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

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«_____» ____________ 2020

BACHELOR THESIS

(EXPLANATORY NOTE)

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

Theme: «A complex assessment of the ecological state of the city of Kherson by bioindication method»

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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: «Комплексна оцінка екологічного стану міста Херсон методом біоіндикації»

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КИЇВ 2020

NATIONAL AVIATION UNIVERSITY

Faculty of Environmental Safety, Engineering and Technologies

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

(code, name)

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BACHELOR THESIS ASSIGNMENT

Alina V. Husieva

1. Theme: «A complex assessment of the ecological state of the city of Kherson by bioindication method» approved by the Rector on April 27, 2020, № 527/ст.

2. Duration of work: from 25.05.2020 to 21.06.2020.

3. Output work (project): Kherson city map, characteristics of the city’s economic activity, data on active and decommissioned enterprises.

4. Content of explanatory note: factors in the formation of the ecological situation in the city. Bioindication as a method of studying the state of the environment. Assessment of the environmental situation in the kherson city

5. The list of mandatory graphic (illustrated materials): tables, maps.

6. Schedule of thesis fulfillment

№ з/п	Task	Term	Advisor's signature
1	Getting the topic of the problem, searching for literary sources and analysis of previous studies	25.02.2020	
2	Writing a Problem Review on a Research Topic (Section I)	27.05.2020	
3	The choice of research methodology (section II)	29.05.2020	
4	Experimental research	30.02.2020	
5	Formulation of conclusions and recommendations of qualification work	03.06.2020	
6	Registration of an explanatory note to the previous submission at the department, consultation with Normocontroller	04.06.2020	
7	Advance protection	05.06.2020	
8	Consideration of comments, recommendations	06.06.2020	
9	and preparation for defense	12.06.2020	
10	Submission of work to the department	17.06.2020	

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

Diploma (project) advisor: __________________ __________________

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

Task is taken to perform: __________________ __________________

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

НАЦІОНАЛЬНИЙ АВІАЦІЙНИЙ УНІВЕРСИТЕТ

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ЗАТВЕРДЖУЮ
Завідувач кафедри
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«____» _________ 20__ р.

ЗАВДАННЯ
на виконання дипломної роботи
Гусєвої Аліни Віталіївни

1. Тема роботи «Комплексна оцінка екологічного стану міста Херсон методом біоіндикації» затверджена наказом ректора від «27» квітня 2020 р. №527/ст.

2. Термін виконання роботи: з 25.05.2020 р. по 21.06.2020 р.

3. Вихідні дані роботи: карта міста Херсон, характеристика економічної діяльності міста, данні про активні та виведені з експлуатації підприємства.

4. Зміст пояснювальної записки: фактори формування екологічної ситуації в місті. Біоіндикація, як метод вивчення стану навколишнього середовища. Оцінка екологічної ситуації в місті Херсон.

5. Перелік обов’язкового графічного (ілюстративного) матеріалу: таблиці, карти.

6. Календарний план-графік

№ з/п	Завдання	Термін виконання	Підпис керівника
1	Отримання теми завдання, пошук літературних джерел та аналіз попередніх досліджень	25.02.2020	
2	Написання огляду проблеми за темою дослідження (Розділ I)	27.05.2020	
3	Вибір методики дослідження (Розділ II)	29.05.2020	
4	Проведення експериментальних досліджень	30.02.2020	
5	Формулювання висновків та рекомендацій кваліфікаційної роботи	03.06.2020	
6	Оформлення пояснювальної записки до попереднього представлення на кафедрі, консультація з нормоконтролером	04.06.2020	
7	Попередній захист	05.06.2020	
8	Урахування зауважень, рекомендацій та підготовка до захисту	06.06.2020	
9	Представлення роботи на кафедру	12.06.2020	
10	Захист кваліфікаційної роботи	17.06.2020	

7. Дата видачі завдання: «27» квітня 2020 р.

Керівник дипломної роботи (проекту): ________________ Радомська М.М. ф
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Завдання прийняв до виконання: ______________ ______________
(підпис випускника) (П.І.Б.)

ABSTRACT

Explanatory note to thesis «A complex assessment of the ecological state of the city of Kherson by bioindication »: 65 pages, 3 figures, 26 tables, 19 references.

Object of research: change in the composition of atmospheric air under the influence of anthropogenic activity

Subject of research: the level of air pollution

Aim of research: to assess the ecological state of the city of Kherson, to estimate the anthropogenic load on the city using bioindication methods.

Methods of research – information search, analysis and synthesis of information, comparative analysis, mapping, visual observations, method of phytoindication, method of lichen indication.

The practical value of the work is to determine the anthropogenic impact on the city and the environment. Creation of a map of anthropogenic load on the city and maps of city pollution. The results of the thesis can be used in the course of research and in practice by both local residents and environmental experts. Information of the thesis can serve the development of the environmental awareness of city residents.

BIOINDICATION, PHYTOINDICATION, LICHEN INDICATION, URBAN AIR POLLUTION, ANTHROPOGENIC PRESSURE.

CONTENT

INTRODUCTION **9**

CHAPTER 1. FACTORS IN THE FORMATION OF THE ECOLOGICAL SITUATION IN THE CITY **11**

1.1. The composition of the urban ecosystem and its structure 11

1.2. Features of biotic and abiotic components of the urban ecosystem 14

1.3. Objects of the technosphere and sociosphere as sources of destabilization of the ecological situation in the city 17

Conclusions to Chapter 1 19

CHAPTER 2. BIOINDICATION AS A METHOD OF STUDYING THE STATE OF THE ENVIRONMENT **21**

2.1. The essence of the method of bioindication.. 21

2.2. Species and method of phytoindication 25

2.3. Lichens as bioindicators 27

2.4. Interpretation of the results of bioindication studies...................................... 29

2.5. The methods of phytoindication and lichen indication for research area 32

Conclusions to Chapter 2 34

CHAPTER 3. ASSESSMENT OF THE ENVIRONMENTAL SITUATION IN THE KHERSON CITY **36**

3.1. Characteristic of the city of Kherson 37

3.2. Characteristics of anthropogenic load.. 39

3.3. Evaluation of the air quality by dendroindication method............................ 42

3.4. Evaluation of the air quality by lichen indication method............................ 47

3.5. Integral Air Condition Assessment 58

3.6. Recommendations for Improving Air Condition 60

Conclusions to Chapter 3 61

CONCLUSIONS.. **62**

REFERENCES **64**

INTRODUCTION

Relevance of the topic. Today, humanity is actively developing in all areas of activity, thereby changing the state of the environment. The city of Kherson developed over the years, changing the environment. To find out about the ecological state of the city, studies were conducted using bioindication methods. Recommendations were also given on improving the condition of the studied territories.

The aim of the bachelor thesis is to assess the environmental condition of the city of Kherson, to evaluate the anthropogenic load on the city using bioindication methods.

The main tasks of the work are:

1. To study the literature about the city and define the general condition of the city;

2. To study the methods of bioindication, in particular phytoindication and lichenoindication method;

3. Designate areas with a large anthropogenic pressure on the environment;

4. To analyze the condition of arboreal plants and lichens in the area of enterprise impacts and define the condition of air in the city of Kherson;

5. Develop the recommendations for reducing the anthropogenic load on the city and improving the general environmental condition of the city.

Object of research – change in the composition of atmospheric air under the influence of anthropogenic activity.

Subject of research – the level of air pollution.

Methods of research – information search, analysis and synthesis of information, comparative analysis, mapping, visual observations, method of phytoindication, method of lichen indication.

Practical value. The developed map of anthropogenic load on the city and maps of city pollution can be used for planning nature and human health activities planning. The results of the thesis can be used in the course of research and in practice by both local residents and environmental experts. Information of the thesis can serve the development of the environmental awareness of city residents.

Personal contribution of the author – study and analysis of literature, identification of areas with a large anthropogenic load, development of the map with the distribution of anthropogenic load following the specifics of the location and functioning of the city, development of the map of the anthropogenic load on the city, evaluation of the air condition based on the results of bioindication assessment, recommendations for improving the general condition of the city.

Approbation of the results. The content and conclusions of thesis are presented in the discussion in 2 international conferences: II International Scientific Symposium SDEV'2020 "Sustainable Development - Status and Prospects", and International Science conference of young scientists "Regional problems of environmental protection".

Publications: based on the results of the work 2 theses were published.

CHAPTER 1
FACTORS IN THE FORMATION OF THE ECOLOGICAL SITUATION IN THE CITY

1.1. The composition of the urban ecosystem and its structure

Urbanization is a historical process related to the growth of cities and the spread of urban lifestyle. Urbanization is objective, but it brings a lot of problems to the life of mankind, since with the improvement of living conditions there is a concentration of industrial production, increased transport, reduced green spaces, and as a result the emergence of new mutagens and risks to human life.

Urban ecosystems or urban ecosystems are artificial heterotrophic anthropogenic ecosystems that arise as a result of urban development and are the focus of the population, residential buildings, industrial, domestic, cultural objects, etc. Unlike agrocenoses, they lack elements of self-regulation.

The development of an urban ecosystem requires three main components:

1. The geographical environment is the natural basis of the ecosystem. It is a natural-climatic complex that includes abiotic (relief, soil, climate, water) and biotic (flora and fauna) components.

2. Urban population (social complex) - a set of people connected by public relations and the urban environment. It is a consumer of production products, as well as a carrier of various needs of an intangible nature (science, education, culture). It is this component of the urban system that performs the management function, which ensures the preservation of a certain structure of the city, supports the mode of activity, the implementation of programs and development goals of the system.

3. Urban environment, which includes interconnected and interpenetrating subsystems (environments): a transformed geographical natural environment, landscape-architectural, socio-economic, social and production. The connection between them is so great that virtually none of them individually can fulfill its

functions, and at the same time, the absence of one of them entails the destruction of the urban ecosystem as a whole.

The modern city can be compared with a single complex organism, which actively exchanges matter and energy with the surrounding natural complexes and other settlements. The following territories can be distinguished in its composition of the city: industrial zones where industrial facilities are concentrated, which are the main source of environmental pollution; residential areas (residential or sleeping areas) with residential buildings, administrative buildings, objects of everyday life, culture, etc .; recreational areas intended for people to relax (forest parks, recreation centers, etc.); transport systems and structures that permeate the entire city system (roads and railways, subways, gas stations, garages, airfields, etc.).

The following features are characteristic of urban ecosystems:

- An urban ecosystem is an open system in a specific geographic area. The city, on the one hand, is a powerful consumer of matter, energy, information, and on the other, a source of colossal volumes of emissions into the environment.

- The urban ecosystem is probabilistic, since nature's response to anthropogenic influences cannot be accurately predicted, the functioning of the system is not only according to the laws of nature, but also according to the laws of socio-economic development of society.

- Dependence, i.e. the need for constant supply of resources and energy.

- Nonequilibrium, i.e. the impossibility of achieving ecological balance.

- Accumulation of solid matter by exceeding its import into the city over export (approximately 10: 1). Today, this leads to an increase in the mass of buildings and the area of landfills for the storage of domestic and industrial waste.

- The number of factors affecting a person in the city is unlimited, and the time of this impact is much shorter. Consequently, urban populations are exposed to more severe environmental stress.

- Cities differ in the specific composition of the urban population. Powerful migration flows are accompanied by a high rate of genetic evolution, which proceeds independently of the processes of population growth and fitness, which fundamentally distinguishes the urban population from the natural one. Urban factors contribute to an increase in mutational pressure on residents of large cities, which leads to an increase in hereditary diseases.

- Desynchronization of biological rhythms. One of the significant violations is that the natural synchronization of daylight and human activity is shifted towards the dark part of the day. Daily desynchronization of physiological processes requires the tension of adaptive mechanisms, which depletes the adaptive capabilities of the body.

- Deformation of the visible environment. The city is dominated by gray color and flat surfaces. A long stay of a person in a visible environment, poor in visual elements, is accompanied by impaired eye movements, deterioration of well-being and the emergence of a feeling of discomfort. In urban conditions, homogeneous and aggressive visible fields prevail.

Currently, a significant portion of the solids entering the urban ecosystem is accumulating in buildings and on hard surfaces of streets and squares. In addition, the area of landfills for household and industrial waste is increasing. Cities are "parasites of the biosphere" that consume a huge amount of oxygen, water and other resources, and produce only carbon dioxide and environmental pollution.

Most of all, the natural habitat is changing in large cities. This is facilitated by the specific rhythm of life, the psycho-emotional environment of work and life, etc. The intensity of solar radiation in cities is 15-20% lower than in the surrounding area, while the average annual temperature is about 1.5 ° C higher, the daily and seasonal are not so significant temperature fluctuations, fog more often, more precipitation (10% on average), lower atmospheric pressure.

Urban ecosystems may include industrial ecosystems that form on the territory of industrial enterprises. They are characterized by a high level of pollution (physical, chemical and biological pollution); high dependence on external energy sources; exceptional depletion of species diversity; adverse effects on adjacent ecosystems.

Urban and agricultural ecosystems are closely related. In cities, agricultural products are processed in dairy plants, cannery, confectionery and spinning mills. Agricultural cars, fuel, fertilizers, pesticides, many items needed by rural residents (clothing, building materials, electrical appliances, chemicals, etc.) come from the city to the village. Finally, villagers receive information from the city. Newspapers are published in cities, and radio and television and radio companies work there.

Due to the "sprawl" of cities is a decrease in the area of natural and agricultural ecosystems. In addition, cities negatively affect the surrounding natural and agricultural ecosystems (there is pollution of the atmosphere and water). Adverse environmental factors affect citizens who are affected by chemical pollution of the atmosphere (primarily exhausts from motor vehicles) and water, physical pollution (noise, electromagnetic, radiation), as well as video pollution (“aggressive” monotonous surfaces of architectural structures).

The city dweller constantly has to solve problems that require great psychological effort; he is forced to increase the length of his working time, reducing his rest and constantly feeling a lack of time. Citizens experience a constant excess of information. As a result, many people develop neuroses and the so-called diseases of civilization. Social conditions, informational and intellectual overloads that cause mental fatigue and emotional stress in the townspeople, cause the majority of stomach ulcers and cases of myocardial infarction, provoke conflict situations, disorganization of the person’s immediate social environment, and contribute to the development of diseases.

A significant role in human life, especially in large cities, is played by noise. A high noise level contributes to an increase in the number of hypertension and hypotension, gastritis, gastric ulcer, diseases of the endocrine and metabolic glands, psychoses, neuroses, and circulatory diseases. In people living in noisy areas, cerebral atherosclerosis, increased blood cholesterol, asthenic syndrome is more often detected. The proportion of newborns with reduced weight increases correspondingly to an increase in noise level [1].

1.2. Features of biotic and abiotic components of the urban ecosystem

Abiotic components are elements of inanimate nature:

- The lithosphere is the solid shell of the Earth. For the construction of cities, large territories are needed that are almost irrevocably withdrawn from the land fund. The most important component of the lithosphere is the soil. In cities, the soil is almost entirely hidden under buildings, concrete and asphalt surfaces of squares, roads and sidewalks. In a few open areas, all living organisms of the soil layer are carefully etched. Used car oils accumulate here, the earth is saturated with salt, scattered every winter and spring on the roads. Many harmful substances are deposited here from the highly polluted urban atmosphere. The soils of streets, squares, car parks are completely hidden under artificial turf. The source soil from here is most often removed and replaced with sand and gravel. Open soil sometimes remains on the sidelines. Here it is very compacted and, as a rule, very dirty. Usually a lot of open ground remains within the city in its parks and gardens. Natural or bulk soils are often preserved there. Here, moderate doses of fertilizers are applied, the soils are taken care of, but still they are deposited on them and they bind a lot of air polluting substances.

- The hydrosphere - is an important component for the life of all living organisms, including humans. Despite the abundance of water resources on the planet, the problem of lack of drinking water is quite acute. The city is a source of waste and a large consumer of fresh water. For his needs (industry, agriculture, communal needs), a person uses a large amount of water, which changes its initial properties. Hydrosphere pollution as a result of urban development is associated primarily with the use of all modes of transport. Another factor in the pollution of the hydrosphere is the insufficient treatment of discharged wastewater. In addition to pollution, the construction of cities leads to a change in the hydrological regime of rivers. The construction of dams for energy needs leads to flooding of large areas, and the improper use of surface and underground water sources can lead to their depletion or pollution.

- The atmosphere is also an important component of nature. Natural pollution of the atmosphere existed before the appearance of man, but with the increase in population and the growth of cities, anthropogenic pollution is also imposed on natural pollution. Up to 20 billion tons of this technogenic gas are released into the atmosphere annually. Green spaces are not able to process such an amount of gas, therefore, over the past decades, the CO_2 content in the air has increased by 12%. In addition to chemical, thermal pollution is also characteristic of cities. High population density, constant emissions of hot vapors into the atmosphere, heating, a change in the underlying surface leads to heating of the atmosphere, which is not characteristic of it in natural conditions.

Biotic components are elements of wildlife. Biota is a collection of animals, plants, fungi and microorganisms.

- green plants - Despite the poor soil, cities have a kind of vegetation. Usually these are not peculiar species for a given area, since the plant regulates the planting and growth of plants in the city, especially trees and shrubs. Moreover, a person in his efforts to saddle a greener city sometimes relies on the principle “the more the better”, not caring about quality (skillful selection and distribution of species of trees and shrubs in the territory). An example is poplar fluff, which is the strongest allergen and makes life difficult for a large number of citizens in the summer months. The selection of trees and shrubs in the city should be carried out by specialists. This is an important element in the structure of the human habitat; the stability of the community created in the city depends on it in many ways. The main elements of green spaces can be copied from the natural environment, the landscape to which this city belongs. In the features of the selection and planting of trees, it is necessary to proceed from at least two reasons:

1) the nature of residential buildings, their size and density;

2) remoteness from the outskirts and natural landscape.

Trees, depending on the species, have different environmental plasticity, that is, they have different attitudes to gas contamination, asphalt flooding, lack of vegetation around. The city should be landscaped with plants of the zone in which it is located. When indigenous plants cannot grow there because of the peculiarities of air or soil, hopelessly spoiled by industrial enterprises, then you have to choose some species that are especially resistant to the effects of urbanization from other zones.

- animal - a stimulator of biospheric processes. Cities negatively affect biota when they function. The emergence of new settlements deprives many types of their habitual habitats, pollution of all components negatively affects the health of living organisms, which may ultimately lead to their death, etc. Nevertheless, there is a process of penetration of animals into settlements, which began a long time ago, and its pace has recently accelerated. The species composition of birds in the city varies depending on the season, which is associated with the flight of birds to the south. Different species of birds settle in their preferred habitat. Sparrows and pigeons habitual for the city dweller in the attics and under the roof roofs. The balconies of houses are sometimes occupied by house sparrows, greenfinches, village swallows and blackbirds. City swallows sculpt nests under balconies. Especially many birds live in parks and near objects of the food industry. In some countries, scientists noted that with the development of urbanization, birds evolved (they became faster, received previously unusual skills).

Mammals populate our cities less noticeably than birds, but in much larger numbers. The biggest problem is the spread of rats and mice in cities. The extent of their distribution can sometimes reach catastrophic proportions. More and more in parks you can find squirrels that are well adapted to life in the city. Along with the penetration of wild animals into our cities, another process is going on - the return of feral pets from cities to the surrounding nature.

Food reserves and good temperature conditions in apartments, contributes to the spread of invertebrates and parasites [2].

1.3. Objects of the technosphere and sociosphere as sources of destabilization of the ecological situation in the city

Recently, the number of natural catastrophes, which is due to the technogenic impact on the planet earth and global warming on it, so over the past 30 years the number of disasters with high economic damage increased 4.1 times with the victims 2.1-3.5 times, premature mortality 3-5%. Disaster Management Costs America About 50 Billion year. China from the floods in 1991-1998 lost from 20 to 30 billion dollars.

The greatest damage in the world is caused by floods, earthquakes, hurricanes, droughts, famines. Thus, starvation killed 42% of people who died in all disasters.

There is a relationship between natural disasters when one catastrophe causes other natural and man-made disasters: dam breaks, fires, explosions, chemical pollution, etc. The increase in the number of catastrophes, disasters of emergency situations, is due to the fact that the development of our civilization has reached the stage of unsustainable development [3].

Radiation pollution of the environment at large nuclear accidents, nuclear explosions lead to significant saturation of the environment with radionuclides that scatter and fall almost all over the planet.

The technosphere is a part of the biosphere that has been transformed by man into technogenic objects in order to best match the social and economic needs of mankind. The best technosphere is fully consistent with the improvement of the ecology of the environment. In general, the technosphere is a combination of artificial objects created by the purposeful activity of man and natural objects changed by this activity.

Technogenesis is all that is associated with human production activities. New substances, products, and equipment created in the process of technogenesis are called technogenic products.

The technogenic problems of our time in terms of their size can conditionally be divided into local, regional and global, and require different means and various scientific developments for their solution.

An example of a local environmental problem is a plant dumping harmful wastewater into a river without treatment. Nature protection authorities or the public should fine such a plant and, under the threat of closure, force it to build treatment facilities.

An example of regional environmental problems is the Kuzbass - an almost closed basin in the mountains, filled with coke oven gases and metallurgical giant smoke, or the drying Aral Sea with a sharp deterioration of the ecological situation on its entire periphery, or high radioactivity in soils in the areas adjacent to Chernobyl.

Sources of emergencies are: the natural environment, the technosphere and society.

The danger of emergencies is the objectively existing probability of a negative impact on society, the individual, the state and the natural environment, as a result of which they can be caused any damage, harm that worsens their condition [4, 5].

The causes of emergencies and the corresponding damage from them are diverse.

The most common ones may be quantitative and qualitative growth of the economy, rapid population growth, uncontrolled growth and concentration of production, urbanization of territories of environmental pollution, etc.

Collective environmental risks are caused by the presence of a certain social group in the area where a potentially dangerous facility is located, employment at the facility, or living near the facility. This type of risk, unlike the individual, serves as an integral indicator of a specific hazard in a particular geographical area and characterizes the scale of a possible accident. Collective risk is estimated by the number of n-deaths as a result of the action of a certain hazardous factor on the considered population of N.

Special safety criteria for special equipment specially developed for society as a whole and for an individual have been developed:

- for society - the mathematical expectation of damage is not more than 1% of the public costs of creating, operating and destroying an object;

- for an individual from the population - the probability of death or serious injury is not higher than domestic or from accidental damaging factors;

- for an individual from the staff servicing the facility - no higher than for the least dangerous professions.

As a regulator of the safety of members of society, along with the concept of acceptable risk, a number of experts recommend starting from the concept of justified risk: the risk that is socially justified is acceptable. Then risking members of the society, whose safety at this stage in the development of science and technology cannot be ensured at an acceptable level, should receive appropriate compensation from the society [6].

Conclusions to Chapter 1

As a conclusion, we can say that the urban ecosystem is a complex system of interactions between living and non-living matter, which is controlled mainly by human activity. Both biotic and abiotic components are an integral part of the functioning of urban ecosystems, they have their own characteristics and continuously intersect.

The city is formed on the basis of natural ecosystem that changes and functions under the influence of technogenic and social factors. Technogenic factors include architectural and planning solutions of cities, industrial production, traffic flows and other types of economic activity. The social factors are management of the urban complex through government and the media, demographic processes, etc.

The geographical location of Kherson affects the specific direction of economic activity in the city and thus determines its environment condition.

CHAPTER 2
BIOINDICATION AS A METHOD OF STUDYING THE STATE OF THE ENVIRONMENT

2.1. The essence of the method of bioindication

Bioindication is the assessment of the environment quality based on the condition of its biotic components. Bioindication involves the study of reaction of indicator species to the environment parameters, which could be changed under the influence of human activity. [7] Indicator species or bio-indicators are biological objects used to assess the state of the environment [8].

The method of bioindication is the determination of the degree of pollution of the natural environment with the help of living organisms (or natural communities). Indication of environmental conditions is carried out on the basis of assessing the changes in both the species diversity of organisms of a particular locality and their chemical composition, which reflects their inherent ability to accumulate compounds and elements coming from the environment. For example, the assessment of the state of the environment by the change in the total number of species is related to the fact that the plant and animal species that are most sensitive to one or another pollutant disappear from the biocenosis (lichens in industrial centers, the May Beetle) or, on the contrary, increase their numbers (blue-green alga, when water bodies are polluted with substances from agricultural land).

The indicator functions as a species that has narrow amplitude of environmental tolerance with respect to any factor. [9] Environmental tolerance is the ability of living organisms to live and develop in a wide range of environmental conditions (including adverse factors). Any factor, if it goes beyond the “comfort zone” for a given organism, is stressful. The organism reacts to such a factor with varying degrees of intensity and duration, the manifestation of which depends on the species and is an indicator of certain parameter value. Bioindication methods determine exactly the response. The biological system reacts not only to individual factors, but also to the impact of the environment as a whole, and the amplitude of fluctuations of physiological tolerance may vary with the internal state of the system – age, nutritional conditions, genetically controlled resistance.

There are two forms of response of living organisms used for bioindication, specific and nonspecific. In the case of specific bioindication, the changes occurring are associated with the action of one factor. The nonspecific bioindication studies different anthropogenic factors, which cause the same reaction.

Depending on the type of response, bioindicators are divided into sensitive and cumulative. Sensitive bioindicators respond to stress by a significant deviation from vital standards, and cumulative accumulate anthropogenic effects, far exceeding the normal level in nature, without visible changes.

Depending on the time of development of bioindication reactions, 6 different types of sensitivity can be distinguished:

I type: the bio-indicator acts after a certain time, during which it did not respond in any way to the action (lack of an effective level), a one-time strong reaction and loses sensitivity (above the upper effective level).

Type II: as in the first case, the reaction is instant and strong, but continues for some time, after which it abruptly disappears.

Type III: the bio-indicator reacts from the moment the disturbed action is determined with the same intensity over a long period of time.

IV type: after an instantaneous strong reaction, it stops, first fast, then slows down.

V type: when a disturbed action appears, a reaction begins, which becomes more intense until it reaches a peak, and then gradually stops.

VI type: V-type reaction is repeated many times; oscillation of bioindicator parameters occurs.

In the book "Bioindication of pollution of terrestrial ecosystems" (1988), edited by R. Schubert, six levels of bioindication are distinguished:

1st level: biochemical and physiological reactions;

2nd level: anatomical, morphological, biorhythmic and behavioral abnormalities;

3rd level: floristic and faunistic changes;

4th level: coenotic changes;

5^{th} level: biogeocenotic changes

6th level: changing landscapes.

Representatives of all the “kingdoms” of living nature can be used as bioindicators - bacteria, algae, higher plants, invertebrates, mammals. When choosing an indicator, it is also necessary to take into account considerations of economy and possibility of using certain organisms. The response of a bioindicator to a specific physical or chemical effect should be clearly expressed, i.e. specific, easy to register visually or using simple instruments. It must be widespread in the study area and not listed in the "Red Book". Organisms damaged by diseases, pests and parasites are not suitable for bioindication.

An ideal biological indicator must satisfy a number of requirements:

- be typical for the given area;
- have high abundance in the studied ecotope;
- dwell in this place for a number of years, which makes it possible to trace the dynamics of pollution;
- be in conditions suitable for sampling;
- enable direct analysis without prior concentration of samples;
- demonstrate positive correlation between the concentration of pollutants in the environment and the intensity of reaction;
- used under the natural conditions of its existence;
- have a short period of ontogenesis, so that the influence of the factor on subsequent generations can be traced.

For bioindication, it is necessary to choose the most sensitive communities characterized by the maximum response speed and intensity. For example, in aquatic ecosystems, plankton communities are the most sensitive, they respond quickly to changes in the environment due to the short life cycle and high reproduction rate. Benthic communities, where organisms have a sufficiently long life cycle, are more conservative: restructuring occurs in them with prolonged chronic pollution, leading to irreversibility of processes.

For guaranteed detection of the presence of a toxic agent of unknown chemical composition in the natural environment, as a rule, a set of objects representing different taxonomic groups is used. With the introduction of each additional object, the efficiency of the test scheme increases, but there is no point in expanding endlessly the range of mandatory objects: it makes the research more complicated and blurs the results.

The bioindication methods that can be used in the study of the ecosystem include the identification of rare and endangered species in the study area. The list of such organisms, in fact, is a set of indicator species that are most sensitive to anthropogenic influences [10].

At the population level, bioindication is carried out if the process of spreading negative changes covers such a number of individuals that significantly reduces the population size, changes its age and sex structure, shortens life expectancy, shifts the phenological phases, etc.

The ecosystem approach to environmental assessment allows early diagnostics of its changes. The alarm signal is the imbalance of production and destruction processes. Diagnostic signs of such changes are, for example, the accumulation of organic matter, siltation, overgrowing of water bodies, and the enhanced development of microorganisms.

The regular observations over the condition of plants are attributed as biomonitoring and are implemented in many countries of the world at non-governmental and regulatory levels. Biomonitoring can be carried out by observing individual indicator species, a population of a particular species, and the state of the phytocenosis as a whole. At the species level, they usually produce a specific indication of a single pollutant, and at the population or phytocenosis level, they produce a general state of the natural environment [11].

2.2. Species and method of phytoindication

Phytoindication is the analysis of environment condition using plants as indicators. It is one of the most common and efficient methods of biological environmental assessment, as plants have a range of important advantages:

- these organisms do not have the ability to move and therefore their reaction is well determined spatially;
- plants are directly connected to all components of environment and thus show the condition of air, soil, ground waters, as well as intensity of such complex processes as climate change and recreational pressure;
- plant associations are basis of habitats and urban ecosystems and any negative changes in plants condition are clear signs of the whole ecosystem degradation;
- plant reactions to environmental factors have been studied and used for a long time already, which proves their reliability and provides well developed evaluation scales for the interpretation of the results.

B.V. Vinogradov classified indicator changes of plants into floristic, physiological, morphological and phytocenotic [12].

Floristic features are differences in the composition of the vegetation of the studied areas, formed due to certain environmental conditions. Indicative value is both the presence and absence of the species. The physiological features include features of plant metabolism.

The morphological indicators are features of the internal and external structure, various types of developmental anomalies. Scientists have systematized various anomalies of plant growth and development into three main groups related to: (1) inhibition or stimulation of normal growth (dwarfism and gigantism); (2) deformations of stems, leaves, roots, fruits, flowers and inflorescences; (3) occurrence of neoplasms (tumors are also included in this group of growth abnormalities) [11].

For the purposes of bioindication, the following deformations of plants are of interest: fasciation - tape-like flattening and fusion of stems, roots and peduncles; the terry of the flowers, in which the stamens turn into petals; proliferation - germination of flowers and inflorescences; ascidia - funnel-shaped, cup-shaped and tubular leaves in plants with lamellar leaves; reduction - reverse development of plant organs, degeneration; filament - filamentous leaf blade; stamen phyllody - their transformation into a flat leaf-like formation.

Some plant species are especially sensitive to the level of air pollution, and they could be used to identify individual air pollutants (Table 1), while others reflect the quality of the natural environment as a whole. According to the state of the plants, it is possible to detect the presence of specific pollutants in the air, and to start measuring the amount of these substances by various methods, for example, testing plants in the laboratory for determination of the certain substances content in their bodies [8].

Table 2.1

Primary plants - indicators of air pollution

Pollution components	The most important tree species	Agricultural and ornamental plants
Ammonia	Common Hornbeam Heart-shaped linden	Celery, shag
Hydrogen fluoride	European spruce European fir Walnut	Grape, apricot, gladiolus, lily of the valley, narcissus, tulip, rhododendron
Sulfur dioxide	Spruce (European, Serbian) European fir Pine ordinary Ash American	Wheat, barley, alfalfa, clover, cotton, violets
Ozone	Pinus strobus	Tobacco, potatoes, soybeans, tomatoes, citrus
Heavy metals	Canadian hemlock Elm smooth	Fescue, orchids, bromeliads

Indicator information is also given by grass plants about the pollution of soil. For example, types of fescue (*Festuca ovina*, etc.), bentholes (*Agrostis tenuis*, etc.) indicate the content of lead in the soil; zinc contributes to the growth of violet species (*Viola tricolor*, etc.), pennycress (*Thlaspi alpestre*, etc.); copper and cobalt - maidenstears (*Silene vulgaris*, etc.). Gigantism and dwarfism of certain plants are also good indicators of some pollutants: an excess of copper in the soil halves the size of the California poppy (*Eschscholzia californica*), and an excess of lead leads to dwarfism of Silene vulgaris.

Thus, it is impossible to obtain accurate quantitative data on the dynamics and magnitude of stress effects based on morphological changes of plants, but it is possible to determine quite accurately the magnitude of product losses and, having a dose-effect graph, calculate the magnitude of the stress effect [13].

2.3. Lichens as bioindicators

Lichens were chosen as one of the main objects of global biological monitoring. Recall that lichens are a very peculiar group of spore plants, consisting of two components - a fungus and a unicellular, rarely filamentous, algae that live together as a whole organism. In this case, the function of the main reproduction and nutrition due to the substrate belongs to the fungus, and the function of photosynthesis - to algae.

Lichens are sensitive to the nature and composition of the substrate on which they grow, to microclimatic conditions and the composition of the air. Due to the extreme “longevity” of lichens, they can be used to date the age of various objects based on measurements of their thalli - in the range from several decades to several millennia.

Lichens were chosen as the object of global monitoring because they are distributed throughout the globe and because their response to external influences is very strong, and their own variability is insignificant and extremely slow compared to other organisms.

Of all the ecological groups of lichens, epiphytic lichens (or epiphytes) have the highest sensitivity, i.e. lichens growing on tree bark.

The study of these species in the largest cities in the world revealed a number of general patterns: the more industrialized the city, the more polluted the air, the less species of lichens occur within its borders, the smaller the area covered by lichens on tree trunks, the lower the "vitality" of lichens.

It was established that with an increase in the degree of air pollution bushy first disappear, then leafy and last - scale (cortical) forms of lichens. The composition of the lichen flora in various parts of cities (in the center, in industrial areas, in parks, in peripheral parts) turned out to be so different that researchers began to use lichens as indicators of air pollution.

One of the first to do this work was the Swedish scientist R. Sernander (1926). He identified the “lichen desert” in Stockholm (the city center and industrial areas with highly polluted air - there are almost no lichens here); the zone of "competition" (parts of the city with average air pollution - the lichen flora is poor, species with reduced vitality) and the "normal zone" (peripheral parts of the city, where many types of lichens are found) [14].

In recent decades, it has been shown that of the components of polluted air on lichens, sulfur dioxide (SO2) has the most negative effect. It was experimentally established that this substance at a concentration of 0.03-0.1 mg / m^3 (30-100 micrograms / m^3 begins to act on many types of lichens. Brown spots appear in the chloroplasts of algae cells, and the degradation of chlorophyll begins. A concentration of sulfur dioxide of 0.5 mg / m3 is detrimental to all species of lichens growing in natural landscapes. However, there is a group of field-tolerant (resistant to pollution) species that can exist in rather polluted air.

In addition to sulfur dioxide, other pollutants are detrimental to lichens - nitrogen oxides (NO, NO_2), carbon monoxide (CO, CO_2), fluorine compounds and others. In addition, microclimatic conditions in the cities have changed significantly: the cities are "drier" compared to natural landscapes (by about 5%), 1-3 ° C warmer, poorer in light.

Thus, lichens are an integral indicator of the state of the environment and indirectly reflect the general "favorable" complex of abiotic environmental factors on biotic.

In addition, most chemical compounds that adversely affect the lichen flora are part of the main chemical elements and compounds contained in the emissions of most industrial plants, which allows lichens to be used precisely as indicators of anthropogenic pressure.

All this predetermined the use of lichens and lichen indications in the global environmental monitoring system.

2.4. Interpretation of the results of bioindication studies

The results obtained from the study of living organisms' condition must be interpreted somehow to set the corresponding status of the environment. The possible approaches are relative and transitional.

Relative methods involve some type of descriptive scale, which differentiates environment condition from healthy or normal to catastrophic.

Transitional is based on the acquisition of certain numerical values: for example, area of lichens cover, level of asymmetry, etc., which are then transformed into the levels of environment degradation or level of pollution by ranging the obtained values over the special scale.

For the purpose of the given research the macrophytes have been used to evaluate the level of air pollution, condition of surface waters and ecological status of soils. The parameters to be used are level of diversity and intensity of morphological abnormalities, including chlorosis, necrosis, defoliation, abnormal size of organs (leaves mostly).

Chlorosis is a change of natural color typical for plants:

- pale color of leaves between the veins (for example, plants on dumps remaining after the extraction of heavy metals, or pine needles with a weak effect of various harmful gases, sometimes reversible in young leaves);
- yellowing of edges or certain leaf areas (for example, in deciduous trees under the influence of chlorides);
- redness (accumulation of anthocyanin in the form of spots on the leaves of currant and hydrangea under the action of SO);

- browning or bronzing (in deciduous trees, often the initial stage of severe necrotic injuries; in spruce and pine trees, it is used for remote study of smoke-damaged zones);

- color changes. in which the leaves seem to be impregnated with water (often the first stages of necrosis; the similarity with frost damage), as well as the appearance of a silver color on the leaf surface.

Necrosis is the dying off of limited areas of tissue. The following types are distinguished:

- point and spotty necrosis (dying off of leaf tissue in the form of dots and spots; for example, silvery spots after exposure to ozone in Bel W3 tobacco varieties, as well as in *Urtica urens* and *Begonia semperflorens*) are very characteristic;

- interstitial necrosis (clearly delimited forms of areas damaged by salt used to melt ice); the combination of interstitial and marginal necrosis leads to the appearance of a fishbone pattern;

- apical necrosis (especially in monocotyledons and conifers; characterized by dark brown, sharply demarcated necrosis of the tips of the needles of fir-tree and pine after exposure to SO_2 or white, discolored necrosis of the leaf tops of Gladiolus "Snow Princess" under the influence of HF);

- pericarp necrosis (for example, after exposure to SO_2 on pome fruits, especially near flowers).

With the development of necrosis, changes in color are first observed. After cell death, the affected areas are deposited, dry out and can be colored brown in color (often in trees) or, after a few days, fade to a whitish color (tulips, onions, gladioli, cereals and other monocots) due to the release of tannins.

Necrotic spots often have dark edges, especially in dicotyledons. Later, in the place of necrosis, gaps may appear (mainly on tender juicy leaves), similar to bites or hail damage. Quantifying necrosis most often occurs by determining the percentage of damaged leaf surface, for which auxiliary tables can be used. It is also possible to plan the gauging or grading on a five-step scale.

Premature wilting occurs, for example, under the influence of ethylene in greenhouses. The carnation flowers are not disclosed, and the orchid petals fade; when exposed to SO reversibly wither raspberry leaves.

Defoliation in most cases occurs after the appearance of necrosis or chlorosis. Examples are the reduction in the life span of the needles, its shedding in spruce, the dropping of the two-sprung shortened shoots of the pine, the premature shedding of the foliage in the lindens and horse chestnuts under the influence of salt used for melting ice, or in the gooseberry and currant under the action of SO.

Defoliation leads to a reduction in the assimilating area and, consequently, to a reduction in growth, and sometimes to the awakening of buds and the premature formation of new shoots.

Changes in the size of organs are mostly non-specific. Thus, in the vicinity of enterprises producing fertilizers, pine needles are extended under the action of nitrate and shortened under the action of SO; in berry bushes, smoke causes a decrease in leaf size. On the other hand, abnormally large leaves of the sprout on dying trees are observed after exposure to HCl.

Changes in the shape, number and position of organs, direction of growth and branching, as a rule, are observed in plants in areas with a high concentration of gaseous emissions. Growth changes are mostly non-specific, however, they are widely used for indication, as they are a more sensitive parameter than necrosis, and allow you to directly determine the decrease in productivity of plants [15].

Still, the above-mentioned plant reactions are not clearly specific, because some natural factors can cause symptoms similar to anthropogenic disturbances. For example, leaf chlorosis can be caused by the lack of iron in the soil or early frost. When defining morphological changes, it is desirable to have some experience in order not to confuse damage symptoms and to be able to assess correctly the impact of climate, soil, developmental stage and season. Some natural factors can cause symptoms similar to anthropogenic disturbances. Therefore, when working with bioindicators, it is necessary to reckon with the possibility of the presence of pests, as well as take into account previous weather conditions. The impact of climatic and edaphic factors on the resistance or on the damage picture has not yet been studied. There is evidence that the symptoms of SO_2 damage in spruce and pine are alleviated by the use of fertilizers. Humidity and light influence decisively on the formation of necrosis during gas pollution. With high humidity and soil, plants become especially susceptible; in winter, a clear decrease in stability is caused by an increase in temperature. So far, too little is known about the role of constantly observed short-term fluctuations in the level of atmospheric pollution. In most cases, its effect increases in proportion to the increase in concentration.

Internal factors also make it difficult to assess changes in plants, as reactions of plants depend on their sensitivity, which is different at certain periods of time:

- at various age stages;
- in organs of various ages;
- at different times of the day and year;
- in different individuals of genetically heterogeneous populations;
- at various predisposition.

Therefore, when determining morphological changes in plants, it is necessary to take into account the possibility of action of other damaging factors.

2.5. The methods of phytoindication and lichen indication for research area

Prior to conduction of the research the territory of the city must be assessed in terms of technogenic pressure distribution. The areas with clear sources of environment pollution are chosen for the following analysis. To conduct the survey at the study area it was decided to apply two methods – phytoindication and lichen indication.

The first method involved evaluation of leaves at the trees for the purpose of finding signs of damage and degradation. At each probe ground 5 trees, preferably of the same species, were chosen and as much leaves as possible were visually examined. The condition of leaves was evaluated using the following scale:

1 - leaves without spots, healthy, normal color

2 - with a silver coating, dull

3 - with yellowed edges or asymmetric

4 - with large yellow zones or zones of a different color (chlorosis)

5 - half and more shriveled leaves

6 - defoliation

The approximate percentage of each type of damage was measured and it was also transformed into the scores using the appropriate scale:

<10% - 1

10-20% - 2

20-30% - 3

30-40% - 4

40-50% - 5

> 50% - 6

The general assessment for each site was calculated as the sum of products of points for type of damage and points for its distribution within the study area. The obtained results were interpreted as follows:

6-8 - favorable condition of the ecosystem, anthropogenic loading is absent;

9-15 - the anthropogenic load is minimal, the state of the ecosystem is normal;

16-20 - continuous anthropogenic loading of a non-industrial nature (transport and utilities); satisfactory condition;

21-27 - significant anthropogenic industrial loading; condition - unsatisfactory;

28-36 - anthropogenic loading above the assimilation potential of the ecosystem; unfavorable condition

The assessment of the environment status by the condition of lichens was conducted for the same probe grounds as those chosen for phytoindication. The research procedure involved the following steps.

1) At each site, 5 trees with trunk diameters greater than 25 cm and approximately the same height were chosen so that the age was the same. We tried to stick to one tree species. Few important issues were accounted:

- to avoid roadside trees;

- to avoid dense stands with very low light;

- to avoid trees that could be treated with pesticides or intensively fertilized (near the fields directly or whitewashed recently);

- to avoid very old trees with the largest number of lichens.

2) Using the measuring tape the area of lichens, covering the trunk to the height of 150 cm from the ground, was measured separately for each species. The area was measured using the reticulation palette with 1x1 cm squares (Fig 2.1).

Fig 2.1 Grid used for lichen indication

3) The girth of each tree was measured at the height of 75 cm. The studied area of the tree was calculated as the product of girth and 150 cm.

4) The lichens species types and names were identified.

5) The lichens condition was studied as well. It was noted whether a lichen is pale, dry, has non-uniform coloration, damaged ends, loosely attached to the trunk, etc.

Conclusions to Chapter 2

Bioindication is the assessment of the environment quality of the based on the state of its biotic components. Bioindication includes the study of the reaction of indicator species to environmental parameters that may change under the influence of human activity. For the study, phytoindication and lichenoindication methods were chosen. Phytoindication is the analysis of environment condition using plants as indicators. Lichens are sensitive to the nature and composition of the substrate on which they grow, microclimatic conditions and composition of the air. These methods helped us to obtain data for studying the general anthropogenic load in the city in order to get an idea about the state of the city environment and possible human health hazard.

CHAPTER 3
ASSESSMENT OF THE ENVIRONMENTAL SITUATION IN THE KHERSON CITY

Kherson region and in particular the city of Kherson is considered environmentally friendly, due to the high biodiversity and low intensity of industrial activity. However, in the city there are several zones in which the situation is characterized by pronounced anthropogenic pressures. In these areas, environmental damage is caused not only by industry, but also by the agricultural sector. The actual problem of the Kherson region is the pollution of water bodies with pesticides and mineral components of fertilizers, with a surface runoff it rinses them from the fields to the Dnieper, estuary and further into the Black Sea.

According to the results of the first half of 2019, Kherson took the seventh place in the air pollution level in Ukraine, according to the National Hydrometeorological Service. Indicators (a comprehensive atmospheric pollution index) for the reporting period significantly increased immediately in eight large cities of Ukraine. Kherson was on a par with Dnieper, Mariupol, Nikolaev, Krivoy Rog. The high level of air pollution was mainly due to significant average concentrations of formaldehyde, nitrogen dioxide, phenol, hydrogen fluoride, carbon monoxide, and suspended solids. According to the results of similar studies in 2018, Kherson was on the 15th place in the list of 39 cities of the country. Kherson also leads in such indicators as the air concentration of nitrogen dioxide (3.5 mg / m3) and nitric oxide (1.8 mg / m3) [16].

Kherson is a city with a large port, which is not only a source of income, but also a source of environmental pollution. At the beginning of 2018, ornithologists of the Kherson region observed the death of birds from contaminated water, in the summer they recorded several cases of mass death of fish in the Kakhovka reservoir, the Dnieper-Bug estuary. A water analysis conducted by the regional department of ecology showed an excess of the permissible concentration of nitrites, nitrates and iron. There is also a big problem of burning more smoothly in spring and summer [17].

The anthropogenic factor affects the biodiversity of both natural and anthropogenic transformed landscapes, which leads to the disappearance of various types of biota from the composition of the biocenosis. One of the most sensitive groups of organisms regarding environmental pollution is lichens. Therefore, to assess the state of the city of Kherson, plots, subjected to an increased technogenic load, were allocated and an analysis of the ecological situation in these zones was carried out using bioindication and lichen indication methods.

3.1. Characteristic of the city of Kherson

Kherson region is located within the Black Sea lowland of southern Ukraine in the steppe zone. Its area is 28.5 thousand square meters. The territory has a complex geological structure. The Quaternary deposits represented by loess, loess-like loams, alluvial, alluvial-deluvial loams, deluvium with aeolian deposits are the most common. They cover all earlier sediments, only in places of the ravine-beam system of watercourses and in river valleys, these rocks are washed away.

The relief of the region is flat, with a slight slope from the north to the south and from the northeast to the southwest, dissected by river valleys, gullies and ravines.

Kherson region is rich in water resources. The Dnieper flows through its territory for 200 km. The attraction of the Dnieper is the floodplains that border it with a strip from the man-made Kakhovka reservoir to the mouth and occupy an area of about 40 thousand hectares. This is a unique corner of nature in the south of Ukraine, where for a long time there have been plant communities that perform a large water conservation and anti-erosion function.

The Dnieper feeds its waters the North Crimean Canal, the Kakhovska and other irrigation systems. In the lower part of the stream, the Ingulets flows into it - the second most important river in the region; its water is used for the Ingulets irrigation system, which feeds the lands of the Kherson and Nikolaev regions. Its tributaries Osokorevka, Burgunk, Tyaginka, etc are of lesser importance are.

The climate is temperate continental. The average annual temperature is + 10 ° C, maximum + 40 ° C, minimum can reach -32 ° C. Winters are warm, with unstable snow cover, frequent thaws. The frosty period on average lasts about 100 days. The transition of daily average temperatures over 0 ° C is observed in the first ten days of March.

The vegetative period of plants lasts 216-230 days. The region is located in the zone of insufficient moisture. During the year, 300-400 mm of precipitation falls, mostly in spring and summer (about 200 mm). High positive temperatures, frequent east and south-east winds, and low relative humidity in summer often lead to droughts.

Under the steppe vegetation and moisture deficit, several types of soils formed on carbonate-rich parent rocks. In the north of the region, southern chernozems predominate, which go south into dark chestnut and chestnut soils. There are also salt marshes and salt marshes, especially in the coastal zone of the Black Sea and the Sivash. Fertile alluvial-meadow soils are common in floodplains. More than 200 thousand hectares are occupied by sands, which are effectively developed and used for growing grapes, fruit, vegetables and other agricultural crops, and the creation of conservation forest complexes.

Geographical location, relief, soil and climatic conditions, human production activities have had and continue to have a great influence on the formation of flora and vegetation in the Kherson region. The most valuable associations are:

- Botanical Garden of Kherson State University (14 ha), founded in 1934. The collections of the botanical garden include more than 200 species of introduced wood and shrub plants, more than 180 species of herbaceous plants (33 species of gymnosperms and 555 species of angiosperms), 16 species of mosses and 23 species of lichens, 60 species of mushrooms.

- Arboretum of Kherson State Agrarian University (2.4 ha), founded in 1951-1952 More than 90 species of coniferous and deciduous trees and shrubs grow there.

- Arboretum of the Scientific Research Institute of Agriculture of the Southern Regions (5.6 ha), founded in 1956.. More than 90 species and forms of trees and shrubs grow in the regular landscape style.

- Park of the Kherson Regional Lyceum ("State Garden", 8 ha). One of the oldest parks in the city, founded in 1868, a monument of landscape gardening, grows about 50 species of trees and shrubs [18].

The territory of Kherson was inhabited in ancient times. The urban activity started in the end of the XVIII century. Its major industry since then has been shipping: in 1847 the shipping company of Kherson and Odessa arose here based on large city port. The other well developed industries now are food, light, agricultural and wood processing.

Now the city of Kherson is a modern, industrial city with a developed culture. Kherson is a part of Ukraine and also continues to develop, and the population is growing every year, at the moment there are about 290 thousand people [19].

3.2. Characteristics of anthropogenic load

The anthropogenic load in the city is not evenly distributed, so we made a map of the anthropogenic load to determine the sources of potential environment pollution (Fig.3.1).

Fig. 3.1 Map of the city with anthropogenic load levels:

Bright green - anthropogenic load is almost absent. This color marks parks, squares, as well as sections of fields where there is almost no load on the environment.

Light green - low level of anthropogenic load - parks and squares near the road, which have certain influence from the outside.

Yellow - moderate anthropogenic load - mainly residential areas, where transport influence is not as strong as near roads, but anthropogenic pressure is still present.

Orange is a strong anthropogenic load - the roads, on which there is active traffic, which greatly affects the state of the environment.

Red is a very strong anthropogenic load. This color indicates unsafe enterprises that may pose a threat to the environment and the health of the population.

Several levels of anthropogenic pressure on the environment were marked on the map, and zones with a strong anthropogenic load were also highlighted, including:

Number 1 on the map - Zone 1. Poultry farm

Number 2 on the map - Zone 2. Meat Factory (decommissioned)

Number 3 on the map - Zone 3. Electromechanical Plant (decommissioned)

Number 4 on the map - Zone 4. Base of building materials

Number 5 on the map - Zone 5. Combined plant

Number 6 on the map - Zone 6. Sea commercial port

Number 7 on the map - Zone 7. Water treatment plant

Number 8 on the map - Zone 8. Cotton Mill (decommissioned)

Number 9 on the map - Zone 9. Bridge construction

Number 10 on the map - Zone 10. Boiler station

Number 0 on the map – Zone 0. “Clear” zone

Zone 1 is considered dangerous due to the presence of a poultry farm on it, which plays a very important role in the general condition of the city. This company poses a huge threat to normal life and public health due to cadaveric poisons from decomposing poultry. Residents of the city in summer complain of an unbearable stench that spreads throughout the city due to the peculiarities of the city planning (during the design of the city there was an active problem with tuberculosis, and houses were built in such a way that the wind would not blow out the courtyards and bacteria were delayed).

Zone 2 is considered unsafe due to the fact that there is a decommissioned meat factory that has been operating for a certain time and has an impact on the environment. Also next to the plant there is a road with active traffic, which also produces large burden on the environment.

Zone 3 was chosen because the electromechanical plant has significant impact on the environment. Also, this plant is located close to the railway, which also has a range of impacts on the environmental.

Zone 4 is the zone near the base of building materials, which mainly produce dust, but due to the fact that all materials are transported by freight the air pollution is intensive.

Zone 5 was chosen because the agricultural machinery combined plant has active productional process and thus intensive environment pollution. The zone is also located near the road with active traffic. Also, this territory is partially abandoned and for this reason there is a lot of garbage left by people.

Zone 6 - Commercial Sea Port is one of the largest ports of Ukraine is located here. Except the varied types of cargo operations, there is a small landfill, producing unpleasant smell in the warm season. This area usually demonstrates critical pollution level.

Zone 7 was chosen due to the influence of a water treatment plant. There is no active traffic in this territory, and the territory is located near the Dnieper River, so the pollution level there is relatively less.

Zone 8 - this site was selected due to the presence of a disabled cotton mill that worked in the USSR. It was a large production, which left a definite imprint on the environment. Additional sources of pollution at this area are active traffic at the shopping and entertainment center.

Zone 9 includes the bridge construction with intensive impacts from cargo operations, working equipment and people. This area is located next to the road, where there is active traffic, as well as traffic jams.

Zone 10 – is one of the city boiler, which was chosen due to easy access to the objects under study.

Zone 0 - the zone that was selected for the study, as an indicator of the clean zone.

In this zone, high levels of environmental cleanliness were found, as well as an apiary in this zone in summer, which indicates good air condition.

3.3. Evaluation of the air quality by dendroindication method

The studies were carried out in August, when active leaf cover was present, and the air temperature was not too high. Tables 3.1 – 3.10 with research results are given below.

Table 3.1

Zone 1. Poultry farm

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	1	1
2	2	4
3	2	6
4	4	16
5	2	10
6	0	0
	Sum:	36 – Unfavorable condition

Table 3.2

Zone 2. Meat Factory (decommissioned)

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	1	1
2	4	8

Table 3.2 continuation

3	3	9
4	2	8
5	5	25
6	0	0
	Sum:	51 – Critical condition

Table 3.3

Zone 3. Electromechanical Plant (decommissioned)

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	3	3
2	1	2
3	3	9
4	3	12
5	0	0
6	4	24
	Sum:	50 – Critical condition

Table 3.4

Zone 4. Base of building materials

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	2	2
2	5	10

Table 3.4 continuation

3	2	6
4	2	8
5	0	0
6	0	0
	Summ:	26 – Unsatisfactory condition

Table 3.5

Zone 5. Combine plant

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	5	5
2	3	6
3	1	3
4	2	8
5	3	15
6	0	0
	Sum:	37 – Unfavorable condition

Table 3.6

Zone 6. Sea commercial port

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	2	2
2	2	4

Table 3.6 continuation

3	1	3
4	2	8
5	4	20
6	4	24
	Sum:	61 – Critical condition

Table 3.7

Zone 7. Water treatment plant

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	5	5
2	2	4
3	3	9
4	1	4
5	0	0
6	0	0
	Sum:	22 – Unsatisfactory condition

Table 3.8

Zone 8. Cotton Mill (decommissioned)

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	3	3
2	3	6

Table 3.8 continuation

3	4	12
4	1	4
5	0	0
6	0	0
	Sum:	25 – Unsatisfactory condition

Table 3.9

Zone 9. Bridge construction

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	1	1
2	3	6
3	5	15
4	3	12
5	0	0
6	0	0
	Sum:	34 – Unfavorable condition

Table 3.10

Zone 10. Boiler station

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	4	4
2	4	8

Table 3.10 continuation

3	2	6
4	1	4
5	0	0
6	0	0
	Sum:	22 – Unsatisfactory condition

Table 3.11

Zone 0. “Clear” zone

Type of damage	Availability in the study group (% converted to points)	Evaluation
1	0	0
2	6	6
3	0	0
4	0	0
5	0	0
6	0	0
	Sum:	6 – Favorable condition

Table 3.12

Summary table (bioindication)

Zone	Evaluation	Condition
Zone 1. Poultry farm	36	Unfavorable condition
Zone 2. Meat Factory (decommissioned)	51	Critical condition
Zone 3. Electromechanical Plant (decommissioned)	50	Critical condition

Table 3.12 continuation

Zone 4. Base of building materials	26	Unsatisfactory condition
Zone 5. Combined plant	37	Unfavorable condition
Zone 6. Sea commercial port	61	Critical condition
Zone 7. Water treatment plant	22	Unsatisfactory condition
Zone 8. Cotton Mill (decommissioned)	25	Unsatisfactory condition
Zone 9. Bridge construction	34	Unfavorable condition
Zone 10. Boiler station	22	Unsatisfactory condition

According to the results we obtained during the data processing, none of the sites examined is in a normal or satisfactory condition. The average across all zones is 36.4, which is an indicator of an unfavorable condition.

3.4. Evaluation of the air quality by lichen indication method

Lichen indication, as well as dendroindication is part of the bioindication method. The studies were conducted in February using the methodology described in Section 2. Tables with research results are given below. These studies were conducted in order to find out the general condition of lichens in the selected areas.

Table 3.13

Zone 1 Poultry farm

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Poplar	56	59	Usnea	The lichen is thick, covers the tree with "spots". It does not have yellowness, brightly colored, without faded parts, tightly attached to the trunk.

Table 3.13 continuation

Poplar	63	80	Usnea	The lichen is thick, covers the tree with "spots". It does not have yellowness, brightly colored, without faded parts, tightly attached to the trunk.
Walnut	66	66	Hypogymnia (20%), Leafy Xanthoria (40%), Cushion Xanthoria (3%), Usnea (3%)	The lichen is thick, covers the tree with "spots". It does not have yellowness, brightly colored, without faded parts, tightly attached to the trunk. Lichens of several species stay close.

All trees are in close proximity to facility number 1 (Poultry Farm), have enough sunlight. All trees are quite thin. There is no high level of vegetation in the territory. Lichens present in this area indicate an increased amount of nitrogen in the air and soil, which is associated with pollution from the facility.

Table 3.14

Zone 2 Meat processing plant (decommissioned)

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Poplar	85	82	Leafy Xanthoria (56%), Parmelia (26%)	The lichen is thick, covers the tree with "spots". They are firmly attached to the tree, but slightly dried at the tips.
Poplar	87	64	Leafy Xanthoria	The lichen is thick, covers the tree with "spots". They are firmly attached to the tree, brightly colored, but some of them (4%) dried.

Table 3.14 contionuation

Poplar	83	76	Usnea (46%), Leafy Xanthoria (30%)	On this tree, lichens are tightly attached to the trunk, but dry, type Leafy Xanthoria severely damaged.
Poplar	91	87	Leafy Xanthoria	Lichens are tightly attached to the tree, but almost half of them are very dry.
Poplar	76	95	Usnea	Lichens are tightly attached to the tree, but are very dry. The color lost its brightness, part turned yellow.

The trees under investigation are located close to the enterprise number 2 (Meat processing plant), and are in close proximity to the road, which has heavy traffic. Trees have plenty of sunlight. Most of lichens has lost their bright color and become dry. This indicates air pollution by exhaust gases.

Table 3.15

Zone 3 Electromechanical plant (decommissioned)

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Poplar	85	83	Cushion Xanthoria	Lichens are firmly attached to the trunk, some are overdried. They also have an overly bright orange color.
Poplar	89	87	Usnea (67%), Leafy Xanthoria (20%)	Lichens are well attached to the trunk, have a bright color, are not dried.

Table 3.15 continuation

Poplar	187	99	Usnea	Lichens are well attached to the trunk, have a bright color, are not dried.
Poplar	74	82	Leafy Xanthoria (60%), Hypogymnia (22%)	Lichens are well attached to the trunk, have a bright color, are not dried.
Chestnut	137	84	Ramalina farinacea (46%), Leafy Xanthoria (38%)	Lichens densely fill the tree, type Ramalina farinacea is bright, dense, type Leafy Xanthoria is slightly dried at the tips.

The trees under investigation are located close to enterprise number 3 (Electromechanical plant) and to the road, which has not heavy traffic. Trees have not plenty of sunlight. Lichens densely cover trees and are mostly in good condition, which indicates a fairly good condition of soil and air.

Table 3.16

Zone 4 Base of building materials

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Poplar	61	52	Cushion Xanthoria	Lichens have a bright color, tightly attached to the tree, in the place where the tree has a crack in the bark.
Poplar	89	49	Leafy Xanthoria (13%), Cushion Xanthoria (36%)	Lichens have a bright color, tightly attached to a tree. Most are dried.

Table 3.16 continuation

Poplar	102	87	Usnea (50%), Leafy Xanthoria (12%), Cushion Xanthoria (10%)	Lichens are dense, have a bright color, tightly attached to a tree.
Poplar	94	93	Cushion Xanthoria (58%), Hypogymnia (35%)	Lichens are dense, have a bright color, tightly attached to a tree.
Poplar	62	72	Leafy Xanthoria (58%), Hypogymnia (14%)	Lichens are well attached to the trunk, have a bright color, are not dried.

The trees under investigation are located close to enterprise number 4 (Base of building materials) and to the road without heavy traffic. Trees have plenty of sunlight.

Lichens do not cover the trees so densely, and their diversity indicates that there is an increased amount of nitrogen in the given area.

Table 3.17

Zone 5 Combine plant

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Apricot tree	61	10	Evernia	Lichens are dry, barely growing on a tree.
Cherry tree	57	88	Leafy Xanthoria (3%), Usnea (41%), Parmelia (44%)	Lichens are rather dull, scattered, slightly dry at the tips.
Acacia	53	-	-	-

Table 3.17 continuation

Cherry tree	64	-	-	-
Cherry tree	59	-	-	-

The trees under investigation are located close to enterprise number 5 (Combine plant), and to the road with heavy traffic. Trees have plenty of sunlight. There are almost no lichens in this territory, which indicates not very good condition of air and soil in this territory. The trees themselves in this zone are also very damaged.

Table 3.18

Zone 6 Sea commercial port

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Poplar	91	86	Leafy Xanthoria (9%), Hypogymnia (77%)	Lichens are tightly attached to the tree, dry, dull and covered with dust.
Poplar	89	97	Evernia	Lichens are tightly attached to the tree, densely spaced, but short and tarnished.
Poplar	92	92	Evernia	Lichens are tightly attached to the tree, densely spaced, but short and tarnished.
Acacia	96	95	Evernia	Lichens are tightly attached to the tree, densely spaced, but short and tarnished.
Apricot tree	49	84	Leafy Xanthoria (24%), Evernia (60%)	Lichens are tightly attached to the tree, dry, dull and covered with dust.

The trees under investigation are located close to enterprise number 6 (Seaport), and to the river and the port. Trees have plenty of sunlight. Lichens are in fairly good condition, but due to the large amount of dust blown by wind, they are slightly dried.

Table 3.19

Zone 7 Water treatment plant

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Chestnut	81	50	Hypogymnia	Lichens are firmly attached to the tree. Unassembled.
Chestnut	93	47	Leafy Xanthoria (11%), Hypogymnia (36%)	Lichens are dense, have a bright color, tightly attached to a tree.
Acacia	56	81	Leafy Xanthoria (7%), Hypogymnia (74%)	Lichens are dense, have a bright color, tightly attached to a tree.
Apricot tree	58	10	Cushion Xanthoria (1%), Hypogymnia (57%)	Lichens are firmly attached to the tree, have a bright color, but they are few.
Poplar	74	30	Hypogymnia	Lichens are firmly attached to the tree, have a bright color, but they are few. The bulk of lichens was above the desired height.

The trees under investigation are located close to enterprise number 7 (Water treatment plant) and to the road without heavy traffic. Trees have not plenty of sunlight. Lichens in the study area are mainly located above the height at which control should be carried out. This is due to the lack of sunlight.

Table 3.20

Zone 8 Cotton plant (decommissioned)

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Poplar	89	71	Leafy Xanthoria (4%), Hypogymnia (67%)	Lichens are tightly attached to the tree, have a bright color.
Poplar	97	4	Leafy Xanthoria	Lichens are tightly attached to the tree, have a bright color.
Poplar	107	80	Usnea	Lichens are tightly attached to the tree, have a bright color, some of them yellowed at the tips.
Poplar	126	84	Usnea	Lichens are tightly attached to the tree, have a bright color, some of them yellowed at the tips.
Poplar	67	41	Usnea	Lichens are tightly attached to the tree, have a bright color, some of them yellowed at the tips.

The trees under investigation are located close to the enterprise number 8 (Cotton plant) and to the road with heavy traffic. Trees have plenty of sunlight.

Lichens that are located close to the idle factory are damaged by the road with very active traffic. Most lichens are in good condition, but have certain signs of weakening, such as yellowing at the tips, and a small prevalence.

Table 3.21

Zone 9 Bridge construction

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Poplar	45	6	Leafy Xanthoria	Lichen is firmly attached to the tree, has a bright color.
Poplar	68	86	Hypogymnia (64%), Leafy Xanthoria (22%)	Lichen is firmly attached to the tree, has a bright color.

All trees are in close proximity to facility number 9 (Bridge construction), have enough sunlight. All trees are quite thin. There is no high level of vegetation in the territory. The trees are located next to the road with heavy traffic.

There are few specimens of trees with lichens on the territory. This is due to the large contamination of the territory.

Table 3.22

Zone 10 Boiler station

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Cherry tree	34	52	Hypogymnia (27%), Leafy Xanthoria (25%),	The lichen is thick, covers the tree with "spots". It is brightly colored, without faded parts, tightly attached to the trunk.
Cherry tree	22	38	Flavoparmelia	Lichens are firmly attached to the tree, scattered, do not have yellowness.

Table 3.22 continuation

Cherry tree	18	6	Hypogymnia (3%), Leafy Xanthoria (3%),	Lichens are firmly attached to the tree, scattered, do not have yellowness.

All trees are in close proximity to facility number 10 (Boiler station), have enough sunlight. All trees are quite thin. There is no high level of vegetation in the territory. Based on the fact that in this territory there is no active vegetation and a sufficient number of samples for research, it is impossible to make accurate conclusions.

Table 3.23

Zone 0 “Clear” zone

Tree name	Barrel width (sm)	Lichen count (%)	Lichen type	Lichen condition
Persian olive	56	78	Leafy Xanthoria (9%), Flavoparmelia (69%)	Lichens are tightly attached to the tree, have a bright color.
Persian olive	61	77	Leafy Xanthoria (5%), Flavoparmelia (72%)	Lichens are tightly attached to the tree, have a bright color.
Persian olive	68	83	Leafy Xanthoria (8%), Flavoparmelia (75%)	Lichens are tightly attached to the tree, have a bright color.
Persian olive	59	94	Cushion Xantoria (2%), Leafy Xanthoria (50%), Flavoparmelia (42%)	Lichens are tightly attached to the tree, have a bright color.
Persian olive	67	96	Cushion Xantoria (62%), Flavoparmelia (34%)	Lichens are tightly attached to the tree, have a bright color.

Table 3.24

Summary table (lichenindication)

Zone	The relative coverage of lichens (%)	Number of species	General condition of the zone
Poultry farm	68,33	4	The lichens are in good condition, but the species is sensitive to nitrogen.
Meat processing plant (decommissioned)	80,8	3	The lichens are dried. The area is polluted more by the exhaust gases due to its close proximity to the road, than by the emissions from the plant.
Electromechanical plant (decommissioned)	87	5	Satisfactory condition.
Base of building materials	70,6	4	The lichens are dried. The area is polluted by the enterprise.
Combine plant	19,6	4	The lichen cover of the trees is almost absent. The condition is unsatisfactory.
Sea commercial port	90,8	3	The lichen cover is very dense, but because of the peculiarity of the territory, dusty.
Water treatment plant	43,6	3	It is difficult to determine the condition due to lack of sunlight in the study area.
Cotton plant (decommissioned)	56	3	Some of the lichens are damaged due to the close proximity to the road. The condition is unsatisfactory.
Bridge construction	46	2	Poor condition. Highly polluted area. Almost no woody plants.
Boiler station	32	3	There is no active vegetation on the territory. It's hard to draw conclusions.

If the degree of lichen coverage of trees is analyzed, then the atmospheric air condition can be considered satisfactory (Table 3.3.1). But if we compare the individual zones, we can conclude that the anthropogenic load is unevenly distributed. For example, in the area of the combined plant, you can see a serious load on the ecosystem. In the area of electromechanical plant and the seaport, the lichen condition and its active growth can be seen. In some areas, it is difficult to determine the state of the atmosphere, due to the lack of woody vegetation, or because of the peculiarities of the territory, for example, in the zone of the water treatment plant there are high fences that cover the sunlight.

3.5. Integral Air Condition Assessment

To integrate the obtained data, the results of studies using phytoindication and lichenoindication methods where summed (Table 3.23) to determine the areas which raise the highest environmental concerns.

Table 3.25

Summary of research

Zone	State due to bioindication results	State due to lichen indication results	General condition
Poultry farm	Unfavorable	Good	Unsatisfactory
Meat processing plant (decommissioned)	Critical	Unsatisfactory	Unfavorable
Electromechanical plant (decommissioned)	Critical	Satisfactory	Unfavorable
Base of building materials	Unsatisfactory	Unsatisfactory	Unsatisfactory
Combined plant	Unfavorable	Critical	Critical
Sea commercial port	Critical	Unfavorable	Critical

Table 3.25 continuation

Water treatment plant	Unsatisfactory	Unsatisfactory	Unsatisfactory
Cotton plant (decommissioned)	Unsatisfactory	Unsatisfactory	Unsatisfactory
Bridge construction	Unfavorable	Critical	Critical
Boiler station	Unsatisfactory	Unsatisfactory	Unsatisfactory

According to the results, we can conclude that neither good nor satisfactory environment condition is typical for the city. The points with the critical level of pollution are unevenly distributed. The obtained results were placed on the final map of anthropogenic load (Fig.3.2). According to the results of phytoindication and lichenoindication, we can say that the city is under serious anthropogenic pressure and all the studied areas are in critical or unsatisfactory condition.

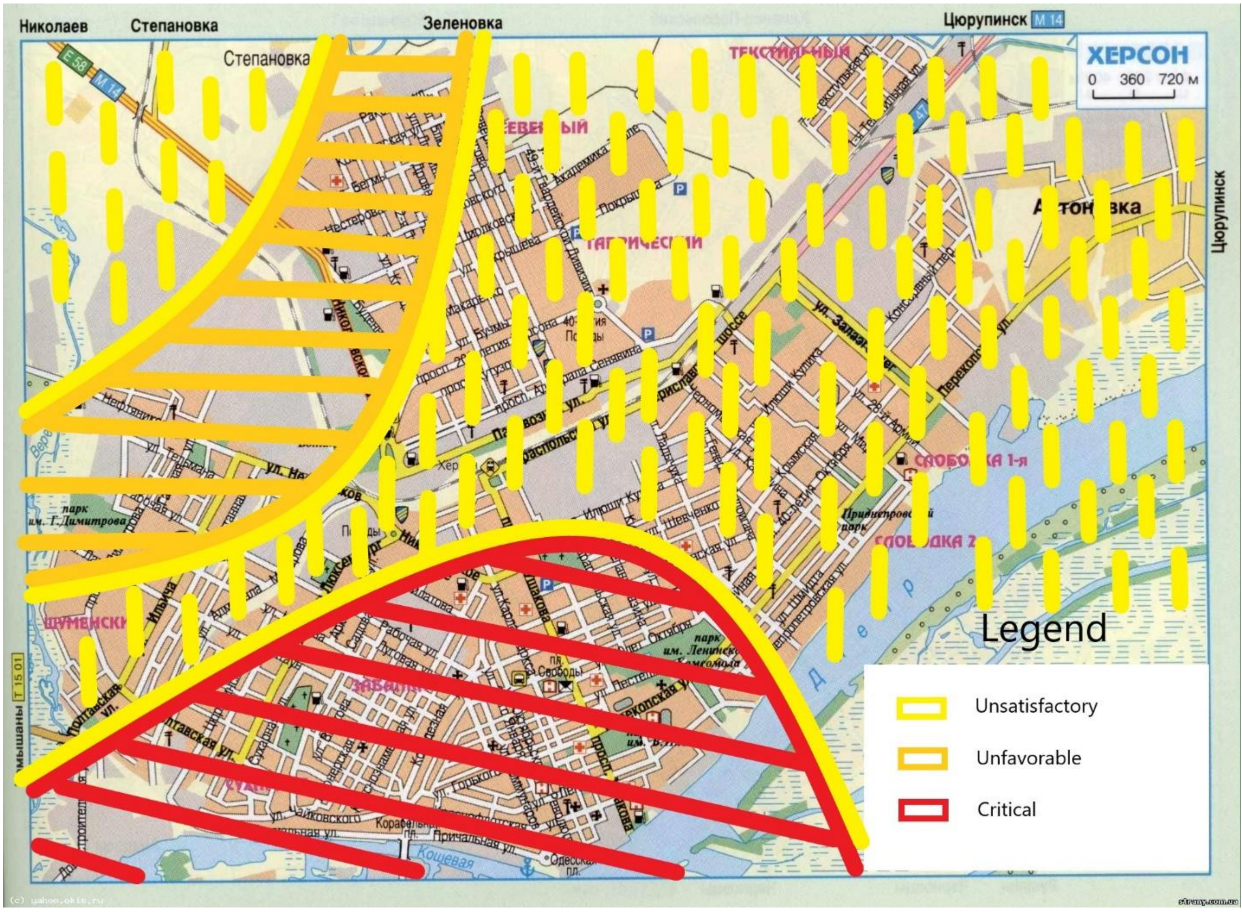

Fig. 3.2 Final map of anthropogenic load

3.6. Recommendations for Improving Air Condition

The main factors of negative influence in our case are emissions into the air and soil pollution with heavy metals as a result of the activities of industrial enterprises, as well as the consequences of activities of decommissioned enterprises. Based on this, the following recommendations can be made to improve the environment:

1. Check the condition of the pollution control equipment.
2. Strengthen control over existing enterprises in the city.
3. Improve air monitoring system for timely response to possible negative changes.
4. Increase the number of green spaces in the city. Also take care of the presence of coniferous plantations outside the city.
5. Strengthen control over the fuel used by ships at the port.
6. Strengthen fire safety in the summer season.
7. Improve the environmental education program.

Conclusions to Chapter 3

Having done all the research, we can say that the environment condition of the city of Kherson is not satisfactory and the city cannot be considered relatively clean area. The city is quite polluted by both operating enterprises and the active movement of automobiles, railway and air transport.

In order to improve the environment, it is necessary to carry out a range of socio-cultural activities for city residents, since most people simply do not recognize the need for a clean environment. It is necessary to amend the education system, as well as introduce higher fines for non-compliance with the rules and standards of emissions and discharges of harmful substances.

All these actions are aimed not only at improving the environmental condition and appearance of the city, but also at improving the living standards of residents.

CONCLUSIONS

1) The city of Kherson and Kherson region were previously considered relatively clean areas, but recently they have dropped to the end of the rating, for this purpose our research was primarily to determine the general environmental situation in the city. To fulfil this task we chose the bioindication method, in particular, phytoindication and lichenoindication methods. Such methods allow quick and accurate determination of the level of environment pollution in the city.

2) At the first stage of research the areas of the city of Kherson subjected to excessive anthropogenic stress were defined – a total of 10 areas. Our studies using phytoindication and lichenoindication methods have shown that the city is subjected to serious anthropogenic stress and needs to improve its general condition. Thus, the condition of arboreal plants, condition and diversity of lichens have showed the condition of the environment from unfavourable to critical.

3) To improve the existing situation we have developed special recommendations for each of the investigated areas:

For zone 1, it is recommended to improve the waste management and conduct a series of environmental checks on the compliance of equipment and the territory with standards.

For zones 2,3 and 8 with decommissioned enterprises and facilities, restoration of territories and remediation of soils are more important.

In zone 4, some dust filters should be installed to prevent dust from entering the atmosphere, as well as to improve the quality of the road surface for lower fuel consumption when transporting materials with large vehicles.

For zone 5, the best option is to clean the area that is no longer in use, and to update equipment in the active part of the enterprise.

Zone 6 needs serious checks for compliance with environmental standards. In the given territory there is a dump of waste metal, which might impose certain environmental hazards. Also, many ships in the port need to improve and update equipment and propulsion systems, as modern models are more eco-friendly.

In zones 7 and 10, equipment and emission control systems need modernization.

Zone 9 is problematic since the construction of the bridge has been carried out there for quite long time, but due to the lack of control, the work is too slow.

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