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: «Assessment of oil pollution of lake ecosystems in Kyiv»

Done by: student of the FESET – 402 group, Maria I. Slobodenyuk
(student, group, surname, name, patronymic)

Scientific Supervisor: Ph. D. in Biol. Sc., Associate Professor of the Ecology Department, Tetiana I. 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: «Оцінка нафтового забруднення озерних екосистем міста Києва»

Виконавець: студентка групи ФЕБІТ - 402, Слободенюк Марія Іванівна
(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.
«____» _____ 2020

BACHELOR THESIS ASSIGNMENT

Maria I. Slobodenyuk

1. Theme: «Assessment of oil pollution of lake ecosystems in Kyiv» approved by the Rector on April 27,2020, № 527/ст.

2. Duration of work: from 27.04.2020 to 16.06.2020.

3. Output work (project): scientific literature on the impact of petroleum products on aquatic ecosystems and methods of treatment of polluted waters, elimination of petroleum pollution of bottom sediments.

4. Content of explanatory note: analytical review of literature sources on the subject of the diploma. Consideration of pollution of aquatic ecosystems by oil products. Analysis of the literature on the features of the impact of petroleum products on the microflora of reservoirs and aquatic organisms. Methods of cleaning lake ecosystems from oil products.

5. The list of mandatory graphic (illustrated materials): figures, graphs.

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Development together with the supervisor of the schedule of the bachelor's thesis	27.04.2020	
2	Search and analysis of literary sources on the topic of work	28.04.2020 – 30.04.2020	
3	Preparation of the main part (Chapret 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	Registration 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	Preliminary defense of the thesis	08.06.2020	
10	Thesis defense	16.06.2020	

7. Date of task issue: «27» April 2020__

Diploma (project) advisor: _____ Tetiana I. Bilyk
(advisor's signature) (S.N.P.)

Task is taken to perform: _____ _____
(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.
«____» _____2020 р.

ЗАВДАННЯ
на виконання дипломної роботи
Слободенюк Марії Іванівни

1. Тема роботи «Оцінка нафтового забруднення озерних екосистем міста Києва» затверджена наказом ректора від «27» квітня 2020 р. №527/ст.

2. Термін виконання роботи: з 27.04.2016 р. по 16.06.2020 р.

3. Вихідні дані роботи: наукова література про вплив нафтопродуктів на водні екосистеми та методи очищення забруднених вод, ліквідацію нафтових забруднень донних відкладів.

4. Зміст пояснювальної записки: аналітичний огляд літературних джерел з тематики диплому. Розгляд забруднення водних екосистем нафтопродуктами. Аналіз літератури з особливостей впливу нафтопродуктів на мікрофлору водойм та на водяні організми. Методи очищення озерних екосистем від нафтопродуктів.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: рисунки, діаграми.

6. Календарний план-графік

№ 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 І)	01.05.2020 – 09.05.2020	
4	Підготовка основної частини (Розділ ІІ)	10.05.2020 – 13.05.2020	
5	Підготовка основної частини (Розділ ІІІ)	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: «27» квітня 2020 р.

Керівник дипломної роботи (проекту): _____ Білик. Т. І.
(підпис керівника) (П.І.Б.)

Завдання прийняв до виконання: _____ _____
(підпис випускника) (П.І.Б.)

ABSTRACT

Explanatory note to thesis «Assessment of oil pollution of lake ecosystems in Kyiv»: 53pages, 22figures, 41 references.

The object of research - is oil pollution of aquatic ecosystems.

The subject of the research - is the assessment of oil pollution of lake ecosystems of the city of Kyiv.

The aim of the work - was to study the degree of oil pollution of the lakes of Kyiv in the spring-summer-autumn period of 2019, as well as to identify sources of oil hydrocarbons in reservoirs.

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

Topicality. Ecological aspects of water management in Kyiv, in particular the state of pollution of urban water bodies, are becoming more and more socially acute and of national importance, as they are one of the determining factors of national security.

Urban lakes play an important role in shaping the ecological well-being of the capital. Within the city of Kyiv today there are 129 lakes that play an important role in maintaining the quality of the urban environment and biotic diversity within the urban landscape. Among the wide range of pollutants entering urban lakes, petroleum products are the most dangerous toxicants, the action of which disturbs the natural ecological balance in water bodies and poses a threat to the safe existence of aquatic organisms. The study of the current state and features of oil pollution of the lakes of Kyiv is relevant in order to assess the potential risk to the life of aquatic organisms and develop a system of measures to prevent their anthropogenic transformation.

Practical significance: the results of the study are prepared for implementation in a comprehensive program aimed at protecting aquatic ecosystems and reducing oil pollution of lakes in Kyiv.

Personal contribution of the author: elaboration of scientific literature on the topic of work, data analysis of the Institute of Hydrobiology of the National Academy

of Sciences of Ukraine, preparation for the implementation of research results.

WATER POLLUTION, PETROLEUM PRODUCTS, ECOLOGICAL ASSESSMENT OF THE CITY OF KYIV, LAKE ECOSYSTEMS.

CONTENT

LIST OF SYMBOLS, ABBREVIATIONS AND NOTIONS

PP – Petroleum products;

OP – oil products;

INTRODUCTION

Relevance of the work. The relevance of the topic is that the intensive development of industry and the expansion of the use of petroleum products of all kinds causes an increase in pollution environment. In this paper, petroleum products were considered as a source of pollution of the aquatic environment and bottom sediments, in particular, their impact on the lake ecosystems of the city of Kyiv, as well as methods of eliminating oil pollution of water systems.

Aim and tasks of the diploma work

Aim of the work – Analyze the prospects for reducing water pollution by petroleum products and their impact on lake ecosystems by fluorimetric method.

Tasks of the work:

1.To describe the features of lake ecosystems.

2. To highlight the impact of petroleum products on aquatic ecosystems and aquatic organisms.

3. To study modern methods of purification of lake ecosystems from oil products.

4. To analyze experimental data on oil pollution of surface waters.

5. To identify ways to solve and regulate the problem of oil pollution.

Object of research is oil pollution of aquatic ecosystems.

Subject of research is the assessment of oil pollution of lake ecosystems of the city of Kyiv.

Methods of research analytical, 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, preparation for the implementation of research results.

Approbation of the results: diploma work for a scientific degree bachelor.

Publications: А. С. Бондаренко, П. С. Тремасова, М. І. Слободенюк Визначення фітотоксичності грунтів з використанням амаранту як біотестера // Матеріали XVI науково-технічної конференції студентів, аспірантів, докторантів та молодих учених. (м. Київ, 20-21 листопада 2019р)

CHAPTER I
DANGER OF OIL POLLUTION FOR LAKE ECOSYSTEMS OF URBAN AREAS

1.1. Features of lake ecosystems

Aquatic ecosystems differ from terrestrial ecosystems primarily in their physical and chemical properties. When considering aquatic ecosystems, they are divided into freshwater and ecosystems of the oceans.

Freshwater ecosystems are widely represented on all continents. The rivers and lakes of the Earth contain most of the fresh water, although in some inland waters the water is salty (this is typical of hot and dry climates)[1].

In freshwater lakes there are always three parts that can be considered as separate ecosystems(fig.1.1):

- coastal part - littoral;
- deep-water part - profundal;
- the main water column is pelagic.

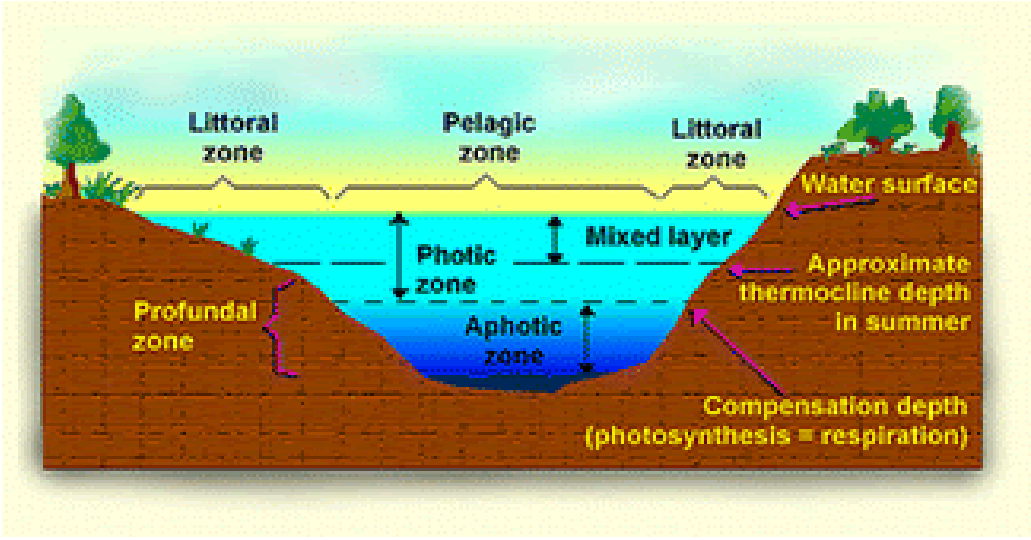

Fig. 1.1. Parts of the lake, which can be considered as separate ecosystems.

Littoral is the most populated with living organisms. Coastal areas of any reservoir are their main trophic areas. In addition to semi-submerged plants, benthic

organisms, which make up benthos, and plankton, which floats in the water column, live in the reservoirs. The products of most reservoirs are often limited by a lack of nutrients. The fact is that life is concentrated in the upper layers of water, where there is enough sunlight, and minerals come from the bottom layers. The upper and lower layers of water are separated by a so-called thermocline, which is especially evident in the reservoirs of the subtropical and tropical zones. Thermocline prevents vertical water exchange and leads to a deficiency of minerals in the surface layers of water.

Littoral is characterized by the presence of a large number of attached plants - macrophytes. The fauna is represented by insects and their larvae.

Rich and predatory fauna. In the coastal part of the lakes such species of fish as gosling, red perch, tench, wild carp, smelt are common. Predatory fish are represented by pike, perch and pike perch. The bottom part of the lakes has almost no plants, the water is stagnant and maintains a temperature of +4 "C for almost the whole year. The fauna of such places is impoverished[2]. It is represented mainly by larvae of bell mosquitoes and mollusks.

In the pelagic plants are represented by plankton of blue-green, diatoms and green algae, floating macrophytes (Elodea, Rdesta). All living organisms have a variety of devices that help them stay in the water column. In plants, these are parachute-like growths, droplets of fat in the body, and animals actively swim. Lake trout and whitefish are found in the pelagic. There are many carnivorous rotifers, otters and cyclops.

The flora and fauna of lakes in many cases is determined by the presence of nutrients in the water. On this basis, lakes are divided into eutrophic, rich in nitrogen, phosphorus, oligotrophic, poor in nitrogen and phosphorus (nitrates less than 1 mg / l) and intermediate lakes - mesotrophic. The fauna of fish differs significantly in these three types of lakes. Oligotrophic lakes are characterized by whitefish, loach, perch, pike and gosling. Eutrophic lakes are home to species that are resistant to frequent oxygen deficiencies - carp, tench, crucian carp, gossip and bream.

Lakes of Ukraine contain 195 species of aquatic macrophytes, as well as many thousands of species of algae. There are 57 aquatic plant formations in Ukraine.

Aquatic ecosystems are an important national asset. This is a storehouse of fresh water, and sources of various products, and recreation areas.

The lake ecosystem includes biotic (living) plants, animals and microorganisms, as well as abiotic (non-living) physical and chemical interactions.

Lake ecosystems are striking examples of standing ecosystems. Standing include stagnant or low-flowing water (from the Latin Lentus-sluggish). Standing waters range from ponds, lakes to wetlands, and much of this article applies to standing ecosystems in general. Standing ecosystems can be compared to flowing ecosystems that include flowing groundwater, such as rivers and streams. Together, these two fields form a broader area of freshwater or aquatic research.

Non-flowing systems get most of their energy from photosynthesis, which is performed by aquatic plants and seaweed. This radical process involves combining carbon dioxide, water and solar energy to make carbohydrates and dissolved oxygen. In a lake or body of water, the potential rate of photosynthesis usually decreases with depth due to a decrease in light intensity. However, photosynthesis often occurs, mainly a few millimeters from the surface, probably due to interference by ultraviolet rays. The exact depth and photosynthetic rate of this curve - a certain system and depends on: 1) the total biomass of photosynthetic cells, 2) the amount of materials that reduce rays and 3) the abundance and frequency range of pigments that absorb light (ie chlorophyll) in photosynthesis of cells. The energy generated by these primary producers is important to the community because it is transmitted to higher trophic levels through consumption[3].

According to the availability of life, lakes are divided into:

- oligotrophic - poor in phytoplankton and nutrients for it. Characterized by high transparency, water color from blue to green, heterogeneous temperature distribution vertically, a gradual decrease in oxygen content to the bottom and its uniform distribution throughout the year.
- Eutrophic - lakes with a high content of nutrients in the water, usually shallow (10-15 m), are well warmed. The color of the water is from green to brown, the oxygen content drops sharply to the bottom, sometimes

freezing in winter. The bottom is peaty or covered with organic silt. In summer, there is a "bloom" of water due to the highly developed phytoplankton. They have favorable conditions for the development of vegetation and fauna.

- dystrophic (from gr. dys - disturbance, loss and trophé - food, nutrition) - usually a shallow body of water, poor in oxygen and nutrients for organisms. The water is weakly mineralized, characterized by high acidity, low transparency, yellow or brown color due to the large amount of humic substances in it, which is why such lakes are sometimes called humic. Phytoplankton and benthic animals are often almost absent on a peat-covered muddy bottom. Dystrophic lakes are common in highly wetlands[4].

Oil and petroleum products act on aquatic fauna in several directions:

- the surface film of oil delays the diffusion of gases from the atmosphere into the water and disrupts the gas exchange of the reservoir, creating a lack of oxygen;

- oily substances, covering the surface of the gills with a thin film, disrupt gas exchange and lead to asphyxia of fish;

- water-soluble compounds easily penetrate into the body of fish;

- at an oil concentration of 0.1 mg / l fish meat becomes indelible "Oil" smell and taste;

- bottom oil deposits undermine the forage base of reservoirs and absorb oxygen from water [4].

1.2. Influence of oil products on the biota of the reservoir

The presence of petroleum products in the water body leads to the suppression of aquatic flora and fauna due to the general deterioration of water quality (changes in pH, color, the appearance of a specific taste and odor)[5]. These changes are due to the presence in the aquatic environment of both petroleum products and products of their chemical and biochemical oxidation, the toxicity of which often exceeds the toxicity of the original petroleum products. Hydrocarbons in a water body interact with the ecosystem: on the one hand, oil affects the biota as a toxicant, and on the

other - aquatic organisms affect the oil, carrying out the process of its transformation.

For aquatic organisms, oil and petroleum products are highly toxic substances and belong to the group of neuro-paralytic poisons. Hydrocarbons are mainly detrimental to the early stages of aquatic life and do not lead to rapid and mass extinction of adult organisms. For caviar, juvenile fish and crustaceans, the concentration of oil is only 0.1 - 0.01 mg / dm, while for adult organisms such a concentration does not have a toxic effect[6].

Oil has an external effect on birds, food, contamination of eggs in buckets, and so on. External oil pollution destroys plumage, tangles feathers, irritates the eyes. Death is the result of cold water, birds are drowning. Birds that spend most of their lives on the water are most vulnerable to oil spills on the surface of water bodies. Birds swallow oil when they clean their feathers with their beaks, drink, eat contaminated food and breathe by evaporation[7]. Swallowing oil rarely causes immediate death of birds, but leads to extinction from starvation, disease, predators. Bird eggs are very sensitive to oil. A small amount of some types of oil may be sufficient for death during the incubation period. Oil spills can have both rapid and long-term effects on birds. Evaporation from oil, lack of food and cleaning measures can reduce the use of the affected area. Deaths and reproduction reductions caused by oil spills are easier to detect locally or in colonies than on a regional or whole scale.

Fish are exposed to oil spills in water when eating contaminated food and water, as well as in contact with oil during the movement of eggs. The death of fish, excluding juveniles, usually occurs in severe oil spills. So a large number of adult fish in large reservoirs will not die from oil[8].

The impact of oil spills on major local plant species can last from a few weeks to 5 years, depending on the type of oil.

1.3. Promising measures to clean aquatic ecosystems contaminated with petroleum products

Today, surface water treatment from oil and hydrocarbons is carried out using:

- Mechanical (fig.1.3.)
- physico-chemical (fig.1.4.)
- biochemical methods of purification (fig.1.5.)

Fig.1.3. Mechanical method of water purification

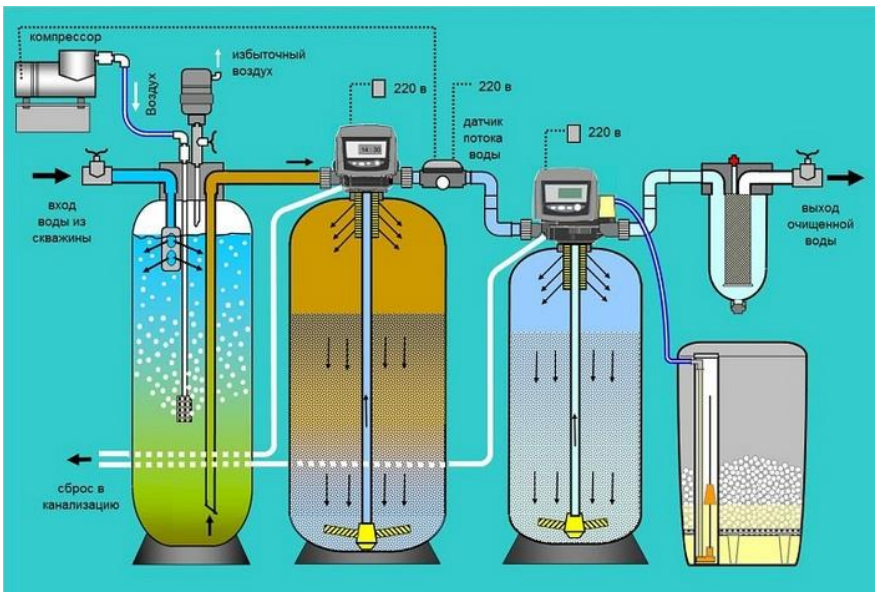

Fig.1.4. physico-chemical method of water purification

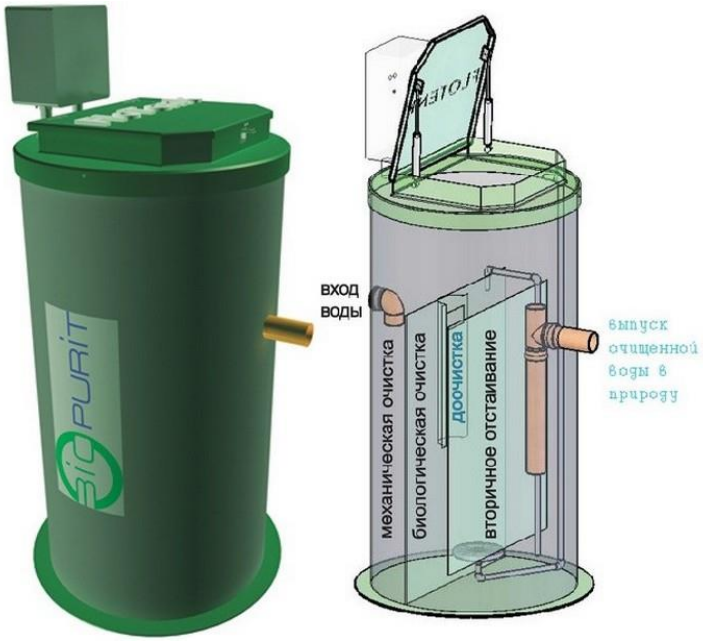

Fig.1.5. biochemical method of water purification

In this intended use, these methods have a number of significant disadvantages. Chemical methods involve the introduction of chemical reagents into the water. As a result of chemical reactions that occur during the purification process, it becomes possible to form more toxic substances than the original ones. Mechanical methods remove only surface oil and oil sludge[9]. Emulsified and soluble oil is not removed, so such purification is ineffective. Flotation treatment involves the introduction of surfactants into the water, which increase the size of the emulsified particles, resulting in additional water pollution. Biological oxidation can be effectively used at low concentrations of oil in surface water, only in a certain range of pH and temperature. Of all the special methods of water purification, adsorption methods are simpler, more accessible and more efficient. The most appropriate method for the removal of petroleum contaminants is the method of adsorption purification using adsorbents of various types. The advantages of the method are high efficiency, variety of forms (granules, fibers, etc.) and a wide range of types of adsorbents that can provide water purification to any desired level[10].

Currently, there are about 200 types of sorbents in the world for the elimination of oil pollution, which can be classified on various grounds: by origin (raw material),

dispersion, purpose, the preferred method of disposal[11]. The quality of sorbents is determined mainly by their capacity relative to oil, the degree of hydrophobicity, buoyancy after sorption of oil or petroleum products, the possibility of desorption, regeneration or utilization of the sorbent. To determine the quality of petroleum sorbents, three main indicators are used: oil absorption, water absorption and the degree of oil extraction. In the process of oil absorption, the sorbent fibers are able to move apart, creating a specific structure, which after harvesting the oil product begins to gradually compress under the action of gravity and drain up to 90% of the collected oil product.

The practice of using known sorbents has shown that in real conditions their sorption capacity is usually 10-15 times lower compared to experimental data. The reason for this may be many factors, including changes in the physicochemical properties of spilled oil due to its evaporation, oxidation, emulsification, etc.

It is known that the increase in oil content of gas, volatile fractions and emulsified water leads to an increase in the cost of the sorbent for its removal from the water surface. Therefore, evaluating the effectiveness of sorbents, guided by three criteria: oil consumption, moisture content and buoyancy.

Solving each environmental problem requires specific measures and the involvement of scientific institutions, specialists in various fields, the public, government agencies and foreign investors. The strategic task is to create a single environmental inspection, which will establish the facts of environmental violations legislation, as well as to fine violators. At the same time, it is necessary to create a single system of environmental monitoring of water bodies (such as monitoring the level of air pollution)[12]. Strict control of environmental offenses on water bodies, as well as a single system of environmental monitoring and audit, will allow to solve or develop ways to eliminate most environmental problems[13].

The following measures can be proposed to reduce the level of pollution of water bodies:

- Mandatory installation of treatment facilities at enterprises and sewage systems, strict regulation of industrial discharges into reservoirs.

Application of traditional methods of mechanical and chemical water purification, as well as innovative developments for water purification.

- Establishment of a department of special ecological inspection, which will be engaged in constant monitoring of the quality of water bodies in Kyiv, will reveal the facts of water pollution, as well as will fine violators on the spot environmental legislation.
- Strict control over untreated wastewater emissions from industrial enterprises, establishment of criminal liability for violation of requirements. Creating a single catalog of surface water pollutants with the requirementrinstallation of treatment systems.
- Deployment of large-scale research on the level of pollution of Kyiv reservoirs with a complex of harmful substances, in order to identify reservoirs with the best and worst water quality, and further development of specific measures for individual reservoirs to eliminate their pollution. Special attention is needed pay attention to the reservoirs of Darnytskyi district, which are characterized by the highest concentrations of pollutants.
- The use of innovative developments in the field of biological treatment of small reservoirs with difficult water exchange methods: biofiltration, aeration tank, bioremediation, septic tank, methane tank, etc.

Given the characteristics of cleaning methods, they can be divided into three main classes: mechanical, physicochemical and microbiological. Each of them has its advantages and disadvantages. From an economic point of view, it is desirable to use those methods that allow to collect spilled oil and use it as a marketable product. However, the use of mechanical oil reservoirs can be effective only in the absence of water surface fluctuations, as otherwise a significant amount of water enters the oil reservoir together. For all the simplicity of the design of oil reservoirs, their construction requires a large area and significant capital investment. And most importantly, the practice of operation has shown that when using this method is achieved only rough water purification from floating oil in the form of an emulsion.

Physico-chemical methods provide better cleaning, less labor-intensive, the

technology of their use is simple, but their use may not always be safe for living organisms. The disadvantages of the physicochemical method include the formation of a large amount of sediment.

The biological method of water purification from oil and state of emergency justifies itself by neutralizing domestic wastewater, which has a relatively stable composition and low concentrations of pollution. In an emergency situation, traditional biological treatment is not enough.

These disadvantages are absent when collecting oil with the help of highly efficient sorbents - substances that are able due to oleophilicity to absorb NP and repel water. The advantages of sorption agents are that they can be delivered to the scene of the accident and, most importantly, their inherent speed of action, is quite important in the fight against emergency oil spills.

There are sorbents based on minerals, synthetic sorbents and sorbents of plant origin.

Recently, the use of vegetable sorbents is becoming increasingly popular. The reason for this is the growing demands on the purity and environmental friendliness of the obtained sorbents and ensuring the appropriate level of water treatment. The possibility of using carbon materials based on agricultural waste to absorb oil pollution from the water surface is noteworthy. However, small reserves of raw materials, the complexity of the technological process of obtaining such sorbents, a high cost prevent their widespread use.

Promising for the purification of the aquatic environment are carbon sorbents based on leaves, straw left in the fields after harvest, and waste from the woodworking industry. The raw materials for obtaining such sorbents are wood (in the form of sawdust), walnut shell, coconut, peanut.

1.4. Conclusions to chapter 1

Summarizing the first chapter, I considered such issues as: features of lake ecosystems, what is the impact of petroleum products on the biota of the reservoir and what promising measures should be used to clean oil-contaminated aquatic ecosystems.

Today, surface water treatment from oil and hydrocarbons is carried out using: mechanical, physico-chemical, biochemical methods of purification.

CHAPTER II
MATERIALS AND METHODS OF RESEARCH OF OIL POLLUTION OF LAKE ECOSYSTEMS

2.1.Characteristics of the Kyiv city lakes

Ecological aspects of water management in Kyiv, in particular the state of pollution of urban water bodies and the quality of drinking water, are becoming more and more socially acute and of national importance, as they are one of the determining factors of national security[14].

Today, the reservoirs of Kyiv, whose resources are actively used by utilities and industry, are partially or almost completely transformed by human activities, but still retain natural features and play an important role in maintaining the quality of the urban environment and biodiversity within the urban landscape[15].

On the territory of Kyiv there are more than 400 reservoirs of various types, the total area of the water mirror of which exceeds 2 thousand. hectares (without the waters of the Dnieper). Among them, urban lakes play an important role in shaping the ecological well-being of the capital. Within the city of Kyiv today there are 129 lakes, which differ in origin, morphometric characteristics and the degree of anthropogenic impact(fig. 2.1; 2.2)[16].

The threat to the ecological safety of the lakes of Kyiv is, first of all, the inflow of polluted industrial, municipal and rainwater, the impact of water transport and hydraulic structures, active construction of the surrounding area, littering of coastal strips and more.

Among the wide range of pollutants that enter urban lakes, petroleum products, along with heavy metals, are the most dangerous toxicants, the action of which disturbs the natural ecological balance in water bodies and poses a threat to the safe existence of aquatic organisms.[17]

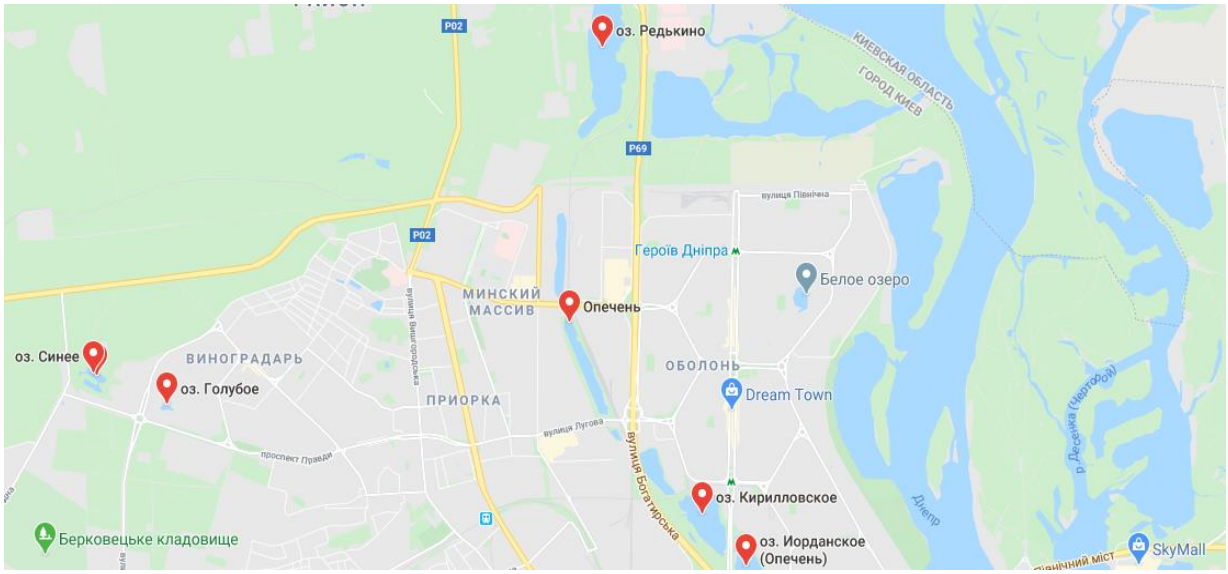

Fig. 2.1. Right-bank lakes

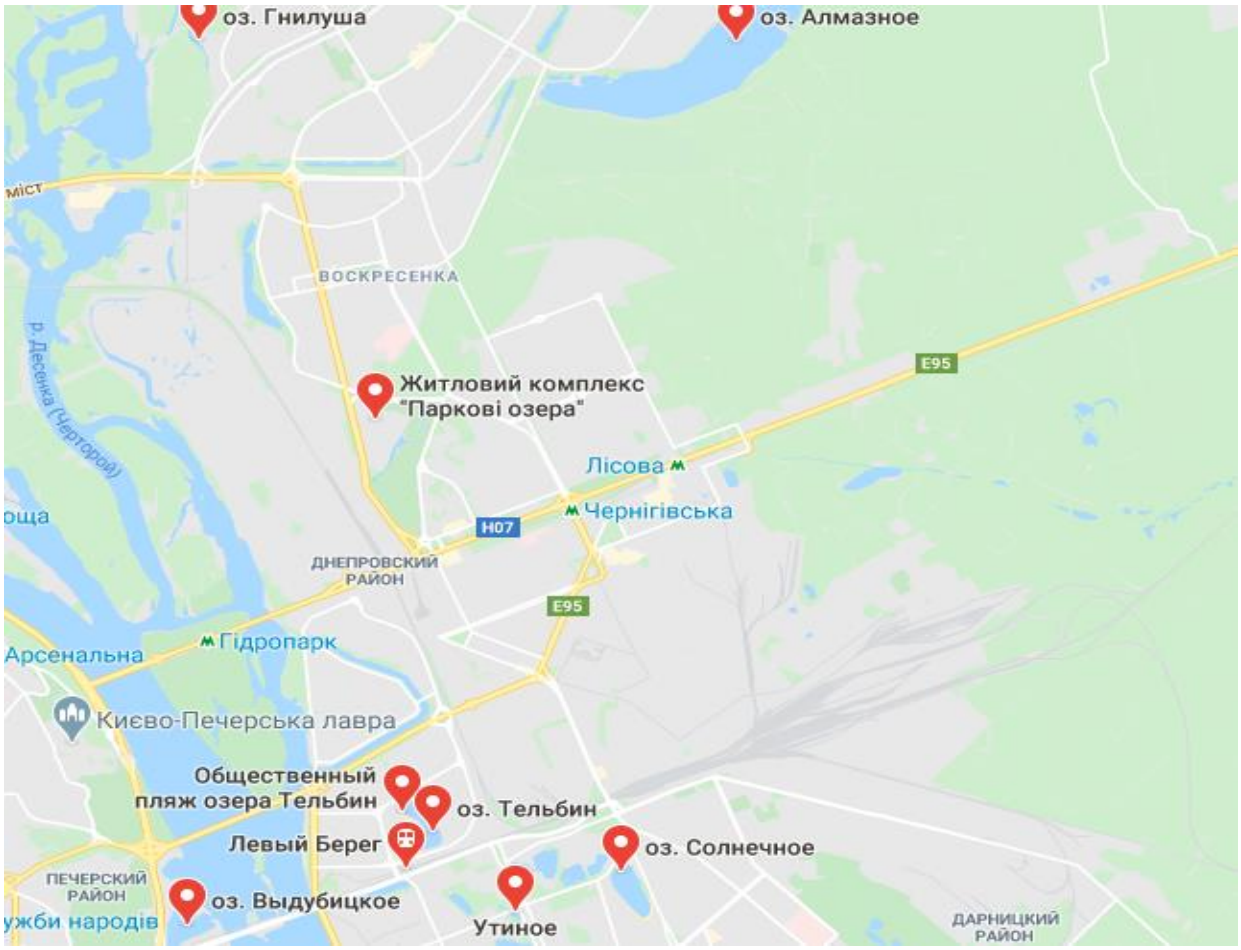

Fig. 2.2. Left-bank lakes

In the process of operation of water transport and self-propelled vessels, technical waste from the operation of engines containing petroleum products is

generated[18]. Their disposal is problematic today, as there is a lack of separators for the purification of this water and its return to the reservoir. A serious problem, in particular, is the lack of a well-established system of surface runoff and rainwater drainage. The composition of surface runoff varies widely, but it is not constantly monitored. Rainwater, which flows through the streets of the city and in large quantities enters the lakes, is usually contaminated with petroleum products. In Kiev, there are many water outlets in the storm sewer, which are virtually uncontrolled and not serviced[19]. A common negative phenomenon is the uncontrolled discharge into the city's water bodies, including lakes, of untreated effluents from car washes, garage cooperatives and service stations, most of which are still not equipped with any treatment facilities.

Petroleum products and fuel oil were found in Lake Luhove on the capital's Obolon. Black reeds near the water, dirt all over the pond. The collector is located under water. This is a canal that connects Lugovo with another lake. Then everything goes to the Dnieper in a cascade of lakes.

Pollution of the lake was recorded in August last year. The excess was two or three times for phenols and petroleum products. Existing fuel oil is actively noticeable. Definitely these are fuels and lubricants.

The analysis of professional publications shows that the ecological and toxicological condition of the lakes of Kyiv has so far been insufficiently studied, and their research has been mostly fragmented and unsystematic. According to the results of previous studies, the concentration of oil products in the water of some lakes in Kyiv was several times higher than the current regulations, especially in the lakes of the Opechen system, as well as Redchin and Verbny.

Every year, the anthropogenic load on the inland waters of Kyiv due to the intensive development of the metropolis and the increase in its number of inhabitants will continue to grow, worsening the environmental situation even in relatively satisfactory water bodies.

In view of this, the study of the current state and features of oil pollution of the lakes of Kyiv, as in previous years, remains relevant to assess the potential risk to

aquatic life and develop a system of measures to prevent their anthropogenic transformation[20].

Fig.2.2. Lake Verbne

Fig.2.3. Lake Yordanske

Fig.2.4. Lake Kyrylivske

Fig.2.5. Lake Syne

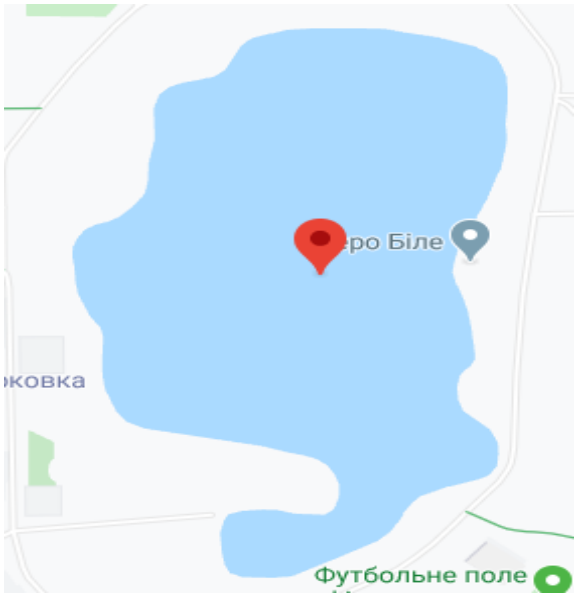

Fig.2.6. Lake Tsentralne(Bile)

Fig.2.7. Lake Redchyne

Fig.2.8. Lake Almazne

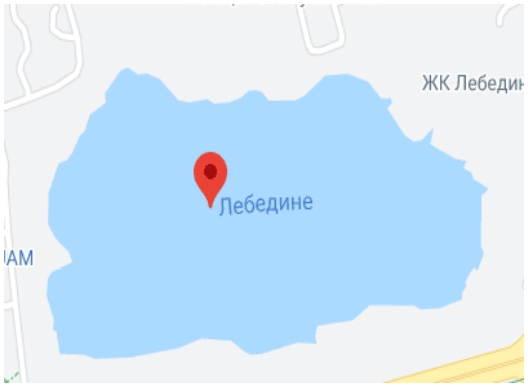

Fig.2.9. Lake Lebedyne

Fig.2.10. Lake Pidbirna

Fig.2.11. Lake Raiduzhne

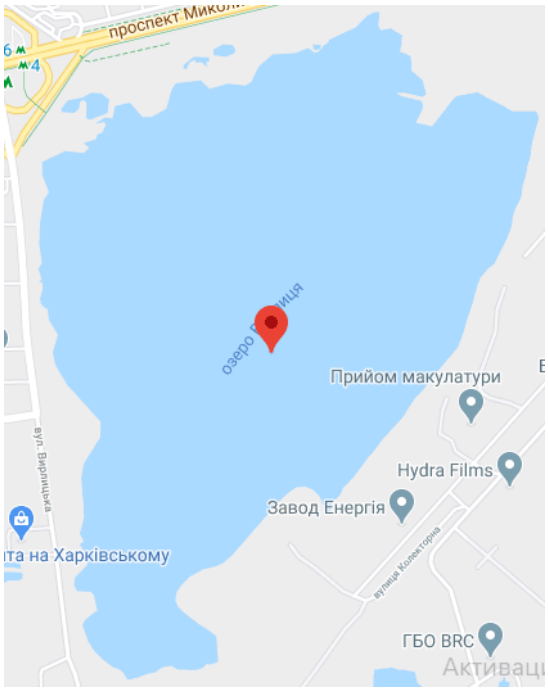

Fig.2.12. Lake Vyrlytsia

Fig.2.13. Lake Tyagle

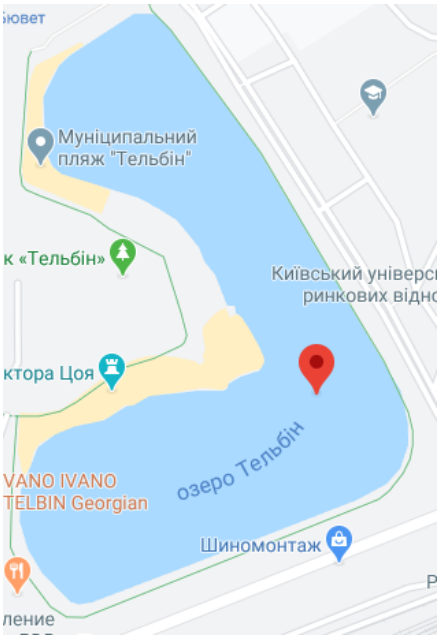

Fig.2.14. Lake Telbin

Most lakes are located on the Dnieper floodplain and are represented by relict old women. The exception to this is Lake. Blue, which is located on the plakorny area and has a glacial origin. The sizes of Kiev lakes are different. The largest among them are Diamond, Redkino, Rainbow, Vyrlytsia, Tyagle, Zaplavne, Martyshiv and others. Left-bank lakes are usually larger in area, often forming whole groups. In the 1960s and 1980s, sand was extracted from their bottoms for the development of housing estates. Reservoirs on the right bank are mostly solitary and small in size. The largest number of reservoirs on the right bank is located in Obolon. The main source of water for reservoirs is precipitation. Underground power survives only in the following lakes: Redkino, Glinka, Syretske. Most lakes are impassable, which worsens the circulation conditions - the duration of external water exchange in some lakes reaches tens of years.

Petroleum products and other solvents can seep through the plastic to contaminate the internal water. If the substance is released from a large area, such as an industrial plant, or from a container such as a drum or bottle, it enters the environment. This issue does not always lead to exposure. Interaction occurs through respiration, food, water and skin contact.

Because modern society uses such petroleum products (gasoline, kerosene, fuel

oil, oil and asphalt), they cause environmental pollution. Contamination caused by petroleum products contains various hydrocarbons. Due to the fact that there are so many of them, it is almost impossible to measure each one individually. However, it is useful to measure the total amount of all petroleum products found together in a particular water sample.

2.2. Methods for determination of oil products in water, bottom sediments and biota

The current state of oil pollution of 18 lakes in Kyiv was studied, which differ in origin (associated with the Dnieper floodplain, formed in riverbeds, artificially created as a result of hydrowashing), size and depth, the degree of anthropogenic impact. In particular, the objects of the study were the right-bank (Redchyne, Minsk, Luhove, Bogatyrske, Kyrylivske, Yordanske, Verbne, Tsentralne, Syne) and left-bank (Vyhurivske Seredne, Almazne, Raiduzhne, Telbin, Sunny, Lebedyne, Vyrlytsia, Tyagle, Pidbirna) lakes. Kyiv.

The concentration of the fraction of oil products dissolved in water in the lakes of Kyiv in the spring-summer-autumn period of 2019 was determined.

Water sampling was performed according to the methods generally accepted in the practice of hydroecological research.

The mass concentration of petroleum products in water was determined by the fluorimetric method on the liquid analyzer "Fluorate-02-3M" according to the method of the device manufacturer (NVF "Lumex", St. Petersburg). The method is based on the extraction of petroleum products from water with hexane, followed by measurement of the fluorescence intensity of the obtained hexane extract. The measurement results were statistically processed[21].

2.3. Conclusions to chapter 2

In chapter II, I described the lakes of the city of Kyiv and determined the method of how to find out whether there are oil products in water and bottom sediments.

The mass concentration of petroleum products in water was determined by the fluorimetric method on the liquid analyzer "Fluorate-02-3M" according to the method of the device manufacturer (NVF "Lumex", St. Petersburg).

CHAPTER III. ASSESSMENT OF OIL POLLUTION OF LAKE ECOSYSTEMS IN KYIV

3.1. Petroleum products in the water of Kyiv lakes

The results obtained to determine the concentration of petroleum products in the surface layer of water in the lakes of Kyiv (Figs. 3.1; 3.2) showed that the degree of water pollution in the studied reservoirs varied quite widely[22].

The maximum concentration of oil products in the water, which is 1.5-2.5 times higher than the permissible level for fishery reservoirs (0.05 mg / dm^3), was found in the right-bank lakes Minsk (0.086 mg / dm^3), Lugovoe (0.145 mg / dm^3).) and in Lake Lebedyne (0.075 mg / dm^3) on the left bank. In Bogatyrske Lake (right bank) the content of oil products in the water was at the level of permissible values, and in the autumn period it exceeded it by 30% and amounted to 0.054-0.065 mg / dm^3.

In the right-bank lakes Kyrylivske and Yordanske during the whole observation period, and in Lake Sunny (left bank) - in summer, the concentration of oil products was very close to the maximum allowable level and was 0.034-0.043 mg / dm^3, 0.029-0.040 mg / dm^3 and 0.043 mg / dm^3 respectively[23].

Lakes Minske, Luhove, Bohatyrske and Kyrylivske belong to the system of lakes Opechen and were formed in the course of the historical river Pochayna as a result of hydro-alluvium of the territory for construction of the Obolon housing estate. All of them are in a zone of strong anthropogenic impact, receiving man-made discharges from numerous industrial and infrastructural facilities located on their shores, usually without local treatment facilities. The ecological condition of these lakes is also deteriorating due to surface runoff from the railway line along their shores and nearby high-traffic roads[24].

In particular, Lake Minsk is surrounded by an industrial zone from the east and north. On the western side of the lake stretches a huge garage cooperative with

numerous sinks and service stations. On the north side there are warehouses for construction equipment, a logistics company, Hydrospetstechservice, and a food processing enterprise. To the south of the lake lies the street. Polar with heavy traffic.

Garage cooperatives and service stations, the construction base of the Kyivmiskbud trust, a plant for the production of fillers for animals, and further to the west - the DBK-4 plant are located on the territory around Lake Luhove. On the east side there are warehouses-shops, bakery № 10, beverage plant "Obolon", refrigeration terminal "Global Fish".

To the north of Lake Bohatyrske there is a residential building and a garage cooperative, to the east there is an electric substation and the world's largest fire station. To the west of the lake there is an industrial zone, within which there is a gas station, service station, garage cooperative, concrete plant, the first pipe plant, metal depots, Betonkompleks LLC, district boiler house[25].

The peculiarity of Lake Kyrylivske is the confluence of the Syrets River, the catchment of which passes through the industrial zone. On the banks of the Syrets River there is a garage cooperative with a service station, a car dealership, an open-air MAF hatchery, a Budshlyakhmash plant for the production of road construction and military equipment, wholesale warehouses of chemical raw materials and chemical products Acrylate-Chemical Contract, and a household chemical plant. , KP "Avtodorservice". The lake is surrounded on the west and east by highways with heavy traffic.

Lake Lebedyne is an artificial reservoir in the Pozniaky residential area on the left bank. The area near Lake Lebedyne also has significant economic development. Nearby is the construction of a residential complex, there are highways and overpasses, service stations and car washes.

On the positive side, the construction of an aeration system and improvement of coastal protection strips is planned for the rehabilitation of Lake Lebedyne in 2019-2020. The arrangement of the aeration system will ensure the restoration of ecological balance, prevention of fish seas and the death of aquatic organisms due to lack of oxygen, improving water quality for recreational and fishing purposes[26].

In the remaining studied lakes located in the residential areas of Obolon, Osokorky, Poznyaky, Troieschyna, Vynohradar, the concentration of oil products in all observation seasons did not exceed the permissible level for fishery reservoirs (0.05 mg / dm^3).

Analysis of the seasonal dynamics of oil pollution shows that there was no clear dependence of the concentration of petroleum products in the water of the lakes of Kyiv on the research season. Among the right-bank lakes, the highest concentration of petroleum products in the lake. Minsk was celebrated in the summer, in the lake. Meadow - in the spring. In Redchyne and Verbne lakes there is a sharp increase in the concentration of oil products in the autumn season. Among the left-bank lakes of Kyiv, a significant increase in the concentration of oil products in the water of Lakes Sunny and Swan was observed in summer, lakes Almazne, Raiduzhne, Telbin - in autumn. In other lakes, the level of oil pollution did not differ significantly for three seasons. In most lakes there is a certain tendency to increase the concentration of petroleum products in summer and autumn[27].

For the purification of water bodies of urban areas in the world practice, a number of methods are used, among which the most acceptable to us seem phytoremediation, namely the creation of alluvial plateaus with higher aquatic vegetation. On the surface of floating mats made of synthetic fibers, herbaceous perennials are planted, forming a developed root system. The application of the phytoremediation method to reduce the degree of oil pollution of wastewater and surface water with the help of aquatic plants is based on the stimulation of the natural community of macrophyte aquatic organisms and active cultures of microorganisms.

There are known examples of effective purification of reservoirs from petroleum products by artificially created bioplateau, where higher aquatic plants were used as phytoremediaries: marsh iris (Iris pseudacorus), broad-leaved hornbeam (Typha latifolia), floating (Potamogémit nátisans), (Sagittaria sagittifolia) with a planting density of 115 plants per 1 m2. Purification occurs due to the activity of vascular plants, microphytes, biofilm and rhizosphere microorganisms, as well as fungi and actinomycetes of the rhizosphere of the roots, which is gradually formed.

The phytoremediation effect is associated with an increase in the enzymatic activity of catalases and dehydrogenases in the area of plant root growth. Floating plateaus have proven themselves well in the purification of water from petroleum products in Germany, the Netherlands and the United States. Taking into account the ecological, economic and aesthetic aspects of phytoremediation technologies for the treatment of oil-contaminated water bodies, we consider it appropriate to use them in Kyiv.

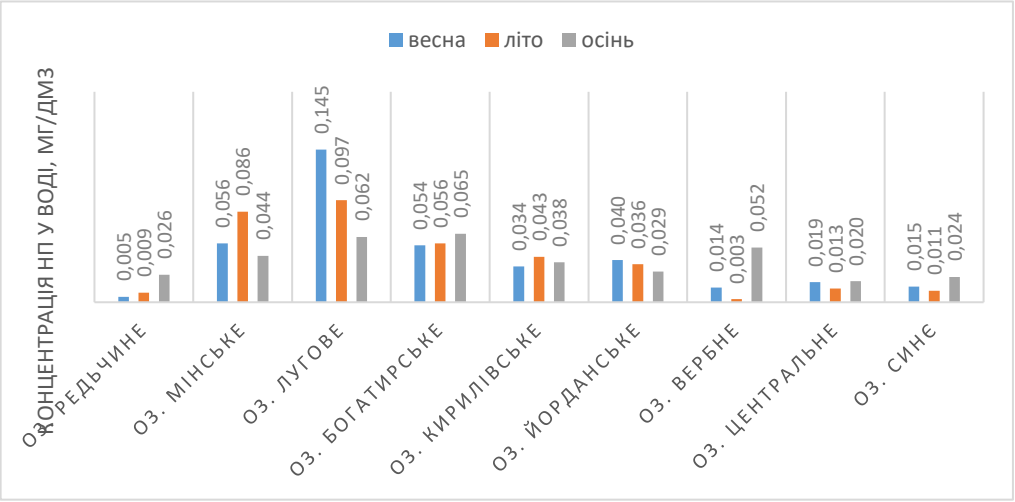

Fig. 3.1. Concentration of oil products in the water of the right-bank lakes of Kyiv,2019

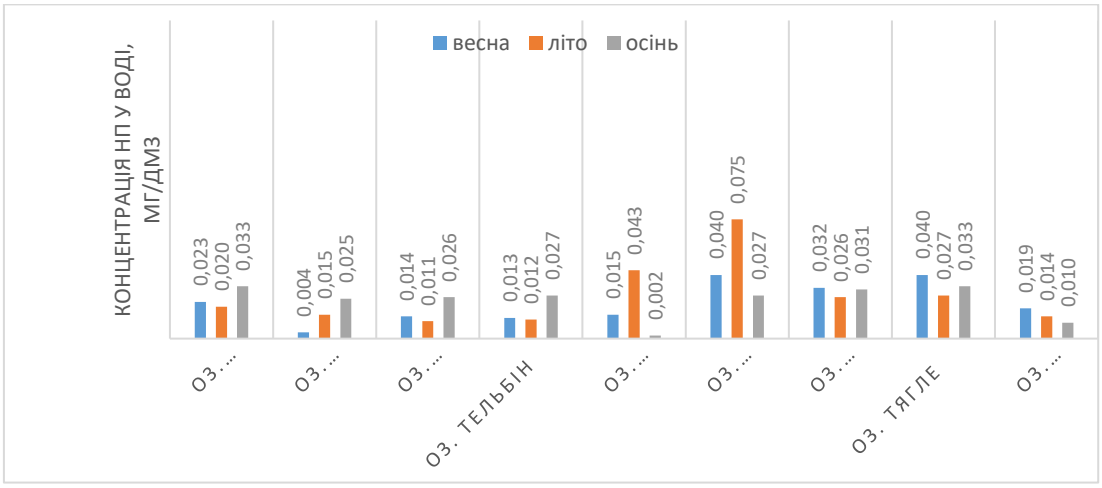

Fig. 3.2. Concentration of oil products in the water of the left-bank lakes of Kyiv, 2019

In the last few decades, a significant share of Kyiv's industrial enterprises has been closed, which has to some extent affected the improvement of the ecological situation of some water bodies. In particular, in the Lybid River there is a significant decrease in the content of nutrients and petroleum products. At the same time, the level of heavy metal pollution is constantly increasing due to their accumulation in bottom sediments. In reservoirs located in industrial areas, the level of pollution by various substances is constantly increasing. For example, from 1990 to 2016 in the reservoirs of the Opechen system there was an increase in the concentration of petroleum products in 15-23 times[28].

3.2. Oil pollution of bottom sediments of lakes

Once in water, oil only appears on its surface for the first time, and then under the influence of various factors it falls to the bottom and accumulates in bottom sediments, penetrating almost their entire depth. Thus, in the surface layer of anaerobic molds of mangroves, high oil concentrations remained for at least 4 years after the oil spill and continued to penetrate to a depth of 18-20 cm. From the deep layers of moles, oil hydrocarbons gradually fall into the water, which leads to chronic pollution. All of them, from naphthalenes to benzene, accumulated in bivalve mollusks. The toxicity of deep layers of sludge is neutralized no earlier than 15–20 years after the oil spill[29].

According to other data, 30% of oil pollution was absorbed by the upper layer of bottom sediments and multiple leaching of oil products from the soil after removal of oil pollution from the surface. Even 7 months after the oil spill, most of the oil pollution remained in the bottom sediments, which led to water pollution[30].

The degree of toxicity and cumulative effect of oil and oil pollution directly depends on their solubility in water, that is, those fractions of oil that contain the maximum amount of water-soluble aromatic hydrocarbons are all the more toxic. Along with this, it was shown that the insoluble oil component has the highest toxicity, and its toxicity depends on the particle size of the emulsified oil and

temperature. The observed higher toxicity of unvaccinated gasoline and diesel fuel is associated with the presence of light water-soluble fractions in them[31].

One of the main pollutants in water bodies is petroleum products. Of the amount that enters the water, about 40% remains in the water as an emulsion and the same amount settles to the bottom, and 20% form a film on the water surface, which impairs the aeration of water. In addition, oil products adsorbed by bottom sediments separate the fauna and flora of the bottom from the rest of the reservoirs and cause secondary water pollution.

The bottom deposits represent an open physical and chemical system, through the boundaries of which (water thicket-bottom sediments), a material exchange with the natural environment is carried out. In the ecological assessment of the hydroelectric system one of the most informative objects of study is bottom sediment. Accumulating pollution arriving in the reservoir for a long period, bottom sediments is an indicator of the ecological state of the territory, a unique integral indicator of the level and extent of technogenic pollution [32].

3.3. Petroleum pollution of aquatic organisms

The presence of petroleum products in the water body leads to the suppression of aquatic flora and fauna due to the general deterioration of water quality (changes in pH, color, the appearance of a specific taste and odor). These changes are due to the presence in the aquatic environment of both petroleum products and products their chemical and biochemical oxidation, the toxicity of which often exceeds the toxicity of the initial petroleum products[33].

Hydrocarbons in a water body interact with the ecosystem: on the one hand, oil affects the biota as a toxicant, and on the other - aquatic organisms affect the oil, carrying out the process of its transformation.

It is known that the environmental hazard of petroleum products depends on the process redistribution of fractions, which occurs over time, due to evaporation, dissolution, chemical and biochemical oxidation, emulsification, sorption,

temperature and other factors. The main result of the redistribution of fractions is change the ratio between water-soluble and insoluble components of oil in the aqueous medium[34].

The water-soluble fraction of oil contains mainly light aliphatic and mononuclear aromatic hydrocarbons, the ratio between which changes very quickly (during the first hours) towards the predominance of the latter. The degree of toxicity and cumulative effect of oil and petroleum products are directly dependent on their solubility in water. Since the most soluble are aromatic hydrocarbons, the most toxic in the series are aromatic hydrocarbons. The addition of additional double or triple bonds also increases the solubility and, consequently, the toxicity of hydrocarbons. Oil and petroleum products have a certain toxic effect on phytoplankton. Negative effect of petroleum products, especially film, in concentrations 0.001 - 10 mg / dm3 affects the development of higher aquatic vegetation (macrophytes)[35].

The toxic effect of oil and petroleum products on zooplankton was noted at a concentration of 0.001 ml / dm3. At a concentration of petroleum products at the level of 0.1 mg / dm, zooplankton dies (Fig.3.3.).

Fig.3.3. Zooplankton

For aquatic organisms, oil and petroleum products are highly toxic substances and belong to the group of neuroparalytic poisons. Hydrocarbons are mainly detrimental to the early stages of aquatic life and do not lead to rapid and mass extinction of adult organisms. For caviar, juvenile fish and crustaceans, the concentration of oil is only 0.1 - 0.01 mg / dm, while for adult organisms such a

concentration does not have a toxic effect[36].

The narcotic effect caused by hydrobionts by oil and oil products is associated with the soluble component, and irreversible toxic action - with heavy fractions that cause disruption of gas and water metabolism, processes, filtration, damage the outer shells, penetrate the body, causing chromosome damage .

The danger of oil pollution for aquatic organisms is exacerbated by the combined presence in the aquatic environment of heavy metals, pesticides, temperature factor, because different combinations of oil with these xenobiotics have a synergistic effect.

A feature of petroleum hydrocarbons is their ability to freely pass from the digestive tract into the bloodstream and be introduced into adipose tissue, which creates a danger of transport of petroleum hydrocarbons in the general trophic connections of hydrobiocenoses and penetration of these substances into the human body[37].

The maximum permissible concentration of petroleum products (in dissolved and emulsified state) for water of water bodies for drinking and cultural use is equal to 0.3 mg / dm^3, for fishery water objects - 0.05 mg / dm^3[38].

Oil and petroleum products are a mixture of extremely toxic hydrocarbons, which can be in various forms of migration. Thus, in water, petroleum products can be subjected to one of the following processes: assimilation by water organisms, sedimentation, emulsification, formation of oil aggregates, oxidation, dissolution and evaporation. Method and intensity of transformation of oil products in water bodies depends on the method of their entry into reservoirs, the distance from the points of discharge of contaminated wastewater, the characteristics of the hydrochemical regime of reservoirs. This changes the color, taste, smell, viscosity of water, surface tension, reduces oxygen content, harmful organic substances appear, water acquires toxic properties and poses a threat not only to humans. In general, the evolution of water pollution by petroleum products depends on their composition, temperature, salinity and acidity of the water environment, which determine the path and kinetics of decomposition of organic matter. Thus, in groundwater due to lower temperatures,

lower oxygen content and microorganisms main methods of self-purification are sorption and ion exchange with the surrounding rocks[39]. And at pollution of surface reservoirs oil products spread on a surface water and form a film from which light fractions are gradually removed due to evaporation (within a few days 25% of the stain is removed), and low molecular weight components are removed from the stain as a result of dissolution.

As for the impact of petroleum products on aquatic ecosystems in general, there are both positive and negative consequences. On the one hand, a kind of bottom groups are formed with a complex structure, increased diversity and productivity due to easily digestible organic matter. And more toxic components of fuels cause the formation of groups with low diversity, simplified structure and reduced productivity of bottom coenoses[40].

The total effect of oil on living organisms can be divided into 5 categories:

1. Immediate poisoning with lethal dad.

2. Serious disorders of physiological activity.

3. The effect of direct envelopment of a living organism with petroleum products.

4. Painful changes caused by the introduction of hydrocarbons into the body.

5. Changes in the biological characteristics of the environment residence.

A feature of oil pollution is the ability to capture and concentrate heavy metals and pesticides. When oil is spilled over a large area, there is a high probability of various reactions, as substances dissolved in oil are able to participate in various chemical processes[41].

3.4. Conclusions to chapter 3

Chapter III shows the results obtained from the experiment. And it turned out that the maximum concentration of oil products in the water, which is 1.5-2.5 times higher than the permissible level for fishery reservoirs (0.05 mg / dm^3), was found in the right-bank lakes Minsk (0.086 mg / dm^3), Lugovoe (0.145 mg / dm^3).) and in

Lake Lebedyne (0.075 mg / dm^3) on the left bank. In Bogatyrske Lake (right bank) the content of oil products in the water was at the level of permissible values, and in the autumn period it exceeded it by 30% and amounted to 0.054-0.065 mg / dm^3.

In the right-bank lakes Kyrylivske and Yordanske during the whole observation period, and in Lake Sunny (left bank) - in summer, the concentration of oil products was very close to the maximum allowable level and was 0.034-0.043 mg / dm^3, 0.029-0.040 mg / dm^3 and 0.043 mg / dm^3 respectively.

Due to the high population growth and the increasing need for emergencies, water pollution is becoming an increasingly acute problem every year, and has already reached a global scale. Devastating consequences are caused by state of emergency which, getting to water, influence all components of emergency - stop access oxygen, disrupt metabolic processes, prevent the development of natural flora and fauna, make water unsuitable for further use. Therefore, there is a need to develop comprehensive measures to respond to pollution, both urgent and preventive.

Today there is a large number of scientific and practical developments on ways and methods to reduce or eliminate oil pollution. Various mechanical, physicochemical, and chemical applications are used to clean water bodies and biological methods. But the problem continues to exist without losing its relevance. Therefore, there is a need to improve a wide range of methods and materials that would be particularly effective in operations to clean and remove oil from contaminated areas.

CONCLUSIONS

1. Today the main source of oil products to the lakes of Kyiv is the surface runoff from the territories of the metropolis adjacent to the reservoirs. The activities of nearby industrial, commercial, transport facilities without local treatment plants cause a significant man-made load on urban lakes, and are probably a constant source of oil pollution.

2. The degree of oil pollution of the lakes of Kyiv in the spring-summer-autumn period of 2019 was studied. Possible sources of oil hydrocarbons entering the reservoirs were identified and the seasonal dynamics of oil pollution of the lakes of Kyiv was analyzed.To clean oil-contaminated lakes in urban areas, in particular the city of Kyiv, it is advisable to use phytoremediation methods that are environmentally friendly, effective and aesthetic. Floating bioplateau is one of such options, successfully used in world practice.

3. The intensive flow of oil hydrocarbons into reservoirs led to the formation of adaptive mechanisms for their biological utilization. The main factors for the self-purification of reservoirs from oil pollution are, first of all, physical processes: evaporation, sedimentation, aggregation and sedimentation. However, the leading role in the process of oil transformation belongs to biological degradation by oil-oxidizing microorganisms using hydrocarbons as a source of carbon and energy. Under favorable conditions, they are able to decompose virtually all hydrocarbons from methane to heavy oil fractions. As for macro-hydrobionts, according to the literature, there is very little research into their role in the biodegradation of petroleum products.

4. As a result of pollution there is a sharp deterioration of water quality in water bodies, native reservoirs lose the ability to self-cleaning. Among the methods of cleaning reservoirs from PP should be preferred to organic and organo-mineral sorbents, taking into account their environmental friendliness and safety, wide raw material base, high oil consumption compared with low cost.

5. Today there is a large number of scientific and practical developments on

ways and methods to reduce or eliminate oil pollution. Various mechanical, physicochemical, chemical and chemical applications are used to clean water bodies and biological methods. But the problem continues to exist without losing its relevance. Therefore, there is a need to improve a wide range of methods and materials that would be particularly effective in operations of purification and removal of oil from contaminated areas.

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