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Sergii Shamanskyi[1], Doctor of Technical Sciences (Engineering), Professor
ORCID ID: 0000-0002-6215-3438 ***e-mail:*** shamanskiy_s_i@ukr.net

Lesia Pavliukh[2], PhD (Engineering), Associate Professor
ORCID ID: 0000-0002-7715-4601 ***e-mail:*** lenyo@ukr.net

Olena Horbachova[2], Graduate Student
ORCID ID: 0000-0002-9478-1009 ***e-mail:*** olenka.lenysia@gmail.com

Victor Repeta[2], PhD (Mathematics), Associate Professor
ORCID ID: 0000-0002-5615-7889 ***e-mail:*** victor.repeta@npp.nau.edu.ua

[1] Kyiv National University of Construction and Architecture, Kyiv, Ukraine
[2] National Aviation University, Kyiv, Ukraine

ANALYSIS OF CONCENTRATIONS OF BIOGENIC COMPOUNDS DISCHARGED INTO WATER BODIES WITH MUNICIPAL WASTEWATER

Abstract. *There were analyzed the effect of increased concentration of biogenic elements, as well as increased temperature on the frequency and magnitude of cyanobacteria reproduction. The goal was to identify the main causes of poor water quality in surface water bodies of Ukraine compared to European countries, as well as the impact of municipal wastewater entering water bodies on the quality of water in them. It is shown that pollution with biogenic elements (compounds of nitrogen and phosphorus) is one of the main reasons for unsatisfactory water quality in water bodies. This, in turn, is the cause of a number of such problems as the change in biological diversity and productivity of water bodies due to the eutrophication of freshwater and marine ecosystems, and the spread of diseases associated with unsatisfactory drinking water quality. One of the main sources of biogenic elements entering surface water bodies is municipal wastewater. Long-term observations of the composition of wastewater from municipal sewage systems indicate that the concentration of biogenic elements in them can be different. It largely depends on the sources of the effluents. In the total amount of nitrogen and phosphorus compounds entering the wastewater, a significant place is occupied by the economic activity of the inhabitants of the residential areas. Experience shows that, regardless of the level of water supply, the total mass of biogens entering the sewage systems from one inhabitant over a certain period of time is constant. However, taking into account the fact that the water availability for residents is different, the concentration of biogens in wastewater will also be different due to different dilutions. The calculation shows that for the entire possible range of water consumption levels (from 100 to 285 l/day per inhabitant according to the standards), the concentration of biogenic elements in wastewater can be: total nitrogen – from 38.6 to 110 mg/l; ammonium nitrogen – from 36.1 to 102.8 mg/l; nitrites – from 2.35 to 6.74 mg/l; nitrates – from 43.27 to 123.67 mg/l; total phosphorus – from 6.31 to 18 mg/l; phosphates – from 15.49 to 44.17 mg/l; organic phosphorus – from 1.26 to 3.60 mg/l.*

Keywords: *contamination; biogenic elements; eutrophication; water supply; water quality*

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Introduction

The anthropogenic and technogenic load on the environment in Ukraine is several times higher than the corresponding indicators of developed countries.

Usable water resources have been significantly reduced due to pollution and depletion. Almost all sources of surface and underground water are polluted [1].

The current unsatisfactory state of water bodies shows that problems in the sphere of water protection against pollution and depletion, not only were they not found solution, but also significantly aggravated, especially in recent years. The main reason for this state of surface water bodies, which are sources of drinking water supply, there is the discharge of insufficiently treated household wastewater [2].

That is why it is important and urgent to search for new promising wastewater treatment technologies that will not only provide the necessary degree of purification but also be harmless to the environment.

In recent decades, numerous water bodies worldwide have shifted from an aquatic vegetation-dominated clear state to a phytoplankton-dominated turbid state. Water transparency has greatly reduced during this process, and the landscape and drinking water values of affected lakes have sharply decreased. Although many studies have been conducted on this topic, the primary factors that promote phytoplankton development remain debated and require further elucidation [3]. Nevertheless, it is commonly assumed that eutrophication and climate change associated with anthropogenic activities are major threats to water ecosystems and are the main factors driving phytoplankton development (*e.g.*, cyanobacterial blooms). Regulation of the content of biogenic elements only recently gained wide publicity due to the sharp deterioration of the condition of water bodies, and their eutrophication. In the case of the arrival of nutrients (biogenic elements) together with sewage, the rate of photosynthesis processes sharply increases, leading to the rapid development of algae in water [4, 5].

Numerous studies have often emphasized that hazardous and harmful substances such as heavy metals, PAHs, PCBs, and pesticides have direct toxic, mutagenic or carcinogenic effects on aquatic ecosystems, and on humans residing within the vicinity. In addition, the quality of surface water can also be compromised by increased nutrient concentrations, primarily nitrogen (N) and/or phosphorus (P) compounds. Problems resulting from nutrient excess can be especially profound in lakes, water accumulations or shallow and slow-flowing lowland water courses. As a result, most of these aquatic ecosystems worldwide suffer from eutrophication, which is mainly caused by (i) the overloading of nutrients from agroecosystems and (ii) the discharge of untreated industrial or municipal wastewaters. Eutrophication as a biological response of an aquatic system to excessive nutrient(s) input results in many adverse effects related to degradation of water quality and its limited use in industry and agriculture. The consequences of eutrophication on aquatic ecosystems are well known and documented in numerous studies. The most profound are water and environmental quality degradation, algal blooms, reduced water clarity, oxygen depletion, alteration of taste and odor, fish deaths, loss of biodiversity including ecosystem services and negative impacts on human health [6].

In Ukraine, all thought was put together for a significant silting of the waters with diffuse sources. The strongest development of lands is overtaking 70% and for the FAO grants it is one of the most important light, but the need for intensification of vibration stimulating producers to a great stagnation quantity of mineral additives. People faced a serious challenge wiping between the viability of food products and the fermentation of waters [7].

Purpose and methods

Rivers, being a natural interface between watersheds and the seas, are a medium that transports both substances of natural origin and pollutant loads from anthropogenic sources. Among various human activities within their watersheds, urban areas are reported to have the most consistent and ubiquitous effects on surface water quality, habitat alteration and reduction in biodiversity due to both the significant load of pollutants from point and non-point sources and the increased impervious surface cover. Direct runoff from urbanized surfaces and sewage discharges not connected to a wastewater treatment plant (WWTP) has emerged as a serious threat, not only to the ecological values of water ecosystems but also to the provision of good quality water required for all socio-economic functions [10].

Water quality is affected by both point and nonpoint sources of pollution in rural and urban areas (Table 1). Some of these sources include sewage discharge, industrial discharge and agricultural run-off [11].

Previous studies have revealed the interactive effects of increased nutrient concentrations and warming in promoting the frequency and magnitude of cyanobacterial blooms [1–7].

The purpose of this article was:

• to reveal the main reasons poor water quality in Ukraine in comparison with European countries;

• to calculate the concentrations of nitrogen and phosphorus compounds in the case of average and total water consumption by a person for a year.

The following *research methods* were used: mathematical methods and formalization, comparison and analogy, analysis and synthesis.

The main research

Wastewater is water that has been used by humans for their domestic or technological needs and is different in physical and chemical properties, the content of pollutants and origin. When various pollutants enter the water, its physical and chemical properties change [8, 9].

Table 1. The main pollutants of water contamination

The main pollutants	**Examples**	**The impact of pollutants**
Petroleum products	Oil, gas, kerosene	Petroleum products fall into water facilities from industrial enterprises, with wastewater from roads, or due to accidents at oil production stations. When inserting into the aqueous object, oil forms a multi-kilometer film, which gradually kills the marine inhabitants, destroys the condition of the soil and gas exchange in water, destroys the structure of biocenoses. Finding on the body of the animal, oil hinders the regulation of heat exchange, causes irritation of the mucous membrane and poisoning, failure of the internal organs.

The main pollutants	Examples	The impact of pollutants
Household waste	Ammonia, nitrates, phosphates, nitrites	Every day we use washing powders, detergents, shampoos, and other hygiene products, sewage that are rich in nitrogen and phosphorus. Nitrogen and phosphorus are complexly cleaned compounds that require high costs, which, when entering the aqueous objects, affect the increase in the amount of plankton and algae, which leads to flowering and stress water. As a result, the balance of water saturation with oxygen, the permeability of the sun rays and also means the death of many living organisms.
Organic waste	Pillows, filtrates, leaves, food, ets	In water, the formation of methane is noticeable by gas bubbles rising to the surface. Depending on the place of origin, we can talk about marsh, putrid, landfill, sewage gas, sewage gas, or, as they are called in agriculture, biogas [12].
Heavy metals	Iron, manganese, lead, zinc, mercury	Heavy metals fall water as a result of plots from industrial enterprises, wastewater from roads (exhaust gases). Heavy metals are accumulated in the body, are toxicants, and cause a number of diseases of the nervous system, a digestive tract, with a reproductive system, cardiovascular diseases, renal and pulmonary failure.
Plastic	Microplastic	The main sources of microplastics are washing synthetic clothes, roads, and cars, hygiene supplies (for an abrasive effect, plastic granules are added to toothpaste, creams, cosmetic powders, etc.), paint, household plastic waste, wearing synthetic clothes. Plastic tends to accumulate toxic substances that lead to cancer, leads to endocrine system disorders, obesity, problems of the reproductive organs, hormonal changes, asthma, and other dangerous diseases.
Pesticides	Carbon trioxide, nitrogen fertilizers	Pesticides fall into the water as a result of the treatment of fields from pests, such as rodents, fungi, insects. Finding into the soil, many pesticides reach superficial waters that are a source of drinking water in many countries. Finding into the human body poisoning it, causing neurological and reproductive problems, poisoning, diabetes, and in large quantities lead to death.

In Ukraine, there is a trend of increasing the share of the urban population and increasing the area of cities. As a result, the impact on the indicators of the quality of natural water resources also changes.

European countries are proud that their population can drink water straight from the tap. In Ukraine, the situation is the opposite: tap water is saturated with salts, iron, manganese, chlorine and its derivatives, and much more.

In general, the number of non-standard samples – indicators that do not meet the requirements of standards – reaches 80–90% in Ukrainian tap water. why the quality of drinking water in Ukraine is much worse than in European countries? Among the reasons are the following (Table 2):

Table 2. Reasons of poor water quality

Firstly	Domestic regulations – hygienic requirements for drinking water – order water to be tested for 86 pollutants. At the same time, the directive of the European Parliament on the quality of drinking water regulates the content of 100 such pollutants.
Secondly	Ukraine mostly uses surface water, while in the West, water is most often taken from underground sources, "after it has undergone at least some natural filtration"
Thirdly	Europe went even further and introduced the so-called indicator parameters – microbiological, chemical, physical indicators of quality, not related to harmful effects on the health of consumers, which demonstrate how useful and tasty the water itself is. While in Ukraine, they focus primarily on general safety when drinking water: its microbiological and chemical data, while there is no list of "indicator indicators".

Every year, the dynamics of the deterioration of the state of natural water systems increases, and the cleaning properties of reservoirs are no longer able to independently cope with the amount and concentrations of pollutants that enter them as a result of human activity. Urban sprawl, population growth, industrial development, and human use of new persistent and complex chemical compounds in everyday life lead to the fact that fewer and fewer treatment plants are able to treat the wastewater that enters them. Outdated technologies and equipment are no longer able to cope with the load of wastewater and concentrations of pollutants, as a result, untreated wastewater enters the channels of rivers, lakes and other water bodies.

At the same time each of the European countries introduces its own innovations. Thus, reverse osmosis systems for river water are widely used in France. And in the capital of Germany, the Berlin water utility covers a fifth of the need for electricity due to its independent production with the help of solar panels, wind farms, and biogas plants. Whereas in Ukraine, most of the expenses of water utilities are electricity – up to 60% with the new tariffs.

Domestic wastewater treatment in Ukraine and other countries of the world showed on figure 1 [13].

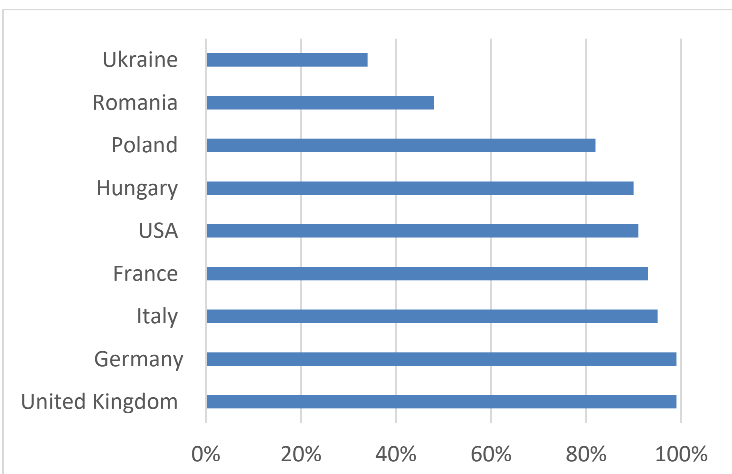

Figure 1. Domestic wastewater treatment in countries

The most contaminated Dnieper influx is the place of resetting the "purified" wastewater after the Bortnytska Aeration Station. Thanks to scientific research, monitoring, and self-identity items, there is a site that shows various types and levels of water pollution, in which we have the ability to analyze the state of the river, which is the main source of fresh drinking water in the capital. The change of ammonia ions in the water dump channel of Bortnytska Aeration Station is shown on figure 2. The change of ions nitrates in the same channel is shown on figure 3 [14].

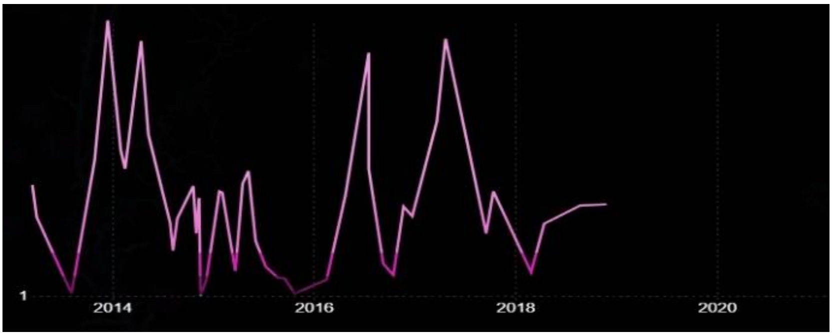

Figure 2. Ammonia ions in the water dump channel of Bortnytska Aeration Station

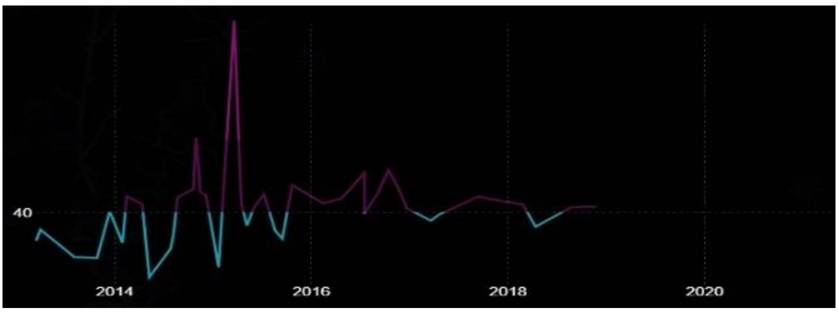

Figure 3. Ions nitrates in the water dump channel of Bortnytska Aeration Station

The presence of biogenic elements in wastewater – nitrogen compounds and of phosphorus initiates the processes of flowering and eutrophication of the reservoir, which changes the physical and chemical properties of the environment: in eutrophic reservoirs the content of biogenic and organic substances increases, the level decreases oxygen saturation of the water, anaerobic zones appear in the bottom layers, the turbidity of the water, its contamination by microorganisms increases, which get there with sewage, including pathogenic ones. Accumulation of excess amount of organic substances in the bottom silt deposits is accompanied by the formation of methane, hydrogen, hydrogen sulfide, and ammonia, which can stand out in the form of bubbles, and when dissolved in water give it unpleasant smell and have a toxic effect on fish, invertebrates and plants, especially at low temperatures, leading to shortages of oxygen and mass death of fish.

According to current paradigms, wastewater is still typically viewed as an energy-demanding problem requiring expensive solutions, rather than a resource. Despite the fact that most countries spend substantial amounts of energy treating sewage to release it as harmlessly as possible into receiving waters, wastewater represents a mostly-untapped, potentially huge source of energy, including intrinsic energy embedded within wastewater organics; thermal energy (5.8 kWh/m^3 per 5°C) recoverable through heat extraction, e.g., by a heat pump; and an external fossil-fuel energy equivalent required for the production of the same amounts of fertilizing elements N and P contained in wastewater (19.3 kWh/kg N and 2.11 kWh/kg P) [15].

An increase in the level of trophicity is accompanied by a change in the composition of phytoplankton – blue-green algae begin to predominate (90...95% of the total population), and coastal shallow water zones are overgrown with higher aquatic vegetation. The extensive development of algae hinders the work water intake facilities and fish industry, reduces hydraulic parameters flow (speed of coastal currents), and the flowering of water bodies also leads to decrease in organoleptic indicators of water. The worst consequences of eutrophication are the deterioration of quality indicators of drinking water and the mass death of fish.

Let’s calculate the amount of nitrogen and phosphorus discharged per inhabitant per day.

According to the [16]. Total nitrogen N = 11 g/day, including ammonium salts – 8 g/day. Total phosphorus P = 1.8 g/day, including phosphorus phosphates – 1.44 g/day.

Average annual water consumption standards [17] per person: Q_{min} = 100 l/day; Q_{max} = 285 l/day.

Concentration of total nitrogen in compounds is the following:

$$S_N^{min} = \frac{N}{Qmax} * 1000 = \frac{11}{285} * 1000 = 38{,}6 \text{ mg/l} \quad (1)$$
$$S_N^{max} = \frac{N}{Qmin} * 1000 = \frac{11}{100} * 1000 = 110 \text{ mg/l} .$$

For average water consumption (150:230 l/day)(baths and local water heaters) we receive:

$$S_N^{min} = \frac{11}{230} * 1000 = 47{,}8 \text{ mg/l} \quad (2)$$
$$S_N^{max} = \frac{11}{150} * 1000 = 73{,}3 \text{ mg/l} .$$

Concentration of ammonium salts:

$$S_{NH_4}^{min} = \frac{8}{285} * 1000 = 28{,}1 \text{ mg/l} \quad (3)$$
$$S_{NH_4}^{max} = \frac{8}{100} * 1000 = 80 \text{ mg/l} .$$

For average water consumption (150+230 l/day):

$$S_{NH_4}^{min} = \frac{8}{230} * 1000 = 34{,}8 \text{ mg/l} \quad (4)$$
$$S_{NH_4}^{max} = \frac{8}{150} * 1000 = 53{,}3 \text{ mg/l} .$$

Concentration of nitrogen in other compounds (NO_2; NO_3) is the following:

$$S_{NO_2\,NO_3}^{min} = S_N^{min} - S_{NH_4}^{min} = 38{,}6 - 28{,}1 = 10{,}5 \text{ mg/l} \quad (5)$$
$$S_{NO_2\,NO_3}^{max} = S_N^{max} - S_{NH_4}^{max} = 110 - 80 = 30 \text{ mg/l} .$$

For average water consumption we receive:

$$S^{min}_{NO_2\ NO_3} = 47{,}8 - 34{,}8 = 13 \text{ mg/l} \qquad (6)$$
$$S^{max}_{NO_2;\ NO_3} = 73{,}3 - 53{,}3 = 20 \text{ mg/l}\ .$$

Concentration of ions of ammonium salts NH_4^+:

$$C^{min}_{NH_4} = \frac{28{,}1}{0{,}778} = 36{,}1 \text{ mg/l} \qquad (7)$$
$$C^{max}_{NH_4} = \frac{80}{0{,}778} = 102{,}8 \text{ mg/l}\ .$$

For average water consumption we receive:

$$C^{min}_{NH_4} = \frac{34{,}8}{0{,}778} = 44{,}7 \text{ mg/l} \qquad (8)$$
$$C^{max}_{NH_4} = \frac{53{,}3}{0{,}778} = 68{,}5 \text{ mg/l}\ .$$

Concentration of Kyiv subscribers in WW (wastewater) (Initialized acceptance of WW into the city's sewerage system):

Nitrites (NO_2^-) – 3,3 mg/l
Nitrates (NO_3^-) – 45 mg/l .

Let's distribute the nitrogen concentration proportionally:
Nitrogen in nitrites (NO_2^-)

$$S^{min}_{NO_2} = 10{,}5\frac{3{,}3}{48{,}3(45+3{,}3)} = 0{,}72 \text{ mg/l} \qquad (9)$$
$$S^{max}_{NO_2} = 30\frac{3{,}3}{48{,}3(45+3{,}3)} = 2{,}05 \text{ mg/l}\ .$$

For average water consumption we receive:

$$S^{min}_{NO_2} = 13 * \frac{3{,}3}{48{,}3} = 0{,}89 \text{ mg/l} \qquad (10)$$
$$S^{max}_{NO_2} = 20 * \frac{3{,}3}{48{,}3} = 1{,}37 \text{ mg/l}\ .$$

Nitrogen in nitrates (NO_3^-):

$$S^{min}_{NO_3} = 10{,}5\frac{45}{48{,}3} = 9{,}78 \text{ mg/l} \qquad (11)$$
$$S^{max}_{NO_3} = 30\frac{45}{48{,}3} = 27{,}95 \text{ mg/l}\ .$$

For average water consumption we receive:

$$S^{min}_{NO_3} = 13 * \frac{45}{48{,}3} = 12{,}11 \text{ mg/l} \qquad (12)$$
$$S^{max}_{NO_3} = 20 * \frac{45}{48{,}3} = 18{,}63 \text{ mg/l}\ .$$

Conversion of nitrogen into nitrite and nitrate ions:
Concentration of nitrite ions (NO_2^-)

$$C_{NO_2}^{min} = \frac{0,72}{0,304} = 2,35 \text{ mg/l} \quad (13)$$
$$C_{NO_2}^{max} = \frac{2,05}{0,304} = 6,74 \text{ mg/l} .$$

For average water consumption we receive:

$$C_{NO_2}^{min} = \frac{0,89}{0,304} = 2,93 \text{ mg/l} \quad (14)$$
$$C_{NO_2}^{max} = \frac{1,37}{0,304} = 4,51 \text{ mg/l} .$$

Concentration of nitrate ions (NO_3^-):

$$C_{NO_3}^{min} = \frac{9,78}{0,226} = 43,27 \text{ mg/l} \quad (15)$$
$$C_{NO_3}^{max} = \frac{27,95}{0,226} = 123,67 \text{ mg/l} .$$

For average water consumption we receive:

$$C_{NO_3}^{min} = \frac{12,11}{0,226} = 53,58 \text{ mg/l} \quad (16)$$
$$C_{NO_3}^{max} = \frac{18,63}{0,226} = 82,43 \text{ mg/l} .$$

The presence of nitrogen and phosphorus plays an important role in the biological treatment of wastewater. Nitrogen and phosphorus as biogenic compounds are part of living bacterial cells. With insufficient concentrations of nitrogen and phosphorus in wastewater, there is inhibition of biological purification processes, and with their complete absence, such processes become impossible. However, the content of total ammonium nitrogen and phosphates in wastewater increases from year to year. Exceeding the maximum permissible concentrations of discharge of biogenic compounds into natural reservoirs lead to flowering and eutrophication of the reservoir, increase in the content of biogenic and organic substances, decrease in the level of water saturation with oxygen, the appearance of anaerobic zones in the bottom layers, increase in water turbidity, changes in the color of water, contamination by pathogenic microorganisms, and as a result, is an obstacle to farming, tourism and has a threatening effect on human health. Biological methods of wastewater treatment are becoming especially relevant, as they are economically beneficial, easy to maintain, not difficult to operate, and certainly environmentally safe.

Results and discussion

Exceeding the maximum permissible concentrations of discharge of biogenic compounds into natural reservoirs leads to flowering and eutrophication of the reservoir, increase in the content of biogenic and organic substances, decrease in the level of water saturation with oxygen, the appearance of anaerobic zones in the bottom layers, increase in water turbidity, changes in the color of water to green, yellow, brown or red, its contamination by microorganisms that get there with sewage, including pathogenic ones [18]. After calculations we received such dates about concentrstions of nitrogen (Table 3). When an excess amount of organic substances accumulates in bottom silt deposits, the processes of methane, hydrogen, hydrogen sulfide, and ammonia formation begin, which can form and be released in the form of gas bubbles, and when dissolved in water, they have a toxic and harmful effect on the flora and fauna of the reservoir, the quality deteriorates significantly indicators of drinking water [19].

Table 3. Summary table of nitrogen concentrations

Concentrations	**The whole range**		**For average water consumption**	
	min	**max**	**min**	**max**
N	38,6	110	47,8	73,3
NH_4^+	36,1	102,8	44,7	68,5
NO_2^-	2,35	6,74	2,93	4,51
NO_3^-	43,27	123,67	53,58	82,43
Nitrogen of ammonium salts N- NH_4^+	28,1	80	34,8	53,3
Nitrite nitrogen N- NO_2^-	0,72	2,05	0,89	1,37
Nitrate nitrogen N- NO_3^-	9,78	27,95	12,11	18,63

The concentration of biogenic elements and their regime depend on the intensity of biological and biochemical processes in the reservoir and on the amount of biogens entering the reservoir with wastewater and surface runoff in the catchment area. Concentrations of nitrogen and phosphorus characterize the trophicity of the reservoir. The regime of biogenic elements is considered as an initial indicator of potential eutrophication. Therefore, for further analysis, we have to calculate phosphorus concentrations. The results of the calculations are presented in table 4.

Concentration of total phosphorus in effluents:

$$S_P^{min} = \frac{P}{Q_{max}} * 1000 = \frac{1,8}{285} * 1000 = 6,31 \text{ mg/l} \quad (17)$$
$$S_P^{max} = \frac{P}{Q_{min}} * 1000 = \frac{1,8}{100} * 1000 = 18,0 \text{ mg/l} .$$

For average water consumption:

$$S_P^{min} = \frac{1,8}{230} * 1000 = 7,83 \text{ mg/l} \quad (18)$$
$$S_P^{max} = \frac{1,8}{150} * 1000 = 127,83 \text{ mg/l} .$$

Concentration of phosphorus in phosphate:

$$S_{PO_4}^{min} = \frac{1,44}{285} * 1000 = 5,05 \text{ mg/l} \quad (19)$$
$$S_{PO_4}^{max} = \frac{1,44}{100} * 1000 = 14,4 \text{ mg/l} .$$

For average water consumption:

$$S_{PO_4}^{min} = \frac{1,44}{230} * 1000 = 6,26 \text{ mg/l} \quad (20)$$
$$S_{PO_4}^{max} = \frac{1,44}{150} * 1000 = 9,60 \text{ mg/l} .$$

Concentration of phosphorus in other forms (organic):

$$S_{PO_4 орг}^{min} = \frac{1,8-1,44}{285} * 1000 = 1,26 \text{ mg/l} \quad (21)$$
$$S_{PO_4 орг}^{max} = \frac{1,8-1,44}{100} * 1000 = 3,60 \text{ mg/l} .$$

For average water consumption:

$$S_{PO_4 орг}^{min} = \frac{1,8-1,44}{230} * 1000 = 1,57 \text{ mg/l} \quad (22)$$
$$S_{PO_4 орг}^{max} = \frac{1,8-1,44}{150} * 1000 = 2,40 \text{ mg/l} .$$

Conversion of phosphorus into phosphate ions ($PO_4{}^{3-}$)
Calculation of phosphorus in phosphates:

$$C_{PO_4}^{min} = \frac{5,05}{0,326} = 15,49 \text{ mg/l} \quad (23)$$
$$C_{PO_4}^{max} = \frac{14,4}{0,326} = 44,17 \text{ mg/l} .$$

For average water consumption:

$$C_{PO_4}^{min} = \frac{6,26}{0,326} = 19,20 \text{ mg/l} \quad (24)$$
$$C_{PO_4}^{max} = \frac{9,60}{0,326} = 29,45 \text{ mg/l} .$$

Conversion of phosphorus of other forms into phosphates:

$$C_{PO_4 орг}^{min} = \frac{1,26}{0,326} = 3,87 \text{ mg/l} \quad (25)$$
$$C_{PO_4 орг}^{max} = \frac{3,60}{0,326} = 11,04 \text{ mg/l} .$$

For average water consumption

$$C_{PO_4 орг}^{min} = \frac{1,57}{0,326} = 4,82 \text{ mg/l} \quad (26)$$
$$C_{PO_4 орг}^{max} = \frac{2,40}{0,326} = 7,36 \text{ mg/l} .$$

Conversion of total phosphorus into phosphates:

$$C_{P}^{min} = \frac{6,31}{0,326} = 19,36 \text{ mg/l} \quad (27)$$
$$C_{P}^{max} = \frac{18,0}{0,326} = 55,21 \text{ mg/l} .$$

For average water consumption:

$$C_P^{min} = \frac{7,83}{0,326} = 24,02 \text{ mg/l} \quad (28)$$
$$C_P^{max} = \frac{12,0}{0,326} = 36,81 \text{ mg/l} .$$

Table 4. Summary table of phosphorus concentrations

Concentrations	**The whole range**		**For average water consumption**	
	min	**max**	**min**	**max**
P	6,31	18,0	7,83	12,0
$PO_4{}^{3-}$ phosphates	15,49	44,17	19,20	29,45
$PO_4{}^{3-}$ organic compounds	3,87	11,04	4,82	7,36
$PO_4{}^{3-}$ total phosphorus	19,36	55,21	24,02	36,81
Phosphorus phosphates $P - PO_4{}^{3-}$	5,05	14,4	6,26	9,60
Organic phosphorus compounds P	1,26	3,60	1,57	2,40

The content of total ammonium nitrogen in wastewater increases from year to year. In wastewater, in the presence of oxygen, the process of nitrification occurs, which goes almost to the end. In this way, ammonium nitrogen turns into nitrites, and then into nitrates. The content of a large amount of nitrates in surface waters is dangerous for health, the use of such water leads to the development of water-nitrate methemoglobinemia – a disease accompanied by oxygen starvation of body tissues and suppression of the activity of enzyme systems [20].

Therefore, the issue of removing nitrogen and phosphorus compounds from polluted wastewater before discharging it into natural reservoirs and improving existing technologies for biological wastewater treatment is urgent.

Conclusions and recommendations

The arrival of biogenic compounds of nitrogen and phosphorus in concentrations exceeding the maximum permissible for discharge into natural reservoirs leads to flowering and eutrophication of the reservoir, an increase in the content of biogenic and organic substances, a decrease in the level of water saturation with oxygen, the appearance of anaerobic zones in the bottom layers, an increase in water turbidity, changes in the color of water, its contamination by pathogenic microorganisms, and as a result is an obstacle to farming, tourism and has a threatening effect on human health.

In this article we calculated concentrations of biogenic compounds dischared into water bodies and analyzed main pollutants of water contamination. Water quality is affected by both point and nonpoint sources of pollution in rural and urban areas. Some of these sources include sewage discharge, industrial discharge and agricultural run-off. The concentration of biogenic elements and their regime depend on the intensity of biological and biochemical processes in the reservoir and on the amount of biogens entering the reservoir with wastewater and surface runoff in the catchment area. The issue of soil water contamination by biogenic elements is extremely acute, especially for regions where there are no centralized water supply systems. The population uses ground water for drinking, which accumulates on the first waterproof layer. Exceeding the maximum allowable concentrations of the content of biogenic elements and, first of all, nitrate compounds in groundwater leads to the risk of diseases in the population.

Wastewater treatment requires special treatment facilities and units with the help of which polluting impurities are isolated, disinfected or neutralized. Domestic wastewater is cleaned by mechanical and biological methods. Industrial wastewater is treated together with domestic wastewater, but if the concentration of pollutants exceeds the permissible level or the wastewater contains highly toxic substances, then such water is pre-treated at the treatment facilities of the relevant enterprises and institutions and only after that it is discharged into general treatment facilities. Before discharging treated wastewater into reservoirs, they must be disinfected. Mechanical cleaning serves to remove insoluble substances from wastewater. Water filtration is used to retain the smallest insoluble particles of pollutants that are in a suspended state. For this, sand and gravel filters or special nets are used. Wastewater purification from mechanical impurities is also carried out with the help of a hydrocyclone – a unit that, in the process of rotating a water tank due to the action of centrifugal forces, removes suspended particles of pollutants from water (centrifugation).

Another important method of cleaning wastewater from biogenic compounds is the microalgae cleaning method.

There is also a need to develop innovative methods of wastewater treatment.

In the futher studies, we plan to investigate the methods of handling concentrations of biogenic compounds in water bodies, as well as the impact and methods of processing organic waste.

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С. Шаманський, Л. Павлюх, О. Горбачова, В. Репета

АНАЛІЗ КОНЦЕНТРАЦІЙ БІОГЕННИХ СПОЛУК, ЩО СКИДАЮТЬСЯ У ВОДОЙМИ З КОМУНАЛЬНИМИ СТІЧНИМИ ВОДАМИ

Анотація. У цій статті було проаналізовано вплив підвищеної концентрації біогенних елементів, а також підвищеної температури на частоту та величину розмноження ціанобактерій. Метою було виявлення основних причин поганої якості води в поверхневих водоймах України порівняно з країнами Європи, а також вплив надходження комунальних стічних вод у водойми на якість води в них. Показано, що забруднення біогенними елементами (сполуками азоту та фосфору) є однією з головних причин незадовільної якості води водних об’єктів. Це, у свою чергу, є причиною цілої низки таких проблем, як зміна біологічної різноманітності і продуктивності водойм внаслідок евтрофікації прісноводних та морських екосистем, поширення захворювань, пов'язаних з незадовільною якістю питної води. Одним з головних джерел надходження біогенних елементів у поверхневі водойми є комунальні стічні води. Багаторічні спостереження за складом стічних вод комунальних систем каналізації свідчать про те, що концентрація біогенних елементів у них може бути різною. Це великою мірою залежить від джерел надходження стоків. В загальній кількості сполук азоту та фосфору, що надходять у стічні води, значне місце займає господарська діяльність мешканців селітебних територій. Досвід свідчить, що, не дивлячись на рівень забезпеченості водопостачанням, загальна маса біогенів, що надходять у каналізаційну систему від одного мешканця за певний період часу, є постійною. Разом з тим, враховуючи той факт, що водозабезпеченість мешканців є різною, концентрація біогенів у стічних водах також буде різною через різне розбавлення. Розрахунком показано, що для усього нормативно можливого діапазону рівнів водоспоживання (від 100 до 285 л/добу на одного мешканця) концентрація біогенних елементів у стічних водах може становити: загального азоту – від 38,6 до 110 мг/л; амонійного азоту – від 36,1 до 102,8 мг/л; нітритів – від 2,35 до 6,74 мг/л; нітратів – від 43,27 до 123,67 мг/л; загального фосфору – від 6,31 до 18 мг/л; фосфатів – від 15,49 до 44,17 мг/л; органічного фосфору – від 1,26 до 3,60 мг/л.

Ключові слова: забруднення; біогенні елементи; евтрофікація; стічні води; якість води

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Сергій Шаманський
доктор технічних наук, професор кафедри водопостачання та водовідведення Київського національного університету будівництва і архітектури
Адреса робоча: пр. Повітрофлотський, 31, м. Київ, Україна, 03037
ORCID ID: 0000-0002-6215-3438 ***e-mail:*** shamanskiy_s_i@ukr.net

Леся Павлюх
кандидат технічних наук, професор кафедри екології Національного авіаційного університету
Адреса робоча: проспект Любомира Гузара, 1, Київ, Україна, 03058
ORCID ID: 0000-0002-7715-4601 ***e-mail:*** lenyo@ukr.net

Олена Горбачова
аспірант кафедри екології Національного авіаційного університету
Адреса робоча: проспект Любомира Гузара, 1, Київ, Україна, 03058
ORCID ID: 0000-0002-9478-1009 ***e-mail:*** olenka.lenysia@gmail.com

Віктор Репета
кандидат фізико-математичних наук, доцент кафедри вищої математики Національного авіаційного університету
Адреса робоча: проспект Любомира Гузара, 1, Київ, Україна, 03058
ORCID ID: 0000-0002-5615-7889 ***e-mail:*** victor.repeta@npp.nau.edu.ua