	IV quarter 2024 p.	I quarter 2024 p.	II quarter 2024 p.	III quarter 2024 p.	IV quarter 2024 p.
		Experimental site № 1				Experimental site № 2				Experimental site № 3			
Concentration of dissolved O_2	mg/dm^3	8,2	7,5	5,4	5,05	8,8	8,9	7,5	6,9	11,1	9,25	8,05	7,5
Seasonal saturation of water with O_2	%	70	70	60	60	70	70	70	70	80	70	80	70
Permanganate oxidizability	O_2/dm^3	9,9	9,12	10,1	8,9	8,25	9,2	8,55	8,4	6,5	8,2	6,21	5
Chloride ions	mg/dm^3	63,5	67,3	72,2	62,7	43,1	68,1	50,3	60,2	32,1	36,0	46,1	33,8
Total hardness	mmol/dm^3	2,8	2,05	3	2,6	2,6	1,04	2,4	1,91	1,4	2,05	1,52	1,53
Temporary hardness	mmol/dm^3	2,2	1,9	0,8	1,2	1,26	0,75	0,63	0,8	0,84	0,8	0,71	0,6
Ca^{2+} and Mg^{2+} content	mmol/dm^3	0,6	0,15	2,2	1,4	1,34	0,29	1,77	1,4	0,56	1,25	0,81	0,93
Total acidity	mmol/dm^3	6,3	6,6	4,2	3,7	4,1	5,3	3,2	2,2	3,5	2,8	3,01	2,6
Total iron	mg/dm^3	0,1	0,1	0,25	0,25	0,05	0,1	0,25	0,25	0,05	0,05	0,1	0,1

temperature in spring lead to a decrease in oxygen concentration at all sites of the water body. The highest level is maintained at the research site № 3.

For more specific indicators of the dynamics of surface water aeration, we determined the percentage of O_2 saturation in each quarter, which allowed us to determine the cyclicity of this parameter and its dependence on the ambient temperature.

Based on the data obtained, it was found that in the first and second quarters of 2024, a stable level of oxygen saturation was established at 70 %, which is classified as moderately polluted water. This indicator suggests an insufficient level of oxygen in winter and spring. A reduction in saturation to 60 % contributes to the intensification of biological processes during the warmer periods of the year, leading to a transition from moderately polluted to polluted water quality. Throughout the entire period, experimental site № 2 maintains a stable 70 % indicator, regardless of seasonal changes, indicating constant moderate water pollution. Seasonal fluctuations between 70 % and 80 % are observed at site № 3, ranging from moderately clean to clean, which is typical for the warmer periods of the year.

The analysis of permanganate oxidation indicators at the three experimental sites obtained in 2024 demonstrates seasonal variations associated with changes in the content of organic matter in the water. The highest values of organic matter concentration at site № 1 (from 8.9 to 10.1 mg O_2/dm^3) indicate more intense organic pollution compared to other sites, especially in the summer and autumn. Site № 2 shows more stable values (8.25–9.2 mg O_2/dm^3), with peak values in the spring, which may indicate active biological processes during this time. Site № 3 has the lowest values (6.21–8.2 mg O_2/dm^3), indicating relatively clean conditions with a noticeable decrease in organic load during the summer.

The variation in the concentration of indicators and seasonal factors suggests local sources of pollution. Among the seasonal factors, changes in the temperature regime were taken into account. A general analysis of the indicator shows that at Site 1, the concentration of chloride ions varies from 63.57 mg/dm^3 to 72.2 mg/dm^3, which is the highest among the other sites. The fluctuations in concentrations from 68.06 mg/dm^3 to 60.26 mg/dm^3 at Site № 2 can be attributed to wastewater discharge and the washing of highway products into the water column during winter and spring. The lowest concentrations of chloride ions were found at Site № 3 (control), with a minimum value in the first quarter (32.12 mg/dm^3) and a slight increase throughout the year.

Monitoring of the total acidity indicator, as a component of a comprehensive assessment, is based on key acid hydrochemical parameters that characterize the buffering capacity of surface waters to withstand changes in pH under the influence of various environmental factors. The total acidity of water determined in 2024 demonstrates significant fluctuations depending on the study site and season.

The concentration of total iron was determined by qualitative analysis according to the generally accepted methodology, with the indicator at all sites fluctuating within the normal range, up to 0.3 mg/dm^3.

The accumulation of iron in the water samples of site № 1 indicates an increased impact of biotic and abiotic factors on the aquatic environment. The value varied from 0.1 mg/dm^3 in the first and second quarters to 0.25 mg/dm^3 in the third and fourth quarters. At the experimental site № 2, we observe an increase in the indicator from 0.05 mg/dm^3 to 0.25 mg/dm^3.

This upward trend clearly demonstrates the impact of local pollution sources, which are active during the warm season. Stable conditions are observed at experimental site № 3, where the indicator does not exceed 0.1 mg/dm^3.

The zone of ecological impact from allochthonous sources of anthropogenic eutrophication of the urban type extends to a distance of 1,000 meters from the wastewater discharge site. This zone is characterized by changes in hydrochemical parameters and intensified eutrophication processes, which threaten the biodiversity of the aquatic environment.

A study of the ionic composition of the Trubizh River surface water conducted in the winter and autumn of 2024 revealed a correlation between seasonal changes in hydrochemical parameters and the level of anthropogenic impact. There are significant variations in the concentration of oxygen, chloride ions, organic compounds, and total acidity, indicating the influence of local sources of pollution, particularly agricultural activities and wastewater. Experimental site No. 3 demonstrates the most stable indicators due to limited anthropogenic impact.

The most intense eutrophication and accumulation of organic matter are observed at site No. 1, due to the high level of nutrient discharge.

Further research will contribute to improving the overall ecological condition of the river section located within the city of Pereyaslav. It is recommended to introduce comprehensive monitoring, optimize wastewater treatment systems, raise environmental awareness among the population, use modern technologies for monitoring, and draw the attention of international organizations to the problem of preserving the water body.

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