MINISTRY OF EDUCATION AND SCIENCE OF UKRAINE
NATIONAL AVIATION UNIVERSITY
FACULTY OF ENVIRONMENTAL SAFETY,
ENGINEERING AND TECHNOLOGIES
DEPARTMENT OF ECOLOGY

APPROVED TO DEFENCE
Head of the Graduate Department
____________ V.F. Frolov
«_____» ____________ 2020

BACHELOR THESIS

(EXPLANATORY NOTE)

SPECIALTY 101 «ECOLOGY»,
TRAINING PROFESSIONAL PROGRAM
"ECOLOGY AND ENVIRONMENTAL PROTECTION"

Theme: «Prospects for reducing the impact of phosphates on aquatic ecosystems»

Done bystudent of the ERIES – 402 group, Kolmykova Alina Igorivna
(student, group, surname, name, patronymic)

Scientific Supervisor: Ph. D. in Biol. Sc., Associate Professor of the Ecology Department, TetianaI. Bilyk
(academic degree, academic rank, surname, name, patronymic)

Standards Inspector: ____________ Andrian A. Iavniuk
(signature) (S.N.P)

KYIV 2020

МІНІСТЕРСТВО ОСВІТИ І НАУКИ УКРАЇНИ
НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ
ФАКУЛЬТЕТ ЕКОЛОГІЧНОЇ БЕЗПЕКИ,
ІНЖЕНЕРІЇ ТА ТЕХНОЛОГІЙ
КАФЕДРА ЕКОЛОГІЇ

ДОПУСТИТИ ДО ЗАХИСТУ
Завідувач випускової кафедри
_____________В.Ф.Фролов
«_____» ___________2020 р.

ДИПЛОМНА РОБОТА

(ПОЯСНЮВАЛЬНА ЗАПИСКА)

ВИПУСКНИКА ОСВІТНЬОГО СТУПЕНЯ БАКАЛАВРА

ЗА СПЕЦІАЛЬНІСТЮ 101 «ЕКОЛОГІЯ»
ОПП «ЕКОЛОГІЯ ТА ОХОРОНА НАВКОЛИШНЬОГО СЕРЕДОВИЩА»

Тема: Перспективи зменшення впливу фосфатів на водні екосистеми

Виконавець: студентка групи ННІЕБ-402, КолмиковаАліна Ігорівна
(студент, група, прізвище, ім'я, по батькові)

Керівник: : к.б.н., доцент кафедри екології, Білик Тетяна Іванівна
(науковий ступінь, вчене звання, прізвище, ім'я, по батькові)

Нормоконтролер: _______________Явнюк А. А.
(підпис) (П.І.Б.)

КИЇВ 2020

NATIONAL AVIATION UNIVERSITY

Faculty of Environmental Safety, Engineering and Technologies

Department of Ecology

Specialty, training professional program: specialty 101 «Ecology», Training Professional Program “Ecology and Environmental Protection”

(code, name)

APPROVED
Head of the Department
___________ Frolov V.F.
«____» _________ 20__

BACHELOR THESIS ASSIGNMENT

Kolmykova Alina Igorivna

1. Theme: «Prospects for reducing the impact of phosphates on aquatic ecosystems» approved by the Rector on April 27, 2020, № 527/ст.

2. Duration of work: from 27.04.20 to 16.06.20.

3. Output work : scientific literature on the impact of phosphates on aquatic ecosystems and methods of treatment of water, data on the content of phosphates insurface watersand washing powders, information on the treatment systems at the Bortnytsia aeration station.

4. Content of explanatory note(list of issues): analytical review of literature sources on the subject of the diploma. Consideration of pollution of aquatic ecosystems by phosphates. Analysis of the literature on the features of the influence of phosphates on the microflora of water bodies and aquatic organisms. Methods of wastewater treatment from phosphates. Investigation of phosphate content in surface waters. Recommendations for reducing phosphate inflow into water bodies and improving wastewater treatment methods.

5. List of obligatory graphic (illustrative) material: tables, figures.

6. Schedule of thesis fulfillment

№ з/п	Task	Deadline	Supervisor's signature
1	Development with scientific supervisor schedule for execute of bachelor thesis	27.04.2020	
2	Research and analysis of the literature on the topic of work	28.04.2020 – 30.04.2020	
3	Preparation of the main part (CHAPTER I)	01.05.2020 – 09.05.2020	
4	Preparation of the main part (CHAPTER II)	10.05.2020 – 13.05.2020	
5	Preparation of the main part (CHAPTER III)	14.05.2020 – 20.05.2020	
6	Preparation of graphic material	21.05.2020 – 24.05.2020	
7	Paperwork of conclusions, results and recommendations	25.05.2020 – 28.05.2020	
8	Work on the report and presentation	28.05.2020 – 07.06.2020	
9	Previous defence of bachelor thesis	08.06.2020	
10	Defence of bachelor thesis	19.06.2020	

7. Date of task issue: «____» ________ 2020

Diploma Supervisor: ________________ Tetiana I. Bilyk
(supervisor's signature)(S.N.P.)

Task is taken to perform: ________________ Alina I.Kolmykova

(graduate's signature)(S.N.P.)

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

Факультет екологічної безпеки, інженерії та технологій

Кафедра екології

Спеціальність, освітньо-професійна програма: спеціальність 101 «Екологія», ОПП «Екологія та охорона навколишнього середовища»

(шифр, найменування)

ЗАТВЕРДЖУЮ
Завідувач кафедри
___________Фролов В.Ф.
«____» _________ 20__ р.

ЗАВДАННЯ
на виконання дипломної роботи
Колмикової Аліни Ігорівни

1. Тема роботи «Перспективи зменшення впливу фосфатів на водні екосистеми» затверджена наказом ректора від «27» квітня 2020 р. №527/ст.

2. Термін виконання роботи: з 27.04.2020 р. по 16.06.2020р.

3. Вихідні дані роботи: наукова література про вплив фосфатів на водні екосистеми та методи очищення забруднених вод, дані щодо вмісту фосфатів у пральних порошках, інформація про реконструкцію очисних систем на Бортницькій станції аерації.

4. Зміст пояснювальної записки: аналітичний огляд літературних джерел з тематики диплому. Розгляд забруднення водних екосистем фосфатами. Аналіз літератури з особливостей впливу фосфатів на мікрофлору водойм та на водяні організми. Методи очищення стічних вод від фосфатів. Дослідження вмісту фосфатів у поверхневих водах. Рекомендації щодо зменшення надходження фосфатів у водойми та удосконалення методів очищення стічних вод. 5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, рисунки.

5. Список обов’язкових графічних (ілюстративних) матеріалів: таблиці, рисунки.

6. Графік виконання бакалаврської дипломної роботи

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Розробка разом з науковим керівником графіку виконання бакалаврської дипломної роботи	27.04.2020	
2	Пошук та аналіз літературних джерел за темою роботи	28.04.2020 – 30.04.2020	
3	Підготовка основної частини (Розділ I)	01.05.2020 – 09.05.2020	
4	Підготовка основної частини (Розділ II)	10.05.2020 – 13.05.2020	
5	Підготовка основної частини (Розділ III)	14.05.2020 – 20.05.2020	
6	Підготовка графічного матеріалу	21.05.2020 – 24.05.2020	
7	Оформлення висновків, результатів і рекомендацій	25.05.2020 – 28.05.2020	
8	Робота над доповіддю та презентацією	28.05.2020 – 07.06.2020	
9	Попередній захист дипломної роботи	08.06.2020	
10	Захист дипломної роботи	16.06.2020	

7. Дата видачі завдання: «____» ________ 2020

Керівник дипломної роботи: ________________ Білик Т.І.

(підпис керівника)(П.І.Б.)

Завдання прийняв до виконання: ________________ Колмикова А.І.

(підпис випускника)(П.І.Б.)

ABSTRACT

Explanatory note to the thesis "Prospects for reducing the impact of phosphates on aquatic ecosystems": 53 pp., 10 figures, 2 tables, 30 references.

The object of research is the pollution of aquatic ecosystems with phosphates.

The subject of research is the reduction of the impact of phosphates on aquatic ecosystems due to the improvement of wastewater treatment systems.

The aim of the work was to analyze the prospects for reducing water pollution by phosphates and their impact on aquatic ecosystems due to the improvement of wastewater treatment system.

Research methods: analytical, chemical, statistical methods of data processing.

Relevance. In recent years, the amount of phosphates in the wastewater entering the treatment facilities of the city of Kyiv - Bortnytsia aeration station, has increased significantly. To date, it reaches almost 30 mg / l, with a standard discharge 8.0 mg / l. At this concentration of phosphates in the incoming water, the old treatment technologies do not allow to reach the established norms for wastewater, which causes eutrophication and death of aquatic organisms. The solution to this problem is to improve wastewater treatment systems and limit the use of phosphorus-containing detergents.

Scientific novelty: an analysis of ways to reduce the impact of phosphates on aquatic ecosystems.

Practical significance: the results of the study are prepared for implementation in a comprehensive program aimed at protecting aquatic ecosystems and reducing the content of phosphates in water bodies of Ukraine.

Personal contribution of the author: elaboration of scientific literature on the topic of work, analysis of data of the Institute of Hydrobiology of the National Academy of Sciences of Ukraine and Kyivvodokanal, preparation for the implementation of research results.

WATER POLLUTION, PHOSPHATES, WASTEWATER TREATMENT METHODS, DETERGENTS, AQUATIC ECOSYSTEMS

CONTENT

LIST OF SYMBOLIC NOTATIONS, ABBREVIATIONS AND NOTIONS

P - Phosphorus;

WWTPs - wastewater treatment plants;

PME - Pulp mill effluent;

TSCA - Toxic Substance Control Act;

SDWA - Safe Drinking Water Act;

POTW - Publically owned treatment work;

TPP – tripolyphosphate;

PYSC - Private joint stock company;

PAO - P accumulating organisms;

EU - European Union.

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INTRODUCTION

Relevance of the work.Phosphates releases due to anthropogenic activity and adversely affect aquatic ecosystems. In recent years, the amount of phosphates in the wastewater entering the treatment facilities of the city of Kyiv - Bortnytsia aeration station, has increased significantly. To date, it reaches almost 30 mg / l, with a standard discharge 8.0 mg / l. At this concentration of phosphates in the incoming water, the old treatment technologies do not allow to reach the established norms for wastewater, which causes eutrophication and death of aquatic organisms. The solution to this problem is to improve wastewater treatment systems and limit the use of phosphorus-containing detergents.

Aim of the work. To analyze the prospects for reducing water pollution by phosphates and their impact on aquatic ecosystems due to the improvement of wastewater treatment system.

Tasks of the work:

1. To describe the ways of enteringphosphatesto theaquatic environment.
2. Toclarifyphosphatesimpact on water ecosystems and on aquatic organisms.
3. To study modern methods of wastewater treatment.
4. To analyze experimental data on phosphate pollution of surfacewater.
5. To identify ways to solve and regulate the problemof phosphates pollution.

Object of research: pollution of aquatic ecosystems by phosphates.

Subject of research:reduction of the impact of phosphates on aquatic ecosystems due to the improvement of wastewater treatment systems.

Method of research:analytical,comparative, chemical, statistical methods of data processing.

Personal contribution of the graduate: elaboration of scientific literature on the topic of work, data analysis of the Institute of Hydrobiology of the National Academy of Sciences of Ukraine and Kyivvodokanal, preparation for the implementation of research results.

Approbation of results. The results of the thesis were reported on X International Scientific and Practical Conference "Comprehensive quality assurance of technological processes and systems." April 29-30, 2020, Chernihiv.

Publications.Basic provisions and results of the bachelor thesis were published and received a positive assessment on the scientific andpracticalconference:

Тирінова А.І./Білик Т.І.,Бондаренко А.О., Гетьман А.О.,Тирінова А.І. Перспективи удосконалення систем очищення стічних вод від фосфатів.//Матеріали X міжнародної науково-практичної конференції “Комплексне забезпечення якості технологічних процесів та систем”. 29-30 квітня 2020 р., м.Чернігів.- Т.2, С.145-147.

CHAPTER 1
DANGEROUS OF WATER OBJECTS POLLUTION BY PHOSPHATES

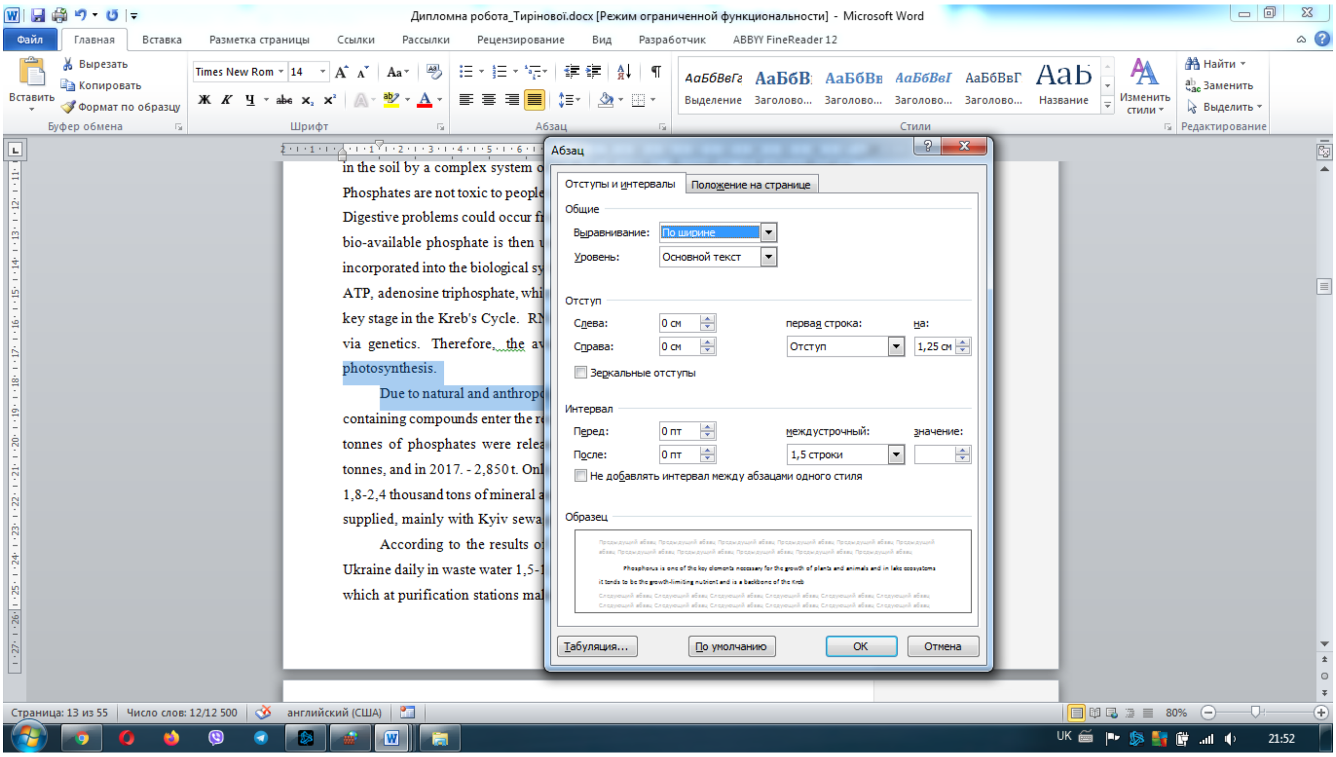
1.1. Sources of supply of phosphorus-containing compounds to the aquatic environment

Phosphorus is one of the key elements necessary for the growth of plants and animals and in lake ecosystems it tends to be the growth-limiting nutrient and is a backbone of the Kreb's Cycle and DNA. The presence of phosphorus is often scarce in the well-oxygenated lake waters and importantly, the low levels of phosphorus limit the production of freshwater systems (Ricklefs, 1993).Unlike nitrogen, phosphate is retained in the soil by a complex system of biological uptake, absorption, and mineralization. Phosphates are not toxic to people or animals unless they are present in very high levels. Digestive problems could occur from extremely high levels of phosphate. The soluble or bio-available phosphate is then used by plants and animals. The phosphate becomes incorporated into the biological system, but the key areas include ATP, DNA, and RNA. ATP, adenosine triphosphate, which is important in the storage and use of energy and a key stage in the Kreb's Cycle. RNA and DNA are the backbones of life on this planet, via genetics. Therefore, the availability of phosphorus is a key factor controlling photosynthesis.

Due to natural and anthropogenic processes, a considerable number of phosphorus-containing compounds enter the reservoirs of Ukraine. According to official data, 3307 tonnes of phosphates were released into the Dnieper basin in 2015, in 2016 - 3054 tonnes, and in 2017. - 2,850 t. Only in the Kremenchug reservoir, during the year, about 1,8-2,4 thousand tons of mineral and 4,6-17,5 thousand tons of organic phosphorus are supplied, mainly with Kyiv sewage [2,3].

According to the results of researches in the calculation for each inhabitant of Ukraine daily in waste water 1,5-1,8 g of phosphorus arrives, efficiency of extraction of which at purification stations makes only 10-20% [3].

The content of phosphorus in natural waters depends largely on itinflow from the outside, so use of its biota by aquatic ecosystems. From the aquatic environment, hydrobionts absorb phosphorus in the form of orthophosphate, polyphosphates, phosphorus esters. Low molecular weight organophosphorus substances can be disposed of by autotrophic organisms only after their hydrolysis on the cell surface with the participation of phosphatase enzymes.



Once in water, the compounds of phosphorus are included in the biochemical cycles of the intracavitary processes of its rotation and practically do not leave it. Apatites and phosphorites are the main natural sources of inorganic phosphorus. In marine and continental reservoirs dissolved phosphorus is in the composition of inorganic and organic compounds. Organic phosphorus can be both dissolved and colloidal. As a component of almost all biological fluids and tissues, it is actively absorbed from the water by algae and higher aquatic plants. Most of the phosphates that are absorbed by plants and animals are returned to the water again as part of the metabolism and in the decomposition of organic matter. Phosphorus is constantly fed into the reservoirs naturally as a result of the processes of vital activity of the decomposition of residues of hydrobionts, weathering and dissolution of rocks and minerals and the like.

Surface water contamination with phosphorus-containing compounds occurs through the flow of domestic wastewater containing phosphates as components of synthetic detergents, photoreagents and water softeners. An important factor is also the erosion of phosphorus fertilizers and pesticides from agricultural lands, runoff of livestock farms and industrial enterprises (Fig. 1.1).

The contribution of each of these sources of phosphorus to aquatic ecosystems is, on average (according to EU data): municipal sewage - 1.1%; detergents - 38,8%; agricultural activity (fertilizers, plant protection products) – 34,8%; soil erosion - 4.7%; seasonal regeneration from bottom mineralized organic sediments - 12.0%; industrial activity - 3,1%; other sources of income - 5.5% [4].

The share of each source of water pollution with phosphorus may differ from the Central European ones, based on the specific natural and climatic conditions and the level of influence of human life.However, recovering P from WWTP effluent has high value, especially with growing P-limitation on global scales (see Fig. 1.1.).

It should be noted that the maximum permissible concentration (MPC) of phosphates in water for fisheries is 3.5 mg PO_4 / dm^3 or 0.2 mg P / dm^3 [5].

In Ukraine, it is known from scientific sources that the main source of revenue P is surface runoff from the area of the water intake basin of the river, the vital activity of hydrobionts and the intrinsic biochemical physicochemical processes. The main factors that determine the content and regime of P are the metrological conditions of the region (wind regime, temperature), volume and regime of water discharges, biological cycles of development of aquatic organisms and anthropogenic products.

These factors determine the significant amplitude of fluctuations in the content of P in time and in the water area of water bodies: from 0.001 to 20.500 mg P / dm^3 [6].

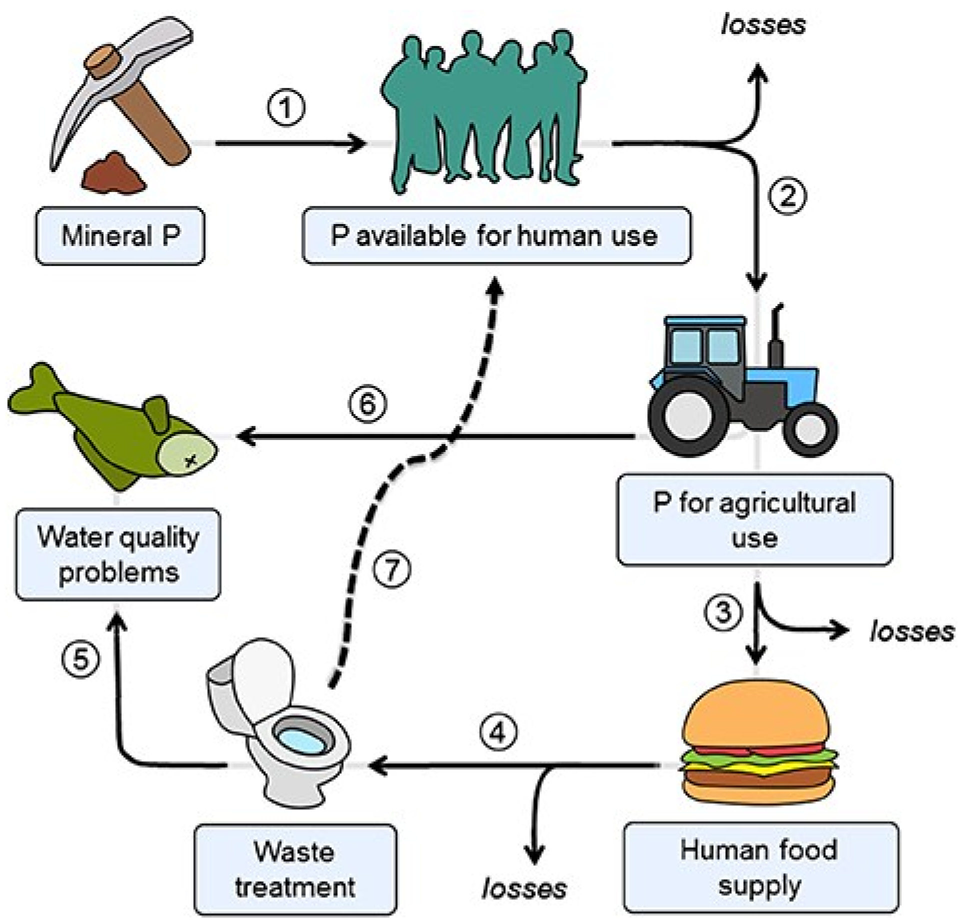


Fig. 1.1. Human P cycle

Solid lines denote the following flows: (1) mining of naturally occurring P mineral; (2) use of P for agriculture (e.g., in fertilizers); (3) P use in food (e.g., as a constituent or preservative); (4) P in human excreta; (5) P discharged to the environment as a result of inefficient P-removal in wastewater treatment; (6) P in agricultural run-off resulting in diffuse pollution (6). Dashed lines show the material flow option that closes the cycle via P recovery from wastewater (7).

In addition, a source of permanent replenishment of mineral compounds P in water may be the high intensity of destructive processes in its thickness, which often exceeds the production of phytoplankton, as well as the regeneration of P by zooplankton. It has been determined that, due to zooplankton regenerated, phosphorus can enter the reservoirs from 10 to 20% of its total content [7].

The only form of P that autotrophs can absorb is orthophosphate. Extracellular enzymes hydrolyze organic forms of P to phosphates. Excessive concentration of P is one of the most common causes of eutrophication of freshwater lakes, reservoirs, rivers and tops of estuary systems, resulting in excess production of autotrophs, especially algae and cyanobacteria. This high productivity leads to an increase in the bacterial population and high rates of respiration, which causes hypoxia or anoxia in poorly mixed bottom waters, as well as in surface waters at night in quiet, warm conditions. The low level of dissolved oxygen causes the death of aquatic animals and the release of many substances usually associated with sediments, including various forms of R. This, in turn, enhances eutrophication [1,5].

As noted above, a large proportion of phosphorus enters the reservoirs of detergents. The study of the hydrolysis process of detergents based on polyphosphates (PF) showed that their half-life in wastewater is 7.3 h at 15 ° C and 3.0 h at 20 ° C. The main factor of PF degradation in wastewater is considered to be enzymatic hydrolysis [8].

It is also important to note that phosphorus is a nutrient from limited and non-renewable sources whose operating speed is now much higher than the percent return of P to its natural cycle. It is anticipated that the known available sources of P will soon be exhausted with serious and irreversible economic, social and environmental consequences. Therefore, the control of domestic runoff, especially the amount of PF used in detergents, is essential for improving water quality, environmental protection and public health [3].

Thus, the level of phosphorus in water attests to the quality of the aquatic environment, indicates the processes occurring in ecosystems, and indicates the sources of contamination of the reservoirs with phosphates.

1.2.Influence of phosphates on the biota of aquatic ecosystems

The historical development of society took place on the basis of ideas about the inexhaustibility and self-renewal of fresh water reserves, which led to a significant degradation of the world's water resources. Currently, there is a shortage, depletion and deterioration due to ever-increasing pollution.

Even today, the limiting factor for water use is the quality of water resources, not their quantity. In the coming decades, demand for quality water is expected to grow sharply and water management problems will worsen. Synthetic surfactants and phosphates occupy a special place among water pollutants. And although aquatic ecosystems are capable of self-regulation and biological self-purification, they are unable to cope on their own with toxic compounds from the washing powders, which are extremely stable and persist in water for years.

Sources of phosphates in surface waters are divided into two categories:

- point sources (for example, industrial enterprises, sewage treatment plants of housing and communal services)

- diffuse sources (for example, effluents from agricultural lands).

However, it is noted that the main sources of phosphorus compounds in reservoirs are: precipitation, surface runoff from built-up areas, river runoff, soil erosion, abrasion (destruction of the shore), bottom sediments, drainage water of irrigation systems, as well as as a result of nitrogen fixation and photosynthesis of aquatic organisms. In addition, continental weathering, fertilizers, animal waste, and direct phosphate disposal are considered sources of phosphate. Of great importance is the contamination of water with detergents (synthetic detergents, which include salts of inorganic acids, phosphates). Detergents cover the surface of the reservoirs with a layer of surface film. It reduces evaporation, which causes increased heating of the water surface. The formation of the film prevents the entry of oxygen into the water and the release of carbon dioxide from the water into the air for a long time [1].

Scientists have proved experimentally that "trigger" water blooms are not so much phosphate fertilizers that get there from agricultural land, as phosphates from SMZ. If we take for 100% all sources of phosphorus in water bodies, then the share of phosphate fertilizers is 5%, and the share of phosphates from SMZ - 95%. Phosphates, which enter the biological sewage treatment plants at a concentration of more than 5 g / t with wastewater, almost completely inhibit the biological functions of activated sludge microorganisms and thus destroy the treatment facilities and join the natural environment untreated.

Algae, cyanobacteria and higher aquatic plants when entering the aquatic environment of nitrogen and phosphorus are able to accumulate them in significant quantities, whichthe initial stage creates conditions for the mass development of phytoplankton, the formation of primary products of organic matter and the enrichment of the aquatic environment with oxygen.

But over time, there is a discrepancy between the increase in phytoplankton biomass, the formation of organic matter and the amount of oxygen expended on the biological destruction and chemical oxidation of organic matter. Organic matter is formed more than it can be decomposed by microorganisms; organic matter accumulates, which pollutes water masses; at the same time, further growth of phytoplankton biomass is stimulated, and this further deepens and accelerates the eutrophication process [2].

Phosphates also cause great harm to the human body. Phosphate impurities create conditions for more intensive penetration of anionic surfactants through the skin: contribute to increased degreasing of the skin, dramatically reduce its barrier function, provoke dermatological diseases. Phosphates also penetrate the capillaries of the skin, are absorbed into the blood and spread throughout the body. At the same time, they change the percentage of hemoglobin, the structure and density of blood plasma, which leads to disruption of internal organs: kidneys, liver, skeletal muscle. The mechanism of metabolic disorders, exacerbation of chronic diseases and the emergence of new ones is launched. The mechanism of action of phosphates is their interaction with lipid-protein membranes and their penetration into the cell structure, which causes changes in biochemical and biophysical processes.

The main negative effect of phosphates in the environment is that they contribute to the mass development of algae in reservoirs, which makes the water unsuitable for household use. Developing algae paint water in different colors. Therefore, this process is called "flowering of reservoirs", which changes the smell, color and taste of water. When these algae die off, putrefactive processes develop in the reservoirs. Bacteria that oxidize organic compounds of algae, actively consume oxygen, so it begins to lack in reservoirs. This process is called "reservoir eutrophication" [9]. This leads to oxygen starvation and death of fish and other fauna in reservoirs (Fig. 1.2.).

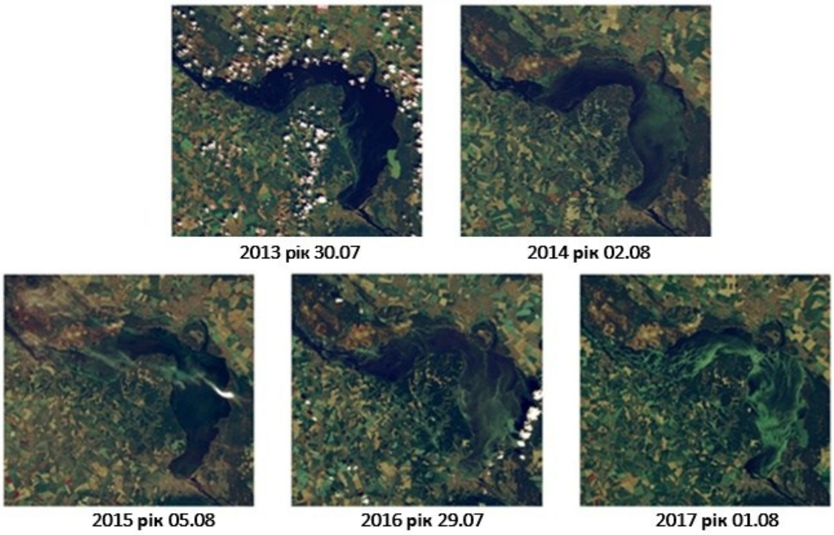


Figure 1.2. Satellite images of blue-green algae bloom in the Kaniv Reservoir in summer (during 2013-2017).

There is a constant exchange between hydrobionts and phosphorus-containing compounds in the aquatic environment. Yes, algae can accumulate in cells so much phosphorus that far exceeds the metabolic demand for it. Phosphorus excess storage can occur through the accumulation of phosphate ions in cell vacuoles or the formation of polyphosphate granules with a diameter of 30–500 μm. It is believed that such phosphorus storage is an adaptive response of algae formed during evolution to significant seasonal variations in its concentration in water. Reserved phosphorus is used by algae when it is deficient in the environment [10].

The metabolic role of phosphorus is evidenced by the fact that at low concentrations in water the process of photosynthesis in algae and higher aquatic plants is suspended. It plays an important role in intracellular metabolism and simply as a structural element of body tissues.

Algae not only utilize phosphorus from the water, but also release it during life or after dying. At various stages of their mass development, the concentration of phosphorus in water can also change significantly. Thus, with the intensive development of phytoplankton in summer, the warmest months in the surface layer of reservoir water, the concentration of phosphorus can drop to 0.03 mg / dm3. With autumn cooling and weakening of photosynthesis, its content in water increases to 0.055 mg / dm3. In places of biomass accumulation of blue-green algae, the content of mineral phosphorus can increase by 5-10 times. In this case, the concentration of organic phosphorus increases in the zone of "flowering" of water to 4.8, and in some cases - to 8.0 mg / dm3 [9, 10].

Increased concentrations of phosphorus affect the life of invertebrates. Thus, with a significant increase in the concentration of phosphorus in water, the death rate of juvenile daphnias, rotifers, diaphtomos increases dramatically, which affects the ability of reservoirs to self-purify due to the activity of filtering organisms [10].

Since phosphorus, as one of the main elements of the phosphate buffer system, plays an important role in the mechanism of maintaining acid-base balance in the blood and other biological fluids of the body of fish, its excess leads to a violation of physiological equilibrium and death. With a significant increase in the concentration of carbon dioxide in water and the threat of carbon dioxide (increasing the acidity of biological fluids), significantly increases the release of phosphates. Due to this, maintaining the balance of acidic and alkaline elements in the blood and, accordingly, acid-alkaline balance in the body of fish can be disturbed [11].

The pollution of surface waters by phosphates and the resulting eutrophication of reservoirs leads to a significant reduction of oxygen in the water and the toxic effects of algae products, especially in the summer, which causes shortness of breath and mass destruction of hydrobionts (Fig. 1.3.).

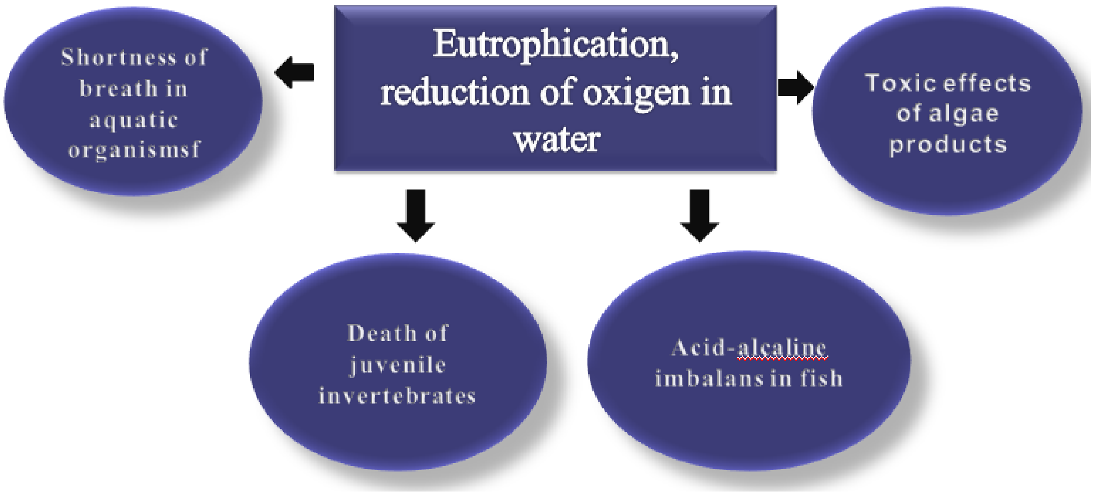


Figure 1.3.Influence of phosphates on the biota of aquatic ecosystems.

Therefore, in order to maintain ecological balance in aquatic ecosystems, it is necessary to control the phosphate content in water and to prevent its excess.

1.3. Phosphates in detergents composition as a factor in water pollution and human impact

The first synthetic detergents for home use were introduced in 1947. These compositions were based on sodium tripolyphosphate (TPP, tripolyphosphoric acid salt) as a component whose main role was to soften water and optimize its properties. The content of TPF in washing powders usually ranges from 15 to 40%. In detergents phosphates are used to bind fats to better remove contamination, so in the process of washing they penetrate deep into the fibers of the tissue. Scientists have proved that even 10 times rinsing in hot water does not completely release the fabric from the chemical compounds contained in the detergent. Therefore, the remaining phosphate compounds in contact with the skin are in direct contact, disrupting the acid-base balance of the protective layer of cells, which can lead to dermatological diseases [13].

Through the pores of the skin, phosphates enter the bloodstream, altering the percentage of hemoglobin and other indicators, which impairs kidney and liver function, which leads to poisoning and exacerbation of chronic diseases. Once inside the cell, phosphorus compounds cause profound changes in biochemical and biophysical processes. In addition, phosphates create the conditions for more intensive penetration through the skin of other chemicals contained in detergents and increase their toxic properties [12,13].

Phosphate contamination of detergents is a danger to aquatic ecosystems. It was established on the example of the Dneprodzerzhinsk reservoir that the indexes of the content of phosphates of return waters exceeded 3 times the norms of the maximum permissible concentrations [3]. Due to its chemical characteristics, TPF easily passes through traditional purification systems. Tripolyphosphate does not only damage the human body but also damages the ecosystem of water bodies. Blue-green algae during reproduction form a dense "coating" on the surface of the water, which does not allow sunlight and oxygen. Bacteria die and decompose, releasing toxins that cause the poisoning of aquatic organisms.

The majority of washing powders used in our country are made on the basis of aggressive components - phosphates, chlorine, zeolites and other dangerous chemical elements. The lion's share of harmful to human organism influence belongs to phosphates and surfactants. In general, laundry detergents sold on the territory of Ukraine contain 5–35% of phosphate substances [12].

The basis of most detergent powders is sodium tripolyphosphate, since this substance, when washing, reduces the stiffness of the water and improves the washing effect of the powder. It is the content of phosphate compounds in the detergent that is the main cause of allergies and impaired immunity after use. In addition, phosphates affect the skin, provoking the development of dermatological diseases, and the health of the body as a whole [11].

Phosphates are potentially dangerous to human health for many reasons. The effects of phosphorus compounds can impair the function of the kidneys, liver, skeletal muscles, which leads to impaired metabolism and poisoning. Phosphates from detergents penetrate the human body through the skin during cleaning, washing and hand washing without rubber gloves; drinking water contaminated with runoff after washing, etc., since even the most powerful filtration systems do not completely purify water; under-rinsed clothing, linen; respiratory tract during cleaning, washing and washing in a non-ventilated area. Sodium phosphate, calcium phosphate, and potassium phosphate are most commonly used in household chemicals and the food industry [13].

Phosphates are one of the most aggressive water pollutants. In view of this, the global community has set very stringent requirements for the content of phosphates in wastewater, drinking water and food.

In particular, in the western countries, the content of phosphates in surface waters should not exceed 1 mg / l, and in drinking water it should be at the level of 0.03 mg / l [4].

Phosphates contained in detergents are only part of the problem. Phosphorus compounds are also widely used in household chemicals, a huge industry that cannot be changed quickly. And equally dangerously, tons of phosphate fertilizers are applied to agricultural fields every year without any control. Some of these compounds eventually also end up in water. Together with sewage, these compounds also enter the Dnieper, stimulating the growth of blue-green algae, which leads to mass death of fish and significantly impairs the quality of river water - the largest source of drinking water in Ukraine.

1 gram of phosphates provokes growth of 5 to 10 kilograms of blue-green algae. When using a pack of 400 grams of detergent with 15% phosphate content, 60 grams of phosphate gets into the waste water!

Many European countries have introduced a legislative restriction on phosphate use two decades ago. Since then, they have achieved significant results, which has improved the ecological status of reservoirs.

1.4. Modern technologies for the extraction of phosphates from wastewater

We have made the analysis of modern perspective methods of extraction of phosphates from wastewater with the determination of the possibility of further use of phosphorus compounds based on the data of modern foreign scientific literature [4,8,14-19]. The application of some of them is planned for implementation during the reconstruction of the Bortnitskaya aeration station.

Phosphorus removal from wastewater can be accomplished by physico-chemical methods, biological treatment and / or combinations of both.

A common method is to add to the polluted waters salts (for example, salts of trivalent metals, ferric chloride), which precipitate P in wastewater, and the sediment is removed by settling under the force of gravity or filtration [8]. Although the precipitates obtained may be rich in P, the separation of chemically bound P can be complicated, making its effective recovery unlikely for future use. This is a disadvantage compared to biological P disposal systems because it limits the economic benefits of using it. Phosphorus concentrations in sewage of 1 mg / l can be achieved by conventional sedimentation, but more stringent wastewater standards generally require more sophisticated methods.

In recent years, there have been many studies to improve phosphorus removal in filtration systems using active media [14]. Unlike traditional filtration systems, filters with reactive media use the P-sorption properties of certain materials to deliberately remove P from wastewater [14-18]. Absorption media are made from natural products (eg apatite, bauxite or limestone), industrial waste (eg steel slag) or man-made products. The level of phosphate removal is 91% when using polonite for municipal wastewater treatment for 1 year with a P-sorption capacity of 120 g / kg.

Another method is the removal of P by the filter medium by the method of sorption or direct deposition. This is due to the movement of inorganic P from the wastewater to the surface of the reactive components (eg calcium or iron) contained in the environments where it accumulates [15]. Therefore, the ability to remove P depends on the content of minerals in the medium, artificial or natural (sand, gravel).

Advantages of using biological methods, in particular, bio-plateau - "adsorption" wetlands, can be attributed to the potential of low maintenance, aesthetic effect and the ability of such systems also reduce the need for biological oxygen consumption (BIA) and ammonium levels. The removal of P in wetlands without the use of absorbing media is limited to 40-60% [16,18].

Ion exchange mechanisms are also used to remove P. The predominant form of P in wastewater is anionic. Phosphate ions are reversibly exchanged between liquid wastewater and solid ionites, offering simultaneous removal and recovery [14]. Immobilized metal cation particles usually form a polymeric exchange base, which is called a polymeric ligand exchanger, which houses P-selective nanoparticles (eg, iron oxide). This approach favors the selection of phosphorus anions in the wastewater over other competing ions such as sulfates or chlorides. This has traditionally been difficult due to the relatively low amount of phosphate ions in wastewater compared to competing species. Recent attempts have increased efficiency by pre-treating ion-exchange media, such as iron oxide or aluminum hydroxide, to increase the selectivity for phosphate ions and result in a phosphorus removal rate of 80-90%.

The biological removal of phosphorus occurs primarily through the accumulation of its microorganisms beyond the "normal" requirements for metabolic processes. The accumulated P is a polyphosphate and is stored as a supply of energy for maintenance or for competitive advantage over conventional heterotrophs [15].

According to research, Accumulibacter phosphatis is the most effective microorganism and is the basis of most metabolic models. Other phosphorus-accumulating microorganisms include the genera Pseudomonas, Paracoccus, and some Enterobacter. It is now accepted that the level of biological removal of P is directly proportional to the amount of organism present in the system [16].

Current methods include membrane bioreactors (ICBMs), granular sedimentary reactors, and sequencing of sequential biofilm reactors. P removal rate up to 88% and final runoff rate 0.3 mg / L. Benefits of excellent wastewater quality and small physical footprint make the use of ICBM attractive for any size of sewage treatment plant. However, membrane contamination continues to be a problem and therefore requires a higher level of maintenance [17].

To sum up, it can be noted that in recent years there has been significant progress in existing technologies. The relative stability of biological removal of P continues to make it attractive to many applications [15 -19]. New technologies offer the potential for high levels of P removal, and some even achieve effective removal over long periods of time on various scales. However, such systems achieve high efficiency phosphorus removal at the cost of operational complexity and / or high energy consumption.

1.5. Conclusions to Chapter 1

In water bodies on the territory of Ukraine, the concentration of phosphates is exceeded several times, which causes the rapid development of algae in them. Eutrophication can lead to degradation of both freshwater and marine ecosystems, cause secondary water pollution and disrupt all water use, discoloration, temperature, reduced dissolved oxygen concentrations and deterioration of organoleptic characteristics, which not only complicates the use of water for water supply in urban areas and industrial enterprises. , and also disturbs the natural processes proceeding in reservoirs.

Surface water contamination with phosphorus-containing compounds occurs through the flow of domestic wastewater containing phosphates as components of synthetic detergents, photoreagents and water softeners. An important factor is also the erosion of phosphorus fertilizers and pesticides from agricultural lands, runoff of livestock farms and industrial enterprises.

The main negative effect of phosphates in the environment is that they contribute to the mass development of algae in reservoirs, which makes the water unsuitable for household use.This leads to oxygen starvation and death of fish and other fauna in reservoirs.

Phosphate contamination of detergents is a danger to aquatic ecosystems.Together with sewage, these compounds also enter the Dnieper, stimulating the growth of blue-green algae, which leads to mass death of fish and significantly impairs the quality of river water - the largest source of drinking water in Ukraine.

Physicochemical and biological methods can be used to remove phosphorus compounds from wastewater. Physico-chemical methods are more efficient than biological ones, but they are also more expensive, and their use produces large amounts of sludge, which is difficult to dispose of. Unfortunately, at the vast majority of treatment plants in Ukraine, phosphates are not removed to the values set by regulations. This is due to the fact that their concentration in wastewater has increased significantly over the last decade, and the modernization of equipment and the replacement of technologies with more efficient ones is not common and occurs only in some enterprises.

In recent years there has been significant progress in existing technologies.Such systems achieve high efficiency phosphorus removal at the cost of operational complexity and / or high energy consumption.

The application of some of them is planned for implementation during the reconstruction of the Bortnichi aeration station.

CHAPTER 2
MATERIALS AND METHODS OF PHOSPHATES RESEARCHIN AQUATIC ECOSYSTEMS AND WASTEWATER TREATMENT

2.1. Characteristics of the wastewater treatment system at the Bortnichi aeration station

Bortnichi Aeration Station (BAS) is a complex complex of engineering structures, equipment and communications, designed for complete biological wastewater treatment. The design capacity of the station is 1.8 million m3 per day. At present, from 700 thousand to 1 million m3 per day are actually treated.

The main problem of the station is that the existing scheme of wastewater treatment and sludge processing was developed and designed in the 50-60s of the last century, and since then no significant changes have been made to it. The quality of water purification was controlled by only three indicators: suspended solids, BSC20 and the concentration of dissolved oxygen. At the same time, today there have been sharp changes in the qualitative composition of wastewater entering treatment and, accordingly, in the quality of sludge formed during the treatment process. The design norms of the 1960s did not provide for wastewater treatment for individual compounds. Biological treatment facilities were designed to achieve only three indicators in treated water. Today, the quality of treated wastewater is controlled by 16 indicators.

To ensure the cleanliness of discharges into the Dnieper to the established norms now it is necessary to apply additional technological decisions – more often to remove activated sludge from constructions biological cleaning, to involve in work all technological constructions simultaneously and so on. However, this only partially solves the problem and it is becoming increasingly difficult to achieve European standards for the quality of treated wastewater at the existing rocks of the station.

The BSA uses a classical wastewater treatment scheme, which provides for mechanical (mechanical gratings, sand traps, primary settling tanks) and biological treatment (aeration tanks and secondary settling tanks). This technology is used on all units of treatment facilities (Fig. 2.1.).

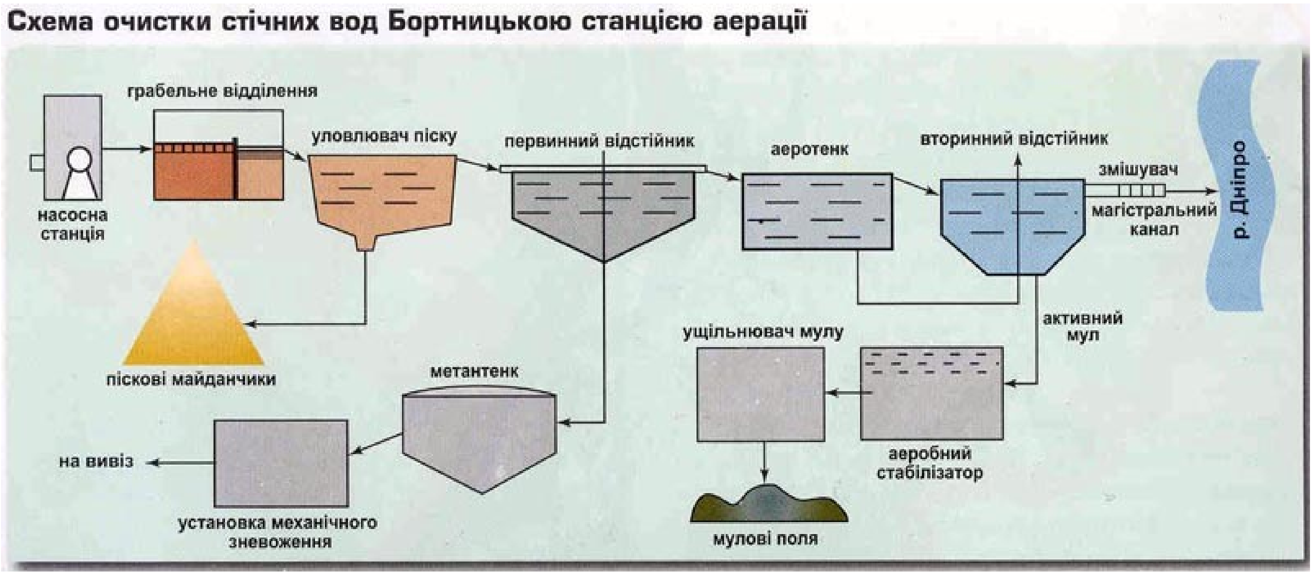


Fig. 2.1. Sewage treatment scheme at Bortnichi aeration station

Wastewater first enters the receiving channel of the rake compartment of the pumping station, and then on the gratings with a mechanical rake. Garbage retained on the grates is collected by a conveyor in a special storage hopper and taken to the Energia plant for incineration.

Wastewater is pumped to the rakes of the rake compartment, and then to the sand traps. Starting from the grates, wastewater moves through all structures by gravity.

Wastewater treatment is performed in the following sequence:

- large and floating debris is removed on the grates;

- heavy mineral contaminants (mainly sand) are released in sand traps;

- coarsely dispersed mineral suspended substances, insoluble organic impurities, floating substances, fats are retained in the primary settling tanks;

- clarified water, which contains fine-dispersed suspension, soluble and colloidal organic matter, enters the aeration tanks, where the biological oxidation of organic substances by activated sludge takes place at intensive saturation of the liquid with air;

- the sludge mixture after the aeration tanks enters the secondary settling tanks, where the mechanical settling of the activated sludge takes place, which is continuously removed from the settling tanks by silos, and then returned to the aerospace by the pumps located in the pumping stations of the aeration tanks;

- biologically purified water from secondary settling tanks enters the drainage channel, and from it - to the main channel.

The treatment of treated wastewater is carried out through a side spillway, which is equipped with thresholds for water saturation with oxygen, to the main channel. Purified water from all queues along the main canal is diverted to the Bortnychi-Vyshenky pumping station, and then through the dispersing outlet to the Dnieper River. The sludge formed in the process of wastewater treatment is subject to processing in order to reduce the volume. Sludge treatment takes place in special facilities - methane tanks and aerobic stabilizers. After treatment, the sludge is pumped to the silt fields for further drying under natural conditions. Stabilized activated sludge is compacted in sludge compactors and then pumped to sludge fields for dehydration

The service life of the main buildings and equipment reaches 30-40 years. There is a constant destruction of reinforced concrete and metal structures of technological structures, due to great wear and tear the main pumping and blowing equipment fails, technological processes are destroyed by corrosion processes.

The task for today is to implement a single project for the complete reconstruction of the station.

2.2. Determination of phosphate content in water

To determine the content of phosphates in surface waters, water samples were taken in the Dnieper River in the area of the BSA and in the discharge channel and in June and September 2019 at points according to the scheme (Fig. 2.2.). Water samples taken in the discharge channel, as well as at a distance of 200 m above and 250 m below the discharge of water from the channel into the Dnieper were used for the study.

In surface waters, phosphorus is present mainly in the form of inorganic soluble phosphates. To determine them, a colorimetric method was used using molybdate and antimony salts, and the complexes formed were reduced with ascorbic acid. The reaction was carried out at room temperature. In this case, polyphosphates are not hydrolyzed, and organic phosphates do not decompose. For analysis, 50 ml of unfiltered, well-mixed sample was measured in a glass or other vessel made of chemically resistant glass. To this sample was added 0.15 ml (3 drops) of hydrogen peroxide and exactly 1.0 ml of 37% sulfuric acid solution.

Fig. 2.2. Map-scheme of water water sampling in the area of discharge of Bortnytsia aeration station: A - above the discharge into the Dnieper 200 m; B - discharge channel BSA; C - below the discharge into the Dnieper 250 m.

At the same time, a blank experiment was performed with 50 ml of distilled water. The mixture was heated to 160 ° C and evaporated for 6 hours. The mineralized sample must be clean and colorless. After cooling, the sample was made up to a volume of 30 ml with distilled water, boiled for some time, cooled and quantitatively transferred to a flask, bringing the volume to 50 ml. After that, orthophosphate ions began to be determined. To do this, 2 ml of ascorbic acid solution was added to the sample. The mixture was stirred. Next, the optical density was measured over a period of 5 to 15 minutes. The content of total and inorganic phosphorus was determined using a calibration graph. Statistical processing of the obtained data was performed by the described conventional methods [20].

2.3.Conclusions to Chapter 2

Bortnichi Aeration Station (BAS) is a complex complex of engineering structures, equipment and communications, designed for complete biological wastewater treatment.

The old treatment technologies do not allow to reach the established norms for wastewater, which causes eutrophication and death of aquatic organisms. The solution to this problem is to improve cleaning systems and limit the use of phosphorus-containing detergents.

The task for today is to implement a single project for the complete reconstruction of the station.

CHAPTER 3

PROSPECTS OF REDUCING THE PHOSPHATES IMPACT ON AQUATIC ECOSYSTEMS IN CONNECTION WITH THE RECONSTRUCTION OF THE BORTNICHIAERATION STATION

3.1. Phosphate content in surface waters after discharge of the Bortnichi aeration station

In recent years, in the wastewater entering the Bortnichi aeration station, according to the information of Kyivvodokanal, the amount of phosphates has increased sharply (Fig. 3.1).

Рік	Концентрація фосфатів, мг/л (середня за рік по Бортницькій станції аерації)
1998	8,46
1999	9,16
2000	8,18
2001	7,99
2002	8,69
2003	7,29
2004	12,2
2005	11,07
2006	14,16
2007	17,78
2008	18,46
2009	19,32
2010	17,74
2011	17,76
2012	16,81
2013	18,5
2014	20,54
2015	20,2
2016	19,91
2017	23,15
2018	23,02
2019(1 півріччя)	26,23

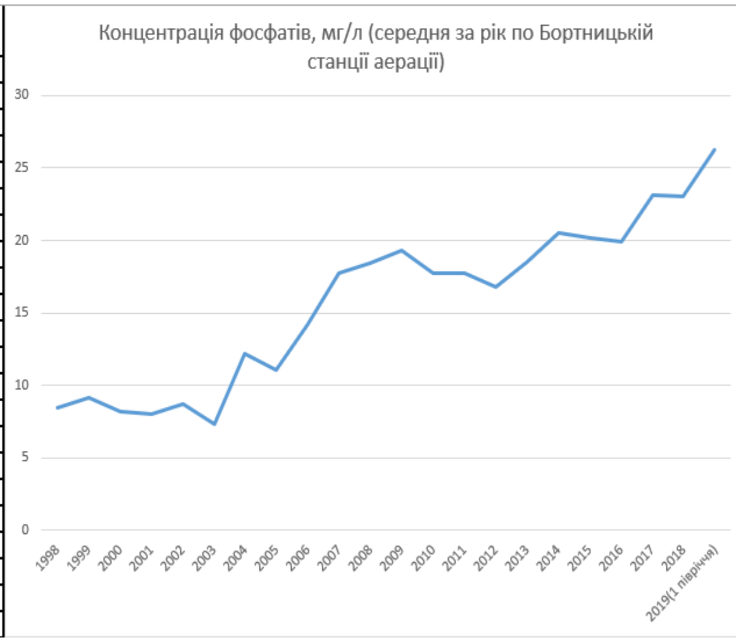


Fig.3.1. Concentration of phosphates, mg / l (average per year) in wastewater entering the facilities of Bortnichi aeration station for the period 1998-2019.

If in the mid-90s of the last century the concentration of phosphates in wastewater supplied to buildings was 6-8 mg / l, today it reaches almost 30 mg / l, with the standard discharge into the city sewer network 8.0 mg / l . Phosphates in such significant concentrations in wastewater significantly impair the quality of treatment, as they affect the biocenosis of activated sludge of aeration tanks, reducing the amount of dissolved oxygen. Therefore, the only way to solve the problem right now is to reduce the amount of phosphates entering the aeration station.

A similar situation with changes in the composition of wastewater, accompanied by increasing concentrations of synthetic surfactants (SPAR) and phosphates, has recently developed at many sewage treatment plants in different cities of Ukraine (Kharkiv, Poltava, Lviv, Kramatorsk and others) [21 -23]. This indicates the universality of the studied problem, as the technology of municipal wastewater treatment using aeration tanks is quite similar.

High concentrations of phosphates in wastewater and outdated technologies lead to insufficient treatment water entering the wastewater channel. Our task was to determine the degree of phosphate contamination of surface waters in different reservoirs and near the discharge of treated effluents by the Bortnichi aeration station. Measurements were conducted in June 2019 on the basis of the Institute of Hydrobiology of the National Academy of Sciences of Ukraine.

Studies have shown that the content of phosphates in the water of the discharge channel of the Bortnytsia aeration station was 22.5 times higher than in the water of the Dnieper above Kyiv and amounted to 4.5 mg per liter (Fig. 3.2).

Determination of phosphates in the surface waters of two rivers showed a significant difference in the degree of pollution of the Nivka in comparison with the river Irpin. This is due to discharges of insufficiently treated effluents from industrial enterprises located on the banks of the Nivka.

Based on the fact that in order to preserve aquatic ecosystems it is necessary to approach the European surface water quality standards, which are 1 mg / l in terms of phosphate pollution, the results obtained so far indicate that BSA does not sufficiently treat Kyiv wastewater from phosphorus-containing compounds. Once in surface water, these compounds are included in the biochemical cycles of intra-reservoir processes and practically do not leave the reservoir. The main biochemical pathway of assimilation of mineral phosphates by aquatic plants is through ATP with the inclusion of their reaction of carbohydrate metabolism and biosynthesis of phospholipids . Excess phosphates partly get into sediments and bottom sediments, partly remain in water, affecting aquatic organisms.

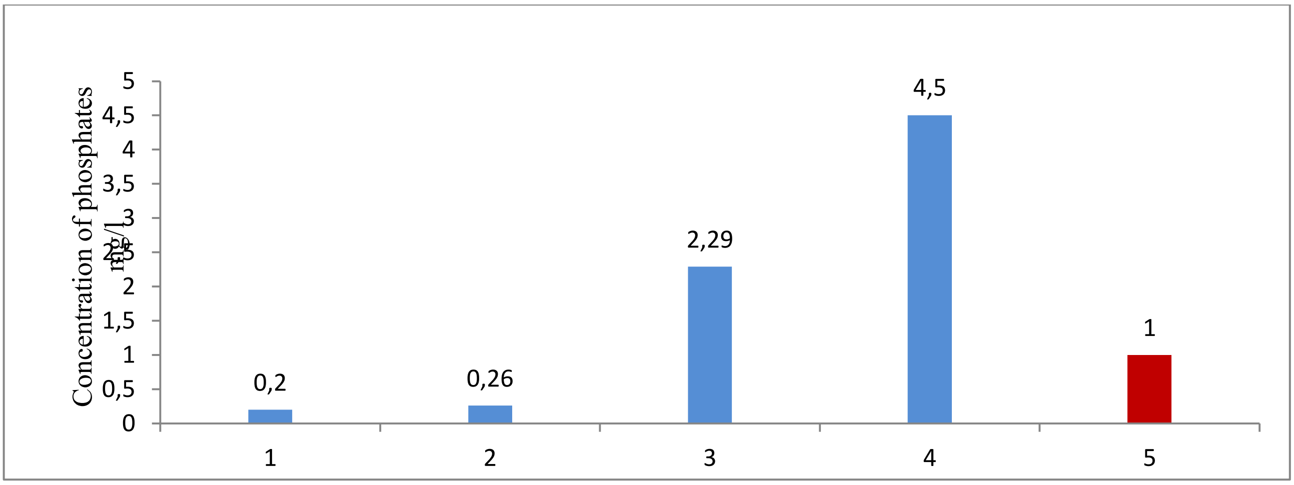


Fig.3.2. Concentration of phosphates in surface waters of reservoirswithin Kyiv:

1 - the Dnieper River above Kyiv;

2 - the river Irpin;

3 - Nyvka river;

4 - discharge channel of Bortnytsia aeration station;

5 - European standard for the concentration of phosphates.

Thus, to reduce the impact of phosphate pollution on aquatic ecosystems, it is necessary to use effective methods of extracting these compounds from wastewater and take measures to reduce their inflow to treatment plants.

3.2. Limiting the content of phosphates in washing powders as a promising measure to prevent contamination

On the basis of PJSC "AK Kyivvodokanal" a study of the content of phosphates in washing powders currently sold in Ukraine was conducted (Table 3.1.)

As can be seen from the table, a number of powders, in particular, intended for washing children's things, contain a significant amount of phosphates, from 4.7 to 9.2%.

Restrictions on the content of phosphates and surfactants in commercial detergents have been introduced in all European countries at the level of legislation. For example, in Germany, after the introduction of restrictions on the content of phosphates in detergents and changes in the technology of their manufacture, the concentration of phosphates in wastewater entering the aeration station, decreased to 8-12.5 mg / liter. The presence of phosphates in detergents is strictly regulated at the highest state level in the countries that put the production of "green chemicals" in the first place in order to preserve the health of the nation. Today, the European Union has legislation banning the use of phosphates in washing powders.

Unfortunately, such laws do not exist in Ukraine.

In Ukraine today, the rate of phosphates in powders is 5.4% (22% in terms of P2O5). Environmental standards for the content of phosphates in wastewater and the size of penalties for exceeding them have been developed, but for unknown reasons they do not apply.

In countries where the use of phosphate-containing SMCs is limited, phosphate-free detergents based on zeolites and copolymers have been introduced to the market. However, it turned out that they also can not be considered completely safe for human health and the environment. Leading EU detergent manufacturers have acknowledged their inability to currently provide society with safe, high-performance household chemicals. Although the program to limit the supply of phosphates to water bodies in some countries has yielded very positive results, but in the world as a whole, this problem remains relevant.As we wrote above, the traditional aerobic wastewater treatment technology does not provide full removal of phosphates and they fall into the reservoirs from which drinking water is taken.

The degree of removal of phosphates by traditional technology is equal to 10-25% depending on the season.

Modern technologies for removing phosphorus from wastewater are:

• chemical (effect on effluents with soluble salts of sodium orthophosphate, as a result of which a fine anhydrous precipitate is formed. At the same time, it coagulates

Table 3.1

Analysis of washing powders

№ з/п	Name of washing powder	Information on the package on the content of anionic and nonionic surfactants,%	The results of studies on the total phosphorus content,%
Samples that meet European standards			
	«Tide Automatic Color Lenor Touch of Scent»	<5/<5	<0.02
	«Ariel Automat Purity Deluxe Color Touch of Lenor Fresh»	5-15/<5	<0.02
	«Green & Clean Color Automat»	<5/ <5	0.02
	“White sails Color»	<5/<5	0.02
	«Persil Expert Pearls of freshness from Silan»	5-15/<5	0.03
	«Galinka», for children	5-15/<5	0.03
	«GalaFrosty freshness Anti-fat»	5-15/<5	0.04
	«Frosch ecologicalCitrus»	-/5-15	0.05
	«Rex 3xActive Mountain freshness»	5-15/<5	0.1
	«Losk 9 Total SystemMountain Lake»	5-15/<5	0.25
Samples that do not meet European standards			
	«Max Automatic Spring freshness»	5-15/<5	4.7
	«Pupsik», for children	-/-	5.4
	«Alenka», for children	-/-	7.7
	«Sarma ActiveMountain freshness»	5-15/<5	7.8
	«Eared nannies ", for children	5-15/<5	9.2

with large flakes of sludge formed by the interaction of the reagent with alkalis);

• physicochemical (magnetic field cleaning, electrocoagulation, crystallization);

• biological methods involve modification of biomass by incorporating phosphorus into the cellular substance and using it for anaerobic water purification.

These methods significantly increase the cost of technology. In high-income countries, where these technologies were introduced, restrictions on phosphate content were still introduced, as it was cheaper to develop and introduce phosphate-free household chemicals than to treat effluents.

The EU has banned the use of household phosphate detergents since 2011, and a ban on the use of phosphate dishwashers has come into force since 2017. It is worth noting that many EU countries in the late 80's of last century abandoned the use of such detergents or significantly limited it. In addition, many EU countries have limited consumption of phosphorus fertilizers. With regard to industry, here phosphorus-containing compounds are also strictly regulated and high fines for draining them into the sewer.

Today in Ukraine the phosphate content is normalized only by the technical conditions for the final product.

The issue of phosphates was first raised in 2013. Then the Cabinet of Ministers of Ukraine submitted to the Verkhovna Rada the draft law 2535, which provided for the gradual introduction of a ban on the production, import and sale in Ukraine of phosphate detergents and household chemicals. Then restrictions were proposed from 2014 - by 17%; from 2016 - by 10%; from 2019 - by 5% and from 2021 - by 0.7%. The bill did not pass the vote.

This issue was actively raised for the second time in 2018 (Bill 8138 of March 15, 2018 "On state regulation in the field of detergents"). But the project was not even considered by the Verkhovna Rada. It was proposed to ban the import of detergents with anionic surfactants that do not meet EU standards, introduce a limit on the maximum allowable phosphorus content of 5% and a total ban on the use of chlorine and organochlorine. From 2021, it was proposed to limit the production, import and sale of products containing anionic surfactants by more than 3% and phosphates by more than 0.2% by weight of detergent.

In October 2019, the Council rejected a similar bill number 1173 and sent it for revision.

Legislation banning phosphates is very important for the ecological status of surface waters.

In Canada, as early as 1973, the amount of phosphorus in detergents was limited to 2.2% (approximately 26% of tripolyphosphate). In 2010, their content was limited to 0.5% (about 6% tripolyphosphate). Not applicable today.

The situation in the United States is generally similar to the European one, but changes began to be introduced later. Today, some states have limited phosphate detergents, some even industrial chemicals. But there is a full-fledged treatment of effluents from phosphates.

Japan has completely restricted the use of phosphates since 1986.

Thus, one way to improve the environment is to introduce stricter standards that reduce the use of phosphates, which are part of washing powders, household chemicals and agricultural fertilizers.

To achieve this goal, a set of measures must be taken with the financial and legal support of the state.Summarizing all the above, we can propose the following measures to reduce the supply of phosphates to aquatic ecosystems (Table 3.2.).

Table 3.2

Measures to prevent water pollution by phosphates

N	Measures
1	Legislative restriction and prohibition on the use of phosphate detergents and restrictions on the use of phosphate fertilizers
2	Introduction of penalties and tax for violation of the content of P in wastewater.
3	Construction of additional treatment systems and reconstruction of existing wastewater treatment plants
4	Introduction of the most effective methods of wastewater treatment, which include a combination of biological and chemical (reagent) methods
6	Application of biological methods of wastewater treatment (phytoremediation technologies)
7	Carrying out of scientific researches for the purpose of creation of safe detergents and improvement of technologies of sewage treatment at maintenance of financial support from the state.

3.3. Introduction of effective systems of wastewater treatment from phosphates during the reconstruction of Bortnichi aeration station

In order to solve the problems of the sewerage system of Kyiv and improve the water quality in the Dnieper River and the state of the environment of Kyiv, the target program "Drinking water of Kyiv for 2011-2020" of the Kyiv City State Administration proposed the reconstruction of the Bortnichi aeration station. .

The Bortnichi aeration station was built in the period from the 1960s to the 1990s, as of today due to significant changes both in the composition of wastewater entering the treatment and as the sludge formed, the available technological schemes are obsolete and unsuitable for use without a full reconstruction. The facilities of the station have been in operation for 30-50 years and have not undergone significant changes. Reinforced concrete and metal structures of technological structures are constantly destroyed, due to heavy wear, pumping and blowing equipment fails, corrosion processes destroy technological pipelines. The total percentage of wear of the Bortnytsia aeration station is 70-90%.

In 2015, the Government of Ukraine and the Government of Japan agreed to provide a loan for the modernization of the Bortnichisewage treatment plant within the project "Reconstruction of sewage treatment plants and construction of a technological line for treatment and disposal of sludge Bortnytsia aeration station." Implementation of direct construction works is scheduled for February 2020 - August 2025.

During the development of the project for the reconstruction of the Bortnytsia aeration station, the latest domestic and world standards were taken into account. The quality of treated wastewater in the future will be monitored by 10 indicators, and the design capacity of the station will be 1,573,000 m3 per day.

Before discharge to the water body, the treated wastewater is disinfected with ultraviolet radiation.

New buildings for mechanical wastewater treatment will be built for each unit of the station, they will include two-stage treatment on mechanized gratings, sand traps, grease traps and primary settling tanks within one building. Reconstruction of aeration tanks of Units 2 and 3 is planned, and new aeration tanks will be built for Unit 1 for complete biological wastewater treatment with the creation of nitrification and denitrification zones.

The method of deep removal of nutrients from wastewater is based on traditional biological treatment with a combination of anaerobic and aerobic processes. The basis of the biological method of removal of phosphorus compounds is the ability of some species of bacteria to store more soluble orthophosphates in cells in the form of insoluble polyphosphate. In the aerobic zone, the cells oxidize previously stored organic matter, and the energy released is used by bacteria to absorb orthophosphate from the aqueous medium, converting it to polyphosphate to repeat the cycle and cell growth.

However, the presence of insoluble forms of phosphorus compounds can lead to a decrease in the level of purification, as insoluble compounds in the solid phase cannot be assimilated by microorganisms, and therefore pre-filtration or settling of effluents before biological treatment is required [3].

With a high content of phosphorus compounds, it is not always possible to remove it by biological methods. In this case, use reagent methods. Chemical methods can be applied before the first settling tank to the anaerobic zone or after aerobic treatment before the second settling tank. The choice of reagent depends on its availability and cost in the region where the effluent is treated. The place of its introduction for 5b5 of each case is established individually on the basis of preliminary laboratory researches with the subsequent check of the received results in industrial conditions. With a high content of phosphates in wastewater, the biological method of treatment should be combined with chemical.

The combination of biological wastewater treatment from phosphorus with chemical treatment is economical and efficient to use if chemical precipitation is used to remove residual phosphates. The improved process of biological wastewater treatment from phosphorus with simultaneous precipitation allows to significantly increase the phosphate content in the dry residue [1].

It is advisable to treat wastewater from phosphorus compounds, because in their excess cyanobacteria are formed, which cause eutrophication of water bodies. It is most effective to use combined purification methods, which combine biological and chemical (reagent) methodThe efficiency of wastewater phosphate treatment depends largely on the nature of the coagulant, the technological scheme and the activity of activated sludge microorganisms.

During the reconstruction of the aeration station the deposition of phosphates with coagulants is provided depending on the degree of pollution of wastewater according to three technological schemes: at phosphate concentration more than 15 mg per l - at the inlet (upper scheme), from 10 to 15 - average, less than 10 - lower scheme . In activated sludge, the new technology involves the use of microorganisms hyperphosphate phosphates, in particular Accumulibacter phosphatis. (Fig. 3.3).

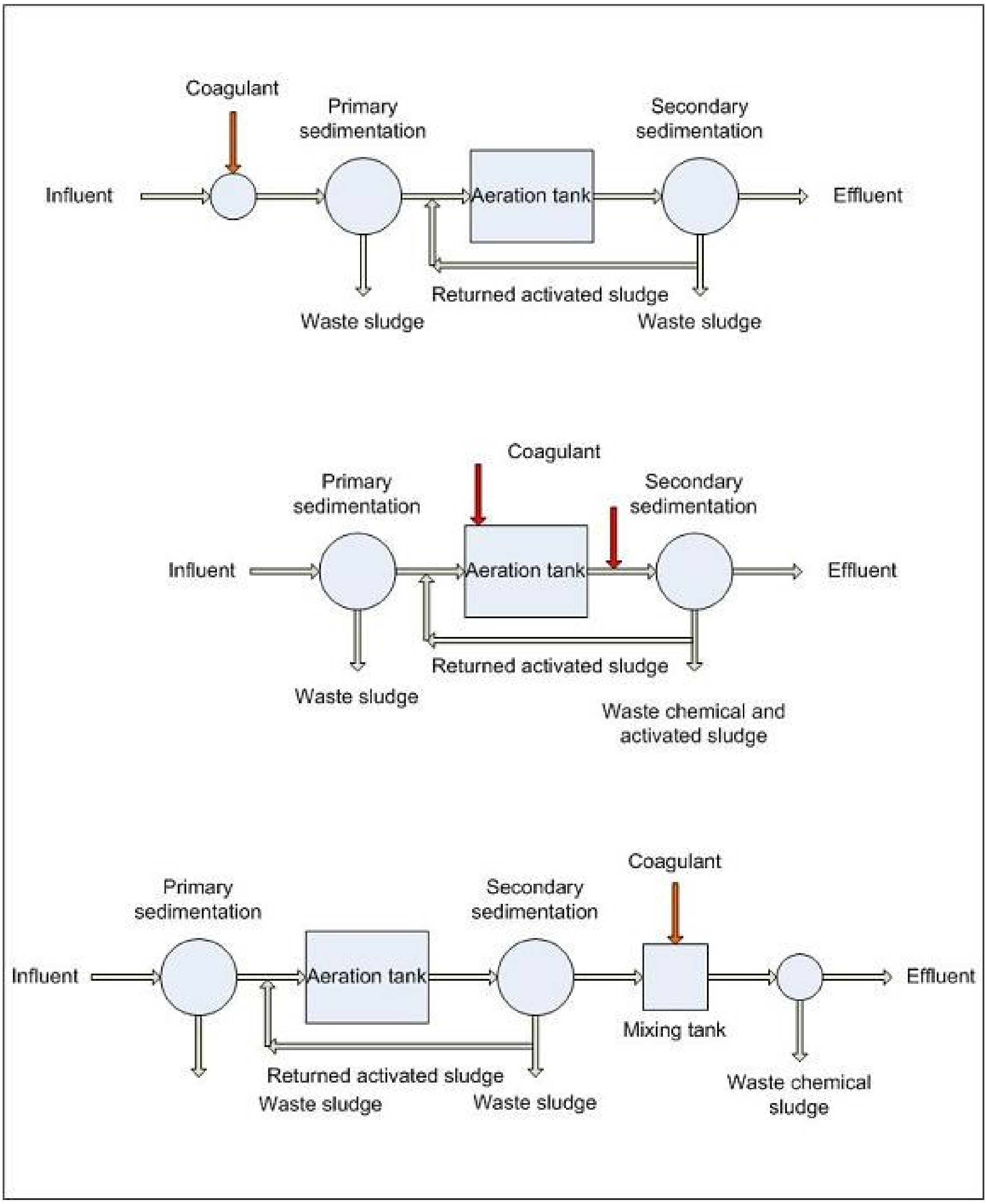


Fig.3.3.Technological schemes of phosphate deposition by means of coagulants at various degree of pollution of entrance sewage.

The principal advantages of biological phosphorous removal are reduced chemical costs and less sludge production as compared to chemical precipitation.

In the biological removal of phosphorous, the phosphorous in the influent wastewater is incorporated into cell biomass, which is subsequently removed from the process as a result of sludge wasting. The reactor configuration provides the P accumulating organisms (PAO) with a competitive advantage over other bacteria. So PAO are encouraged to grow and consume phosphorous.

The reactor configuration in comprised of an anaerobic tank and an activated sludge activated tank. The retention time in the anaerobic tank is about 0.50 to 1.00 hours and its contents are mixed to provide contact with the return activated sludge and influent wastewater.

In the anaerobic zone: Under anaerobic conditions, PAO assimilate fermentation products (i.e. volatile fatty acids) into storage products within the cells with the concomitant release of phosphorous from stored polyphosphates. Acetate is produced by fermentation of bsCOD, which is dissolved degradable organic material that can be easily assimilated by the biomass. Using energy available from stored polyphosphates, the PAO assimilate acetate and produce intracellular polyhydroxybutyrate (PHB) storage products. Concurrent with the acetate uptake is the release of orthophosphates, as well as magnesium, potassium, calcium cations. The PHB content in the PAO increases as the polyphosphate decreases.

In the aerobic zone: energy is produced by the oxidation of storage products and polyphosphate storage within the cell increases. Stored PHB is metabolized, providing energy from oxidation and carbon for new cell growth. Some glycogen is produced from PHB metabolism. The energy released from PHB oxidation is used to form polyphosphate bonds in cell storage. The soluble orthophosphate is removed from solution and incorporated into polyphosphates within the bacterial cell. PHB utilisation also enhances cell growth and this new biomass with high polyphosphate storage accounts for phosphorous removal. As a portion of the biomass is wasted, the stored phosphorous is removed from the biotreatment reactor for ultimate disposal with the waste sludge.

Reconstruction plans for the plant provide for the introduction of new modern technologies for the extraction of phosphates from wastewater. These are the mechanisms of ion exchange using solid ion exchangers, as well as the use of membrane bioreactors. In addition, the use of Accumulibacter phosphatis microorganisms in the activated sludge, which are the most active phosphate accumulators, is envisaged.

The possibility of using plants for wastewater treatment from phosphates in an experimental installation in order to ensure deep removal of phosphorus compounds is shown. A sand-gravel filter withdownward-upward movement of water, on the surface of which plants are planted. Filtration took place using the root system of plants (Fig. 6).

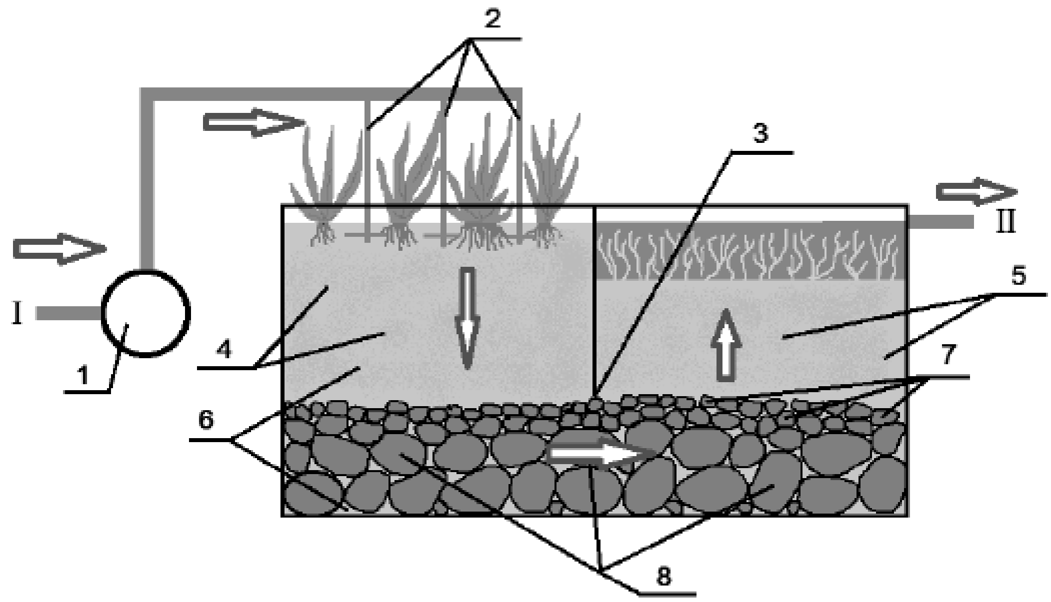


Fig. 6. Scheme of biological treatment of wastewater from phosphates:
1 - pump; 2 - system of uniform distribution and irrigation; 3 - partition for download fixation; 4 - downstream filter with planted plants;
5 - filter with ascending flow and aquatic plants; 6 - sand loading;
7 - gravel loading (small fraction); 8 - gravel loading (large faction); I - wastewater after biological treatment; II - purified water

Plants in the building for post-treatment perform a number of functions: filtration; absorbing; accumulative; detoxification.

It is established that the use of additional treatment allows to obtain the value of the concentration of phosphates in wastewater 0.5-1 mg / dm3. In the future, the resulting crop of plants can be used as raw material for productionbioethanol or biomass for combustion.

To reduce the concentration of phosphorus in wastewater treatment, the construction of a new facility - Unit 1 - using the above-mentioned modern technologies, which will achieve European quality standards. The design indicators of wastewater treatment provide for a total phosphorus concentration of 1.0 mg / l.

Achieving such a concentration meets European standards for surface waters and will preserve the ecological balance of aquatic ecosystems of the Dnieper River, as well as provide quality drinking water to a significant part of the population of Ukraine.

3.4. Regulatory requirements of the European Union and Ukraine on prevention of water pollution

Adaptation of Ukrainian legislation to EU legislation is one of the main components of the process of Ukraine's integration into the EU and a priority direction of Ukraine's foreign policy. In the EU, much attention is being paid to preventing environmental pollution and ensuring the quality of wastewater treatment.

In order to completely ban the use of synthetic detergents and household chemicals based on phosphates in Ukraine, the State Water Agency has developed a draft resolution of the Cabinet of Ministers of Ukraine "On Amendments to the Technical Regulations of Detergents".

Adoption of the draft resolution of the Cabinet of Ministers of Ukraine will help reduce discharges of phosphates and other phosphorus compounds together with wastewater to surface water bodies.

This, in turn, will improve water quality and reduce the intensity of flowering processes in reservoirs.

Implementation of the EU-Ukraine Association Agreement means, among other things, the need for introduction of European standards and norms in the field of environmental protection. Implementation of European environmental policy in Ukrainedemands obligatory coordination of organizational, economic and legal aspects ofgovernance that is crucial for its effective functioning.

Current ecological situation in Ukraine has extremely negative parameters.

Industrial accidents became more frequent, that have demonstrated improper situation concerning the compliance by business entities, which activity is highly hazardous, with requirements of environmental legislation and ignoring of basic safety rules.

One of the most important vital human needs is the satisfaction of need for qualitative and safe drinking water. The human right to drinking water is considered by us as a physical right without which human existence is impossible.

Therefore, we consider it necessary to improve organizational and legal mechanism of control of quality and safety of drinking water and to adopt the State concept of realization of human right to qualitative and safe drinking water.

Requirements of the article 13 of the Council Directive 98/83/EC concerning measures necessary to ensure that adequate and up-to-date information on the quality of water intended for human consumption is available to consumers also is not implemented in practice, although are provided by Article 9 of the Law of Ukraine "On Drinking Water and Drinking Water Supply" and by Order of preparation and publication of national reports on water quality and state of drinking water in Ukraine, approved by the Cabinet of Ministers of Ukraine of 29.04.2004, № 576.

Most European directives and regulations are formulated very specific, with the establishment of parameters and criteria of quality of environmental components, specific responsibilities of specific subjects. Instead, Ukrainian environmental legislation establishes general requirements, defines the principles, goals, but does not determine the ways of their achievement. Specific regulatory parameters can be found only in the state standards, most of which are not in the public domain.

Ukrainian environmental legislation is declarative, does not contain the terms for achieving quantitative and qualitative results, does not establish effective system of control. Penalties for failure (improper execution) of relevant requirements are not set.

Provisions of Ukrainian legislation are not sufficient to ensure the prevention and elimination of damage caused to the environment and must be improved. In particular, Law "On prevention and elimination of damage caused to the environment" and State concept of realization of human rights to qualitative and safe drinking water should be adopted.

To ensure the implementation of European environmental standards into Ukrainian legislation just adoption of laws is not enough. For implementation it is also necessary to ensure the availability of appropriate institutions and budgets for the implementation of these laws and other normative legal acts. Also it is necessary to create an effective system of monitoring and sanctions in order to insure that requirements of the laws are implemented completely and appropriately.

3.5. Conclusions to Chapter 3

Thus, the problem of significant pollution of surface and wastewater by phosphates needs to be addressed immediately, as the anthropogenic impact on the biota of aquatic ecosystems has recently become catastrophic. All over the world have come to the conclusion that there is a need for strict restrictions and even a total ban on the use of phosphorus-containing washing powders and dishwasher detergents.

On the other hand, it is necessary to improve wastewater treatment systems at all enterprises, both municipal and industrial, and in farms and households. It is advisable to use the latest technologies. Reconstruction of the Bortnichi aeration station is a necessary and only the first step towards cleaning the environment from phosphates and saving aquatic ecosystems.

CONCLUSIONS

1. The danger of water pollution by phosphates due to the impact on biota and humans due to the deterioration of surface water quality has been determined. Eutrophication of water bodies due to the significant development of blue-green algae leads to the death of aquatic organisms, the release of toxic substances and the degradation of ecosystems.

2. Sources of phosphate pollution of aquatic ecosystems on average are: municipal sewage - 1.1%; detergents - 38.8%; agricultural activity (fertilizers, plant protection products) – 34,8%; soil erosion - 4.7%; seasonal regeneration from bottom mineralized organic deposits - 12.0%; industrial activity - 3.1%; other sources of income - 5.5%.

3. Contamination of surface waters with phosphates is largely due to the inflow of domestic wastewater containing phosphates as components of synthetic detergents. Washing powders sold on the territory of Ukraine contain 5–35% of phosphate substances that are not removed by outdated cleaning technologies at the Bortnichi aeration station. To solve this problem, it is necessary to impose restrictions on the use of phosphorus-containing detergents.

4. The analysis of modern perspective methods of phosphate extraction from sewage with determination of possibility of further use of phosphorus compounds on the basis of data of foreign scientific literature is made.

5. The content of phosphates in the water of the discharge channel, as well as above and below the discharge of wastewater after treatment at the Bortnytsia aeration station was studied. The obtained results testify that in order to achieve European standards it is necessary to improve the treatment of wastewater from phosphorus-containing compounds.

6. It is shown that the introduction of effective wastewater treatment systems from phosphates during the reconstruction of Bortnichi aeration station to achieve the degree of wastewater treatment from phosphates to the planned indicators for wastewater 1 mg / l it is advisable to use modern advanced treatment technologies. In addition, the use of Accumulibacter phosphatis, the most active phosphate accumulators, in activated sludge is recommended.

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