CLIMATE CHANGE & SUSTAINABLE DEVELOPMENT: NEW CHALLENGES OF THE CENTURY

MONOGRAPH

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Mykolaiv – Rzeszow 2021

Petro Mohyla Black Sea National University, Ukraine
Rzeszow University of Technology, Poland

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edited by
Olena Mitryasova
Piotr Koszelnik

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The monograph is devoted to problems strategy of sustainable development as a road map of civilization; sustainable development of territories; sustainable use and protection of flora and fauna; environmental biochemistry, physiology and medicine; food technology in the context of sustainable development; monitoring of the atmosphere, hydrosphere and climate management; circular economy; rational use of water resources and wastewater treatment; rational use of land resources and reclamation of disturbed lands; environmental education for sustainable development..
The book is written for scientists, lecturers, postgraduate students, engineers and students who specialize in the field of environmental researches.

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Dedicated to the 25th anniversary of
the Petro Mohyla Black Sea National University

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FOREWORD

Quality of life and sustainable development of society depends on the ability to join forces. Today the sustainable development concept is one of the main documents of development of the world and European countries, in particular the Visegrad countries. Among the great priorities of the movement of Ukraine to Europe, there are directives and regulations concerning sustainable development goals, namely the issue of climate change. Environmental management and climate change issues, environmental security and quality of natural resources, monitoring remain important, and the issue of adapting the national strategy for the future country's development to European policies is extremely relevant.

The problem is that in order to stop the worsening weather conditions by 2050, the increase in global temperature must be limited to about 1.5°C, in line with preindustrial levels. However, the world has already warmed to 1.2°C, thanks to the greenhouse gases that are released into the atmosphere, and the prospects for limiting further temperature increases over the next 30 years look distant. In fact, estimates based on current country pledges to cut emissions suggest that temperatures are likely to rise more than 2°C above pre-industrial levels by mid-century. In such a future, most of the planet is likely to suffer from drought; rainforests are at risk of extinction, and melting ice sheets will cause dangerous sea levels to rise and cause major changes in the behavior of ocean currents such as the Gulf Stream.

Environmental policy is a priority area of cooperation between Ukraine and the Visegrad. The innovative element is that Visegrad–Ukraine partners join efforts of academic and civil societies in the environmental field. Integration in the field may be achieved through the creation of a harmonized legal, regulatory, methodological, and organizational base that should meet the requirements of European and national environmental security. Actual new challenges are in implementing new Visegrad–Ukraine different methodologies into national practices aimed at goals of improving sustainable development. It is extremely important to improve the understanding of the content of European environmental activities in Ukraine. Professionals are gathered to exchange practices and experiences in the field of climate change and sustainable development. The attractive and close collaboration of the partners provides discussion and reflection on Visegrad–Ukraine research partnership and study experience with regard to environmental management, eco-innovations. The content of the monograph has a strong impact on all students, young researchers, and also officials, and publicity through getting knowledge about actual environmental policy in the field of climate change and sustainable development in the EU.

The main thematic topics of the monograph:

- ✓ Strategy of sustainable development as a road map of civilization;
- ✓ Sustainable development of territories;
- ✓ Sustainable use and protection of flora & fauna;
- ✓ Environmental biochemistry, physiology and medicine;
- ✓ Food technology in the context of sustainable development;
- ✓ Monitoring of the atmosphere, hydrosphere and climate management;
- ✓ Circular economy;
- ✓ Rational use of water resources and wastewater treatment;
- ✓ Rational use of land resources and reclamation of disturbed lands;
- ✓ Environmental education for sustainable development.

The book is co-financed by the Governments of Czechia, Hungary, Poland and Slovakia though Visegrad Grant from Inretnational Visegrad Fund. The mission of the fund is to advance ideas for sustainable regional cooperation in Central Europe.

There are chapters of scientists from Visegrad countries and Ukraine on the book's pages. There is especially the wide geography of Ukrainian scientists on the pages of the monograph.

The monograph is the result of the scientific achievements of scientists, leading specialists from universities and organizations:

We express our sincere thanks to all the authors, esteemed colleagues, who in a short time presented the own, original, interesting researches on the problems of climate change and sustainable development, contributing to this book was published.

In the future we hope that the scientific works are on the pages of this edition will find creative affiliate cooperation through successful joint implementation of actual ideas, proposals, scientific and practical developments.

We would like to thank the International Visegrad Fund for supporting the publication of the book within the Grant #22110149.

Prof. Olena Mitryasova & Prof. Piotr Koszelnik

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STUDY OF CHANGES IN THE ECOLOGICAL CONDITION OF THE PSEL RIVER

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ABSTRACT

The article analyzes the changes in the ecological status of the water of the Psel river and identifies possible causes of its pollution. The change in the ecological status of the surface water body was carried out by analyzing the data of monitoring and ecological assessment of water resources of Ukraine of the State Agency of Water Resources of Ukraine for the period 2010-2020. The change in the content of the main normative indicators that determine the ecological status of the surface water body is analyzed: polyphosphates, chlorides, nitrates and nitrites, ammonium and sulfates. The analysis was carried out according to the control of water intake from 6 posts along the entire length of the watercourse of the river Psel in Ukraine. As a result of the analysis, it was found that further change in the ecological status of the surface water body in the direction of its improvement requires the development and implementation of a reliable and effective model for forecasting its ecological status. In the future, the results of the study can be used in the development and implementation of a reliable and effective model for forecasting the ecological status of surface water bodies, including the river Psel.

Keywords: surface water bodies, pollutants, water intake posts, concentration of normative indicators, Psel river

INTRODUCTION

Ukraine is one of the countries with insufficient water resources. Water natural resources of Ukraine are, first of all, local and transit runoff of rivers, water reserves of lakes, artificial reservoirs and underground horizons.

Due to the constant development of industry, pollutants are released into the atmosphere, into surface water bodies and the disposal of hazardous waste. Thus, the objects of the natural environment are continuously polluted. Mankind makes a lot of efforts to regulate emissions into the environment: install treatment plants, dispose of waste, introduce new processes in the enterprise, which are environmentally friendly, etc. [1, 4]

Water resources are an important component of human life. Every year, the man-made load is constantly growing and issues related to water quality are becoming increasingly important. Continuous human activity constantly leads to deterioration of water quality and ecological regime of river runoff. Man-made activities can lead to regional and global environmental changes. Changes in the quality of water with a tendency to constant deterioration are observed in almost all surface sources of water supply in the country. Today, quite acute and vital

environmental problems associated with the hydrosphere of the planet are the conditions for providing the population with quality drinking water and the ability to improve its quality, including by improving the ecological status of surface water bodies.

The problem of assessing water quality at the present stage of development of society is important and of paramount importance and occupies a central place in water protection activities [2]. The ecological problem of hydrosphere protection at the economic and technogenic level has a significant impact on the ecological state of surface water bodies, which requires monitoring studies using modern interactive online cartographic resources.

To obtain a holistic picture of the current environmental situation, large enough administrative-territorial units of the industrialized countries of the world, in particular Ukraine, even with the gradual reduction of industrial potential, use environmental monitoring. The main component of such monitoring is the process of obtaining the necessary initial data (for example, the results of analysis of surface water samples).

In Ukraine, the main thing is the monitoring of surface water bodies within the river basin. Following the approval in 2018 by the Cabinet of Ministers of Ukraine of the Procedure for State Water Monitoring, surface water monitoring is carried out to ensure the collection, processing, storage, synthesis and analysis of information on the status of surface water bodies, forecasting its changes and developing scientifically sound recommendations for decision-making in the field of use, protection of water and reproduction of water resources.

Objects of state water monitoring are: massifs of surface waters (surface water bodies or their parts), including coastal waters and zones (territories), which are subject to protection; massifs of groundwater (groundwater bodies or parts thereof), including areas (territories) that are subject to protection; sea waters within the territorial sea and the exclusive maritime economic zone of Ukraine, including zones (territories) subject to protection.

State monitoring of waters is carried out by the Ministry of Environmental Protection and Natural Resources of Ukraine, the State Agency of Water Resources of Ukraine, the State Service of Geology and Subsoil of Ukraine, the State Emergency Service, and the State Agency of Ukraine for Exclusion Zone Management (in the exclusion zone and the zone of unconditional (compulsory) resettlement of the territory that was exposed to radioactive contamination as a result of the Chornobyl catastrophe).

According to the Procedure [1], state water monitoring is divided into several types: diagnostic monitoring, operational monitoring, research monitoring and seawater monitoring.

Diagnostic monitoring is performed to assess the impact of man-made loads on surface and groundwater bodies. For surface water bodies, diagnostic monitoring is carried out only in the first year of state monitoring, and for groundwater - the first two years.

Operational monitoring is carried out annually to assess changes in the ecological and chemical status of surface water bodies and in the quantitative status and chemical composition of groundwater. They also study the trends of increasing concentrations of pollutants in water bodies, which are caused, inter alia, by man-made impacts on the environment.

Research monitoring is carried out only for surface water bodies in order to establish the reasons that lead to the impossibility of achieving environmental standards for these objects. In order to conduct research monitoring, the subjects of state monitoring independently determine the sampling points for its conduct.

Seawater monitoring is carried out for the territorial sea and the exclusive maritime economic zone of Ukraine. The purpose of this monitoring is to study the ecological status of seawater and assess the impact of natural and anthropogenic factors on the status of seawater.

Subjects of monitoring conduct monitoring on certain indicators and enter the obtained data into the relevant documents with further analysis, summarizing and indicating recommendations, if necessary.

METHODS AND EXPERIMENTAL PROCEDURES

In Ukraine, almost 80% of the population is supplied with drinking water from surface water bodies. Within Ukraine, the Psel river flows through the territory of Sumy and Poltava regions. The river Psel is part of the Dnieper river basin (it is its left tributary). The length of the Psel river, which flows through the territory of Ukraine is 502 km, and in total – 717 km. The catchment area of the Psel river in Ukraine is 16.27 thousand km^2. The sources are located in the Russian Federation, within the Belgorod region. About 10 small reservoirs have been created on the Psel river. Most of them are located at HPPs (Nizivska, Malovorozhbyanska, Mykhailivska, Bobrivska, Shyshatska, Ostap'evska, Sukhorabivska). The right tributaries of the Psel river are Oleshnya, Sumka, Vorozhba, Mezhyrichka, Grun, Vuzka, Vovnyanka, Balakliyka, Khorol, and the left - Udava, Syrovatka, Vilshanka, Budylka, Borovenka, Vepryk, Bobryk, Lyutenka.

In the water of the main waterway of the country - the Dnieper river, environmentalists have identified more than 160 pollutants, namely: acids, alkalis, mineral salts, petroleum products and pesticides and others. It is known that pollutants have been found in the river, to which water treatment systems are not adapted.

The main problems of surface water bodies today are:

– large littering of shores;

– construction of coastal protection strips;

– deterioration of hydraulic structures, which threatens accidents and pollution of water bodies; excessive overgrowing of water area with aquatic vegetation;

– drainage of rain sewerage practically without cleaning;

– discharge of untreated municipal wastewater from apartments that are not connected to the centralized sewerage system;

– weakening of state control over environmental offenses;

– inefficient water monitoring system;

– imperfection of the existing system of public administration in the field of use, protection and restoration of water resources, lack of clear delineation of functions;

– non-full use of domestic scientific innovations in the field of biochemistry.

The main sources of man-made load on surface water bodies in Ukraine are:

– industrial wastewater;

– outdated systems, drainage and wastewater treatment;

– domestic wastewater, which is dominated by feces, surfactants, fats, microorganisms, including pathogenic;

– precipitation, which contains chemicals of air of industrial origin;

– precipitation and meltwater from agricultural lands with residues of mineral fertilizers and plant protection products, organic matter;

– sewage from city streets - they contain petroleum products, phenols, oxides of heavy metals;

– Lack in some regions of Ukraine of the basin principle of management, control and responsibility for the state of surface sources of drinking water supply [6].

In wastewater containing large amounts of organic matter, blue-green and brown algae, phytoplankton multiply rapidly, and biological oxygen consumption increases. As a result, anaerobic processes that determine eutrophication (increase of biological productivity during the accumulation of nutrients under the influence of anthropogenic or natural factors) begin to predominate in the reservoir.

Analysis of changes in the ecological status of surface water bodies is carried out on the basis of comparative analysis of their hydrophysical, hydrochemical, hydrobiological, bacteriological, toxicological and other indicators that reflect the characteristics of abiotic and biotic components of aquatic ecosystems.

Standardized indicators, which are most often used to determine the quality of surface water bodies, are divided into:

1) oxygen - includes dissolved oxygen in water, biochemical oxygen demand, chemical oxygen demand;

2) toxicological - combines ammonium nitrogen, nitrites and heavy metals;

3) sanitary-toxicological - determines the content of nitrates, heavy metals and mineralization with all its components;

4) fishery - combines petroleum products, phenols and pesticides.

Assessment of the quality of surface water bodies is necessary in cases where it is necessary to trace the trend of spatio-temporal changes in water status under the influence of natural and man-made processes.

The State Agency of Water Resources has launched an interactive map «Monitoring and environmental assessment of water resources of Ukraine» [3]. On the map it is possible to track the data of monitoring of surface water bodies for a certain period of time on indicators such as: nitrates, nitrites, phosphates, ammonium ions, sulfates.

Based on the monitoring data of the State Agency of Water Resources, an analysis of changes in the ecological status was carried out, according to the main indicators of the Psel river for 2010-2020.

The analysis was carried out on the basis of data from 6 water sampling posts in the Psel river (Figure 1): 1) Psel river, 528 km, Krasnopil district, administrative road of the city; 2) Psel river, 480 km, the village of Velyka Chernetchyna, the administrative road of the city above the technical water intake of Sumy; 3) Psel river, 444 km, Chervone village, below Sumy, administrative road of the city; 4) Psel river, 405 km, Bishkin village, administrative road of the city; 5) Psel river, 350 km, Kaminne village, administrative road of the city, border of Sumy and Poltava regions; 6) Psel river, 172 km, Velyka Bagachka urban-type settlement, technical water intake of the settlement [3, 5].

THE RESEARCH RESULTS AND DISCUSSIONS

To date, the assessment of qualitative changes in surface water bodies is performed by comparing the chemical composition of water at sampling points upstream and downstream. The reliability of the obtained results should be carried out taking into account the error of determination and averaging of concentrations of substances, due to the expediency of taking into account the condition of seasonal recurrence of the chemical composition of water in the annual cycle each year. In this regard, a comparative analysis was conducted on an average annual basis [7].

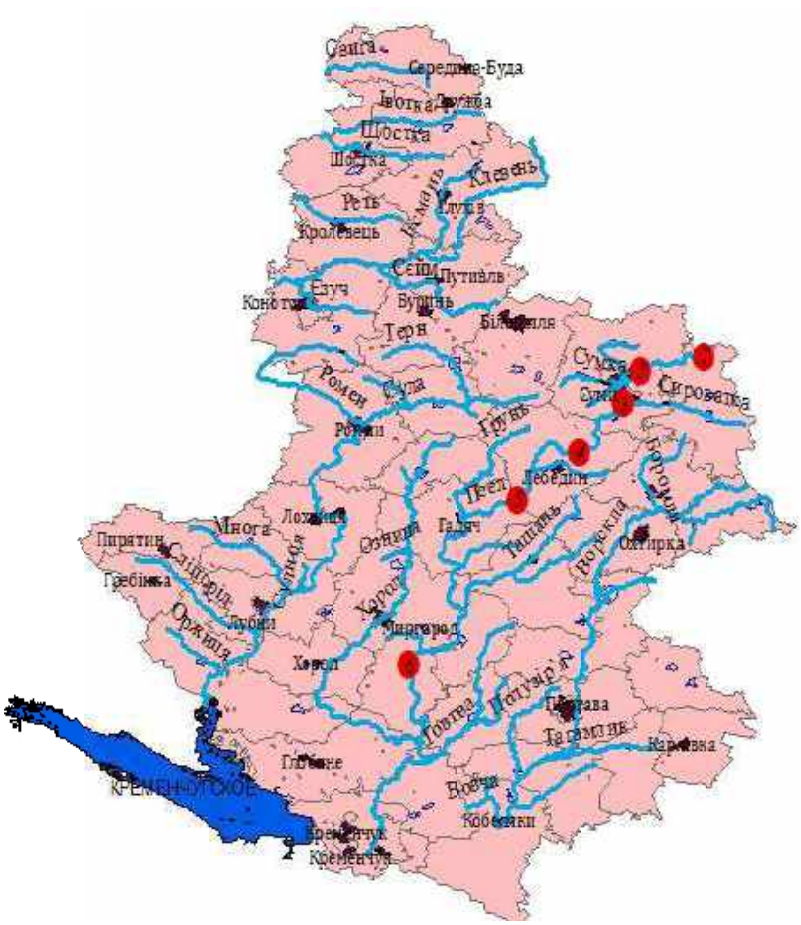

Fig. 1. Schematic placement of the existing 6 checkpoints of water intake, according to which the study was conducted (names are given in the original language)

Nitrogen and its compounds get into surface water bodies with domestic and industrial effluents from waste of livestock complexes and farms, mineral fertilizers. The increased content of ammonium indicates the deterioration of the sanitary condition of the water. The increase in concentration is due to the inflow into domestic waters of domestic wastewater, nitrogen and organic fertilizers. The content of ammonium in high concentrations in drinking water has a negative effect on the human body. Blood pressure may rise, there are various disorders of the liver and kidneys. The main source of nitrates and nitrites in the environment is nitrogen fertilizers. The source of nitrogen in natural waters is decomposed protein residues.

The content of chloride ions in surface water bodies is due to its widespread use in public utilities, such as water disinfection and the destruction of bacteria. Lack of chlorine in the human body leads to general weakness, decreased blood pressure, loss of appetite, etc. When chlorine is added to water, trihalomethane compounds can be formed. Getting into the human body cause asthma, skin diseases, diseases of the cardiovascular system, disorders of the gastrointestinal tract. Also, these compounds are carcinogenic, provoking the development of cancer.

Phosphorus is a necessary chemical element necessary for living organisms. When it hits surface water, it causes algae, especially blue-green ones, to grow rapidly, disrupting the natural biosystem. Phosphates have a negative effect on human health. If there is a large amount of water used for bathing and washing dishes, dermatitis and irritation may occur.

The content of nitrates and nitrites is an indicator of the chemical composition of natural water used in environmental assessment. This information is also needed when deciding on the balance of nutrients, the relationship between the life processes of aquatic organisms and the chemical composition of water. Nitrates enter water bodies during the decomposition of animal and plant proteins by microorganisms, when ammonium compounds are released, which are oxidized to nitrites and nitrates upon contact with air. The consequence of nitrate consumption is the formation of methemoglobin. The transport of oxygen to human tissues is disturbed, in the future there is a violation of the nervous system. Excess nitrate content also leads to disorders of the pancreas and thyroid glands, cancer, heart failure, kidney disease, cardiovascular disease.

The content of sulfates in natural waters varies widely and is due to the leaching of salt-containing rocks or discharge into reservoirs of industrial and domestic wastewater. The main source of sulfates in surface waters are the processes of chemical weathering and dissolution of sulfur-containing minerals, mainly gypsum, as well as oxidation of sulfides and sulfur. Significant amounts of sulfates enter the reservoirs in the process of extinction of organisms, oxidation of terrestrial and aquatic substances of plant and animal origin and with underground runoff.

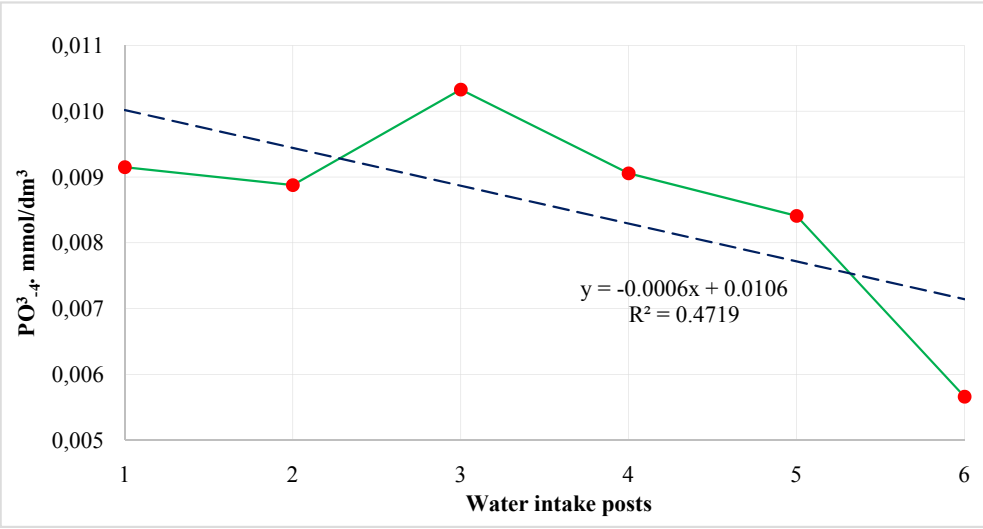

Fig. 2. Average annual concentrations of phosphate ions (polyphosphates) at the posts of water intakes of the river Psel for the period from 2010 to 2020

After analyzing Figure 2, we can conclude that in the river Psel there is a decrease in the total phosphate content from post 1 to post 6. Regression equation of the detected dependence: $y = -0.0006x + 0.0106$ reliability of approximation $R^2 = 0.471$.

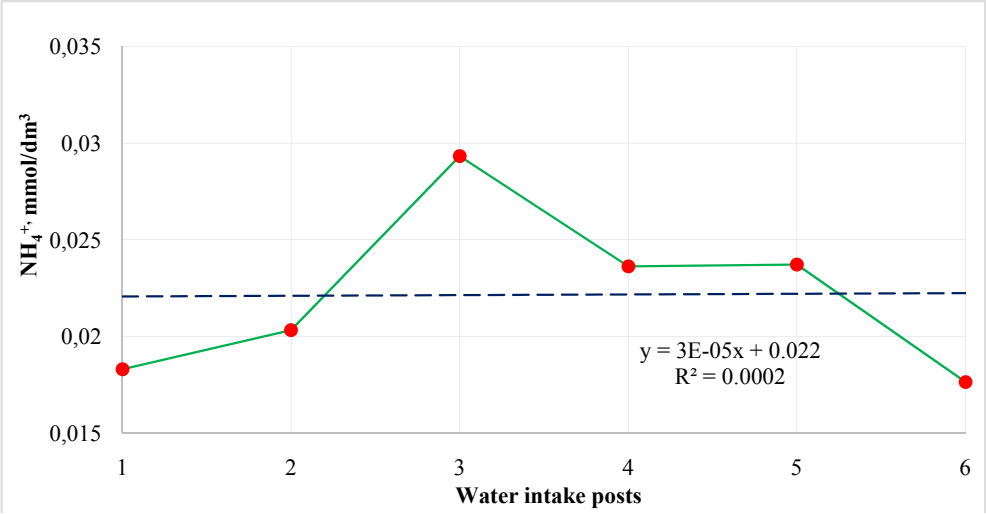

Fig. 3. Average annual concentrations of ammonium ions at water intake posts of the Psel river for the period from 2010 to 2020

At the same time there is a significant increase in post 3. Figure 3 shows that in the river Psel there is no change in the total ammonium content from post 1 to post 6. Regression equation of the detected dependence: $y = 3E + 05x + 0.022$ reliability of approximation $R^2 = 0.0002$. The ammonium content increases in post 3.

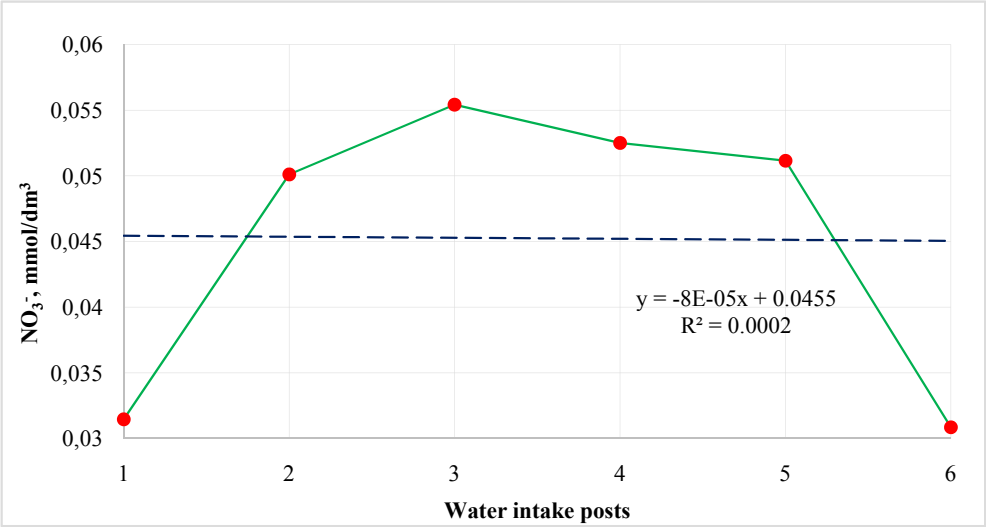

Fig. 4. Average annual concentrations of nitrate ions at the posts of water intakes of the river Psel for the period from 2010 to 2020

Considering Figure 4, we can say that in the river Psel decreases the content of nitrates from post 1 to post 6. Regression equation of the detected dependence: $y = -8E - 05x + 0.0455$ reliability of approximation $R^2 = 0.0002$.

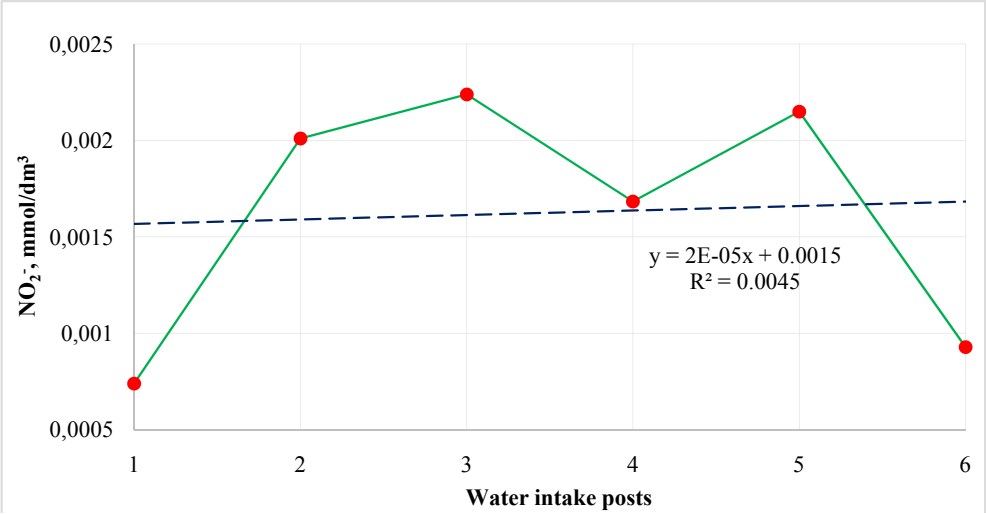

Fig. 5. Average annual concentrations of nitrite ions at the posts of water intakes of the river Psel for the period from 2010 to 2020

Analyzing Figure 5 revealed a slight increase in the total nitrite content from post 1 to post 6. There is a significant increase in post 3. Regression equation of the detected dependence: $y = 2E - 05x + 0.0015$ reliability of approximation $R^2 = 0.0045$.

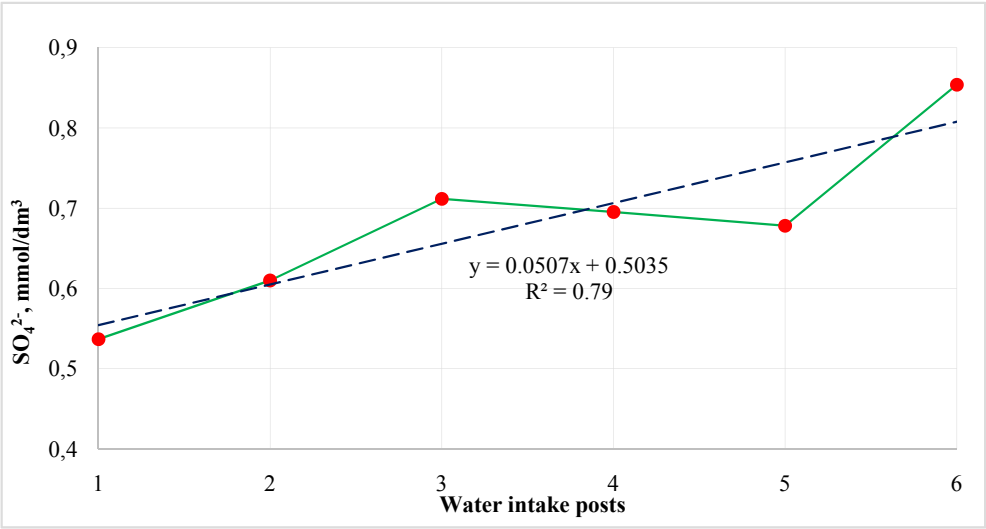

Fig. 6. Average annual concentrations of sulfate ions at the posts of water intakes of the river Psel for the period from 2010 to 2020

Figure 6 shows an increase in the content of sulfates Regression equation of the detected dependence: $y = 0.0507x + 0.5035$ reliability of approximation $R^2 = 0.79$.

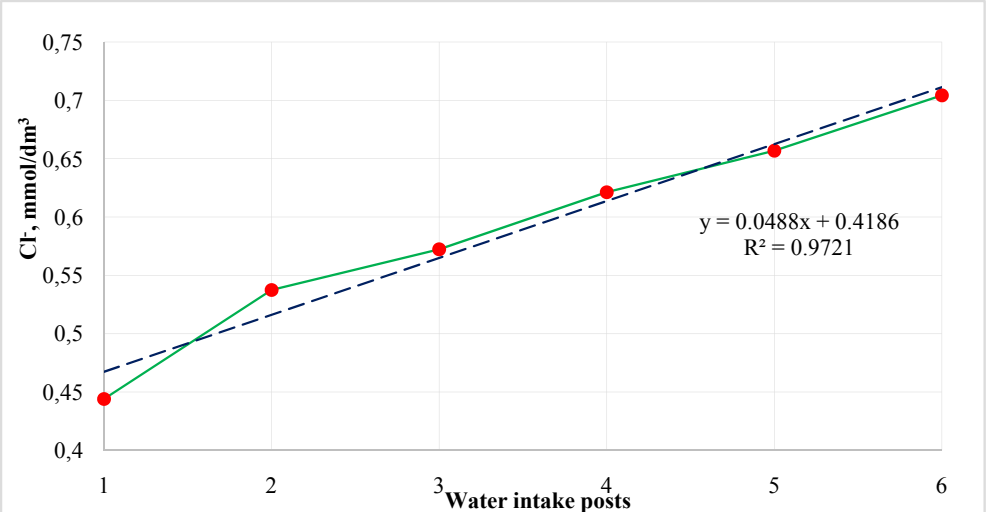

Fig. 7. Average annual concentrations of chloride ions at the posts of water intakes of the river Psel for the period from 2010 to 2020

Figure 7 shows an increase in chloride content. Regression equation of the detected dependence: $y = 0.0488x + 0.4186$ reliability of approximation $R^2 = 0.9721$.

Table 1 shows the average annual data on the content of pollutants (polyphosphates, ammonium ions, nitrate ions, nitrite ions, sulfate ions, chloride ions) in total at posts 1 – 6 of the river Psel.

Table 1. Average annual data on the content of pollutants in total for posts 1 – 6

Years	2010	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020
Average annual values (PO^{3-}_4), mmol/dm^3	0.008	0.014	0.008	0.006	0.007	0.005	0.009	0.006	0.012	0.007	0.011
Average annual values (NH_4^+), mmol/dm^3	0.017	0.019	0.027	0.022	0.022	0.023	0.025	0.020	0.025	0.022	0.020
Average annual values (NO_3^-), mmol/dm^3	0.0013	0.0021	0.0016	0.0016	0.0034	0.0005	0.0009	0.0010	0.0021	0.0008	0.0010
Average annual values (NO_2^-), mmol/dm^3	0.031	0.064	0.047	0.042	0.051	0.069	0.026	0.040	0.042	0.018	0.022
Average annual values (SO_4^{2-}), mmol/dm^3	0.633	0.907	0.810	0.752	0.795	0.721	0.581	0.450	0.457	0.735	0.495
Average annual values (Cl^-), mmol/dm^3	0.674	0.715	0.647	0.461	0.607	0.490	0.459	0.532	0.656	0.561	0.504

Based on the data obtained, the following conclusions can be drawn. In the Psel river there is a significant increase in the content of pollutants at post 3 (Psel river, 444 km, the village of Chervone, below Sumy, administrative roads of the city). The reason for such a point increase may be the location of the fence post in the village (village of Chervone), where there are no treatment facilities. The population can discharge domestic wastewater, which contains harmful

pollutants, into surface water bodies. For example, phosphates are part of washing powders, detergents, etc. At present, there are no standards for the content of phosphates in household detergents in Ukraine. Elevated levels of nitrates indicate that the technology of water treatment is violated. Nitrates and nitrites enter the water from the effluents of industrial and agricultural enterprises. Developed agriculture also pollutes the environment, including surface water bodies, with mineral fertilizers that contain pollutants. An additional source of pollutants in the waters of the Psel river may be industrial wastewater from enterprises, in particular PJSC «Sumykhimprom».

The results of the research allow us to state a significant deterioration of the ecological condition of the river Psel, which today, due to man-made impact, leads to a deterioration of water quality and the regime of its river runoff.

CONCLUSION

Based on the data of the «Monitoring and Environmental Assessment of Water Resources of Ukraine» of the State Agency of Water Resources for 2010-2020, an analysis of changes in the ecological status of the Psel river on the average annual content of pollutants in total at posts 1 – 6. The tendencies to deterioration of the ecological condition of the surface water body have been revealed. This can be explained by the increase in man-made load on the surface water body.

This approach allows its use to analyze changes in the ecological status of such surface water bodies.

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Climate Change & Sustainable Development: New Challenges of the Century:
Monograph

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The monograph is devoted to problems strategy of sustainable development as a road map of civilization; sustainable development of territories; sustainable use and protection of flora and fauna; environmental biochemistry, physiology and medicine; food technology in the context of sustainable development; monitoring of the atmosphere, hydrosphere and climate management; circular economy; rational use of water resources and wastewater treatment; rational use of land resources and reclamation of disturbed lands; environmental education for sustainable development.
The book is written for scientists, lecturers, postgraduate students, engineers and students who specialize in the field of environmental researches.
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