ECOLOGICAL AND METHODOLOGICAL PRINCIPLES IN THE DEVELOPMENT OF RESEARCH ON AIR POLLUTION OF UKRAINIANS

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Abstract. *The possibilities of human impact on nature are constantly growing and have already reached a level where humans can devastate the planet, destroy all living beings, and completely alter the climate. High levels of pollution are characteristic of areas around regional centers in Ukraine, especially in the suburban zone of industrially developed Kyiv. The higher the pollution level, the greater the risk to the health of the population and the state of the environment. Long-term pollution of the atmospheric air with sulfur dioxide, carbon oxides, nitrogen oxides, and other harmful substances negatively affects human health. This can result in an increase in overall morbidity caused by damage to specific organs and body systems, such as respiratory diseases (pneumonia, bronchial asthma, and other non-specific lung diseases) and cardiovascular diseases (hypertension, myocardial infarction, chronic diseases, etc.). The purpose of the article is to identify negative factors that affect the worsening of the environmental situation in the country and individual regions. The main task of my work is the analysis of negative changes in the ecological state of Boyarka and advocacy of possible ways to improve the ecological situation in the city. This study also shows the importance of chemistry as a science in the understanding and development of current environmental problems of our time. On the basis of a systemic approach, the tasks of creating ecologically safe living conditions for the population of suburban areas of the city were solved by conducting noise protection measures. Experimental studies were carried out using modern acoustic measuring devices "Octava-101" and "Ekofizika-Octava". Data processing involved the use of mathematical statistical methods. Mathematical and statistical methods were used to assess the reliability of experimental results. The main results of the article were the measures (economic, legal, urban planning, etc.) to solve the environmental problems of the city of Boyarka.*

Keywords: *Earth's atmospheric envelope, environmental pollution, intensive traffic, ecological problem, population health issues, suburban areas, sanitary conditions.*

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Introduction. The possibilities of human impact on nature are constantly growing and have already reached a level where humans can devastate the planet, destroy all living beings, and completely alter the climate. The Earth's atmospheric envelope is one of the most crucial conditions for life. Without food, a person can live for a month, without water - a week, but without air, they can only survive for a few minutes. The atmosphere has significant ecological importance as it protects living organisms from harmful cosmic radiation and meteorite impacts, and serves as a carrier of heat and moisture. It facilitates processes like photosynthesis and the exchange of energy and information, which are fundamental in the biosphere. The presence of the atmosphere on the planet leads to various complex exogenic processes, such as the weathering of rocks, the movement of air masses, and natural water cycles. For some organisms, like bacteria, flying insects, birds, and others, the atmosphere is their primary living environment.

High levels of pollution are characteristic of areas around regional centers in Ukraine, especially in the suburban zone of industrially developed Kyiv. The higher the pollution level, the greater the risk to the health of the population and the state of the environment. Long-term pollution of the atmospheric air with sulfur dioxide, carbon oxides, nitrogen oxides, and other harmful substances negatively affects human health. This can result in an increase in overall morbidity caused by damage to specific organs and body systems, such as respiratory diseases (pneumonia, bronchial asthma, and other non-specific lung diseases) and cardiovascular diseases (hypertension, myocardial infarction, chronic diseases, etc.).

Undoubtedly, the most dangerous atmospheric pollution for human health reduces the body's adaptation capabilities, leading to changes in respiratory functions and an increase in lung pathologies. Additionally, specific pollution is characteristic of areas with industrial plants, which can also have adverse effects on human health. For instance, in areas with intense traffic, chronic poisoning and lung diseases are common. High pollution levels pose a threat not only to the current generation but also to future ones.

Human activities disrupt the balance in nature, leading to the emergence of ecological problems such as the greenhouse effect, ozone depletion in the atmosphere, smog, acid rain, and atmospheric pollution. Air pollution is no longer just a problem of a single country; it is a problem of every city and every individual. We cannot ignore the gradual deterioration of air quality and the negative impact of various harmful pollutants on the human body. Therefore, I consider the topic of atmospheric pollution to be relevant. I am interested in researching the level of harmful emissions in Boyarka in relation to the amount of automobile transport, investigating the negative impact of gas pollutants on the surrounding environment, and calculating the amount of clean air required to dissolve harmful substances to ensure sanitary-acceptable living conditions for humans [2].

Literature review. The main reason for the deterioration of the ecological state of cities is the imperfect planning and placement of industrial enterprises in residential areas, resulting in air pollution from emissions of stationary and mobile sources, as well as low green coverage and noise pollution. The increasing number of

automobiles in recent decades has a particularly hazardous impact on the atmospheric air quality of cities (M.O. Klymenko, Y.O. Molchak, T.L. Melikhova, 2001). Technogenic pressure on the state of atmospheric air in cities contributes to the increase in population morbidity, primarily caused by air pollution from pollutants such as dust, carbon (II) oxide, sulfur (IV) oxide, and nitrogen (IV) oxide. The lack of monitoring the spread of diseases in specific parts of the city makes it impossible to establish a connection between the level of morbidity and the pollution status, and therefore to zone the city's territory based on environmental risks, especially in small cities. Thus, there is a need for a detailed assessment of the ecological situation and the state of atmospheric air in cities. Currently, conducting instrumental monitoring across the entire territory of the city of Zhytomyr is not feasible as it requires significant financial resources, time, and qualified personnel. Research (I.M. Shvadchak, A.I. Horova, A.I. Kurninny, A. Mekhandzhiev, L.V. Chastokolenko, M. Miller, W.F. Grant, E.T. Owens) indicates the possibility of evaluating the ecological state of the city's atmospheric air using bioindication methods, particularly lichen indication. This involves using the values of bioindicator plant indicators and assessing the territory based on an evaluation scale that characterizes the condition of the surrounding environment according to the indicators of plant damage [3].

Aims. The purpose of the article is to identify negative factors that affect the worsening of the environmental situation in the country and individual regions. The main task of my work is the analysis of negative changes in the ecological state of Boyarka and advocacy of possible ways to improve the ecological situation in the city. This study also shows the importance of chemistry as a science in the understanding and development of current environmental problems of our time. In practice, this work can be evaluated in lessons, seminars [4].

Methodology. On the basis of a systemic approach, the tasks of creating ecologically safe living conditions for the population of suburban areas of the city were solved by conducting noise protection measures. Experimental studies were carried out using modern acoustic measuring devices "Octava-101" and "Ekofizika-Octava". Data processing involved the use of mathematical statistical methods. Mathematical and statistical methods were used to assess the reliability of experimental results.

Results. In the modern world, it is impossible to preserve a stable atmospheric composition, and consequently, the chemical composition of the air. The atmospheric envelope contains a significant amount of undesirable impurities. The cleanest atmosphere is located above the ocean surface and at high altitudes in mountains, while the most polluted air is often near sources of natural or human origin. Additionally, atmospheric pollution can be categorized based on its origin as natural or anthropogenic, based on its chemical dispersion into gaseous and aerosol forms, and based on its effects on organisms, the environment, and material valuables as either positive or negative.

Natural sources of atmospheric pollution include dust storms, volcanic eruptions, cosmic dust, and similar phenomena. About three-quarters of the products of natural atmospheric pollution consist of inorganic substances. These products arise

from the weathering of rocks, particles from soils, ashes, salts, hydrocarbon alcohols, organic acids, ethers, aldehydes, and more [5].

Artificial pollution of the atmosphere is the result of industrial activities, transportation emissions, and the disposal of household waste. Major sources of artificial atmospheric pollution also include facilities in the municipal sector and agricultural practices. Atmospheric pollutants can be categorized into primary pollutants, which are directly emitted into the atmosphere, and secondary pollutants, which are formed as a result of the transformation of primary pollutants. For instance, sulfur dioxide undergoes oxidation to form sulfur trioxide, which, in the presence of water vapor, further reacts to produce sulfuric acid. Similarly, through chemical, photochemical, and physicochemical reactions between pollutants and atmospheric components, secondary pollutants are formed.

The atmosphere is polluted as a result of various factors, including industrial activities, household heating systems, transportation, and more. Among the industrial sectors, the primary sources of atmospheric pollution are the power generation industry (27%), metallurgy (26%), and the construction industry (13%). Thermal power plants, metallurgical, and chemical facilities, as well as boiler installations, consume approximately 70% of solid and liquid fuels extracted annually. Their activities result in the emission of harmful gases into the atmosphere.

The most common harmful gas pollutants include: sulfur oxides (IV and VI) - SO2, SO3; hydrogen sulfide (H2S); carbon disulfide (CS2); nitrogen oxides - NOx; benzopyrene; ammonia; chlorine compounds; fluorine compounds; hydrogen sulfide; hydrocarbons; synthetic surfactants; carcinogens; heavy metals; carbon oxides (II and IV) - CO, CO2.

So we will consider some of them.

Carbon dioxide (CO2) is a byproduct of fuel combustion, with over 2 billion tons being released into the atmosphere annually. It is not harmful to the human body and is commonly used for domestic and industrial purposes. However, carbon dioxide poses a significant danger as it contributes to the greenhouse effect by trapping heat radiation in the lower atmosphere. This property of carbon dioxide in the atmosphere is known as the greenhouse or greenhouse effect.

Carbon monoxide (CO) is produced during incomplete combustion of carbon-containing substances. It enters the air through the burning of solid waste, exhaust gases, and emissions from industrial facilities. Annually, at least 250 million tons of this gas are released into the atmosphere. Carbon monoxide is odorless, colorless, and tasteless. It is a compound that actively reacts with components of the atmosphere, contributing to an increase in the planet's temperature and the creation of the greenhouse effect.[6].

Sulfur dioxide (SO2) is released during the combustion of coal, processing of sulfur-containing ores (up to 70 million tons per year), and burning of sulfur-rich fuels, among other sources. The annual emissions into the atmosphere amount to approximately 200 million tons. Sulfur dioxide undergoes oxidation through photochemical and catalytic reactions, forming aerosols or dissolving in rainwater,

which then acidifies soils and water bodies, accelerates metal corrosion, and exacerbates respiratory illnesses in humans.

Sulfuric anhydride is formed through the oxidation of sulfur dioxide. The final product of this reaction is an aerosol or a solution of sulfuric acid in rainwater, which acidifies the soil and exacerbates respiratory illnesses in humans. The deposition of sulfuric acid aerosol from the smokestacks of chemical plants is observed during periods of low cloudiness and high humidity in the air. The leaves of plants growing within a distance of less than 1 km from such plants are often densely covered with small non-necrotic spots formed by the deposition of sulfuric acid droplets. Pyrometallurgical plants in non-ferrous and ferrous metallurgy, as well as thermal power plants, annually release tens of millions of tons of sulfuric anhydride into the atmosphere.

Hydrogen sulfide and carbon disulfide are released into the atmosphere separately or together with other sulfur compounds. The main sources of emission are industrial facilities involved in the production of synthetic fibers, sugar, coke-chemical, oil refineries, and oil fields. In the atmosphere, they slowly oxidize to form sulfuric anhydride.

Nitrogen oxides are formed during fuel combustion, fertilizer production, acid and viscose silk manufacturing, and celluloid production. The main sources of emission are plants that produce nitrogen fertilizers, nitric acid, nitrates, aniline dyes, nitro compounds, viscose silk, and celluloid. Approximately 20 million tons of nitrogen-containing compounds are emitted into the atmosphere annually from industrial sources.

Chlorine compounds are released into the atmosphere from chemical industry plants, pesticide production, organic dyes, hydrolysis alcohol, soda, and hydrochloric acid. In the atmosphere, they are observed as impurities in chlorine molecules and hydrogen chloride vapors. The toxicity of chlorine is determined by the type of compounds and their concentration.

Fluorine compounds are released into the atmosphere by plants involved in aluminum, steel, enamel, glass, ceramics, and phosphorus fertilizer production. Fluorine-containing substances enter the atmosphere in the form of gaseous compounds like hydrogen fluoride or sodium and calcium fluoride dust. Fluorine derivatives are strong insecticides and exhibit highly toxic effects. Excessive concentrations of fluorine compounds in feed cause chronic intoxication in animals known as fluorosis. Insects are highly sensitive to fluorine compounds.

Metallurgical industry, during iron smelting and processing to steel, releases various heavy metals and toxic gases into the atmosphere. For example, for every 1 ton of pig iron produced, about 2.7 kg of sulfur dioxide and 4.5 kg of dust particles consisting of arsenic, phosphorus, antimony, lead, mercury vapor, and rare metals, as well as resinous substances like hydrogen cyanide, are emitted.

There are various types of pollution: chemical, automobile emissions, aerosol, hydrocarbon, radiation, noise, and electromagnetic pollution. However, pollution from chemical transformations has the most significant impact on the environment. Chemical pollutants include solid, gaseous, and liquid substances, as well as chemical

elements and artificial compounds that enter the biosphere and disrupt natural cycles of matter and energy.

Emissions and leaks of hazardous chemical substances, burning of various materials, equipment, construction, accidents during transportation of hazardous chemicals, explosive, and flammable cargoes result in environmental pollution. Chemical accidents are very dangerous because chemical emissions can spread over large areas, leading to significant pollution of the environment. Among the hazardous gaseous compounds that pollute the atmosphere and pose risks to human health are Cl2, HCl, HF, HCN, SO3, SO2, CS2, CO, CO2, NH3, COCl2, nitrogen oxides, and others.

Transport vehicles of all kinds are an important source of atmospheric pollution. Automobile emissions consist of a mixture of about 200 substances, including aldehydes with a pungent odor and strong irritant properties, as well as carcinogenic substances that can cause cancer and other illnesses [8].

On average, a typical automobile consumes approximately 4.35 tons of oxygen and emits 3.25 tons of carbon dioxide, 0.53 kg of carbon monoxide, 0.093 tons of hydrocarbons, and 0.027 tons of nitrogen oxides per year. By the end of the 20th century, there were about 1 billion automobiles worldwide.

Automobile transportation primarily contributes to atmospheric pollution through three main channels:

Exhaust gases released through the tailpipe.

Crankcase emissions. Hydrocarbon emissions due to fuel evaporation from the tank, carburetor, and pipelines.

Among the exhaust gases of automobiles, the most significant volumetric weights include carbon monoxide (0.5-10%), nitrogen oxides (up to 0.8%), unburned hydrocarbons (0.2-3%), aldehydes (up to 0.2%), and soot.

In absolute quantities, for every 1000 liters of fuel consumed by a carburetor engine, the emissions include 200 kg of carbon monoxide, 25 kg of hydrocarbons, 20 kg of nitrogen, 1 kg of particulates, and 1 kg of sulfur compounds.

The accumulation of carbon dioxide in the atmosphere is also having a negative impact, and unfortunately, its quantity is increasing. This may lead to an increase in the average annual temperature on Earth in the near future.

In rural areas, the main sources of air pollution are livestock farms, poultry complexes, agrochemical warehouses, storage facilities for treated seeds, and fields treated with pesticides and mineral fertilizers [9].

Aerosol pollution is also considered one of the atmospheric pollutants. Aerosols are solid or liquid microscopic particles suspended in the atmosphere. Solid components of anthropogenic aerosols include products from thermal power plants, enrichment plants, metallurgical, magnesite, cement, and soot plants.

These solid components of aerosols are highly hazardous to living organisms, causing specific diseases in humans. Aerosols can be classified as passive or active, depending on their impact on the human body. Passive aerosols accumulate on the respiratory system's walls and can cause various illnesses at certain concentrations.

On the other hand, active aerosols can enter the bloodstream, making them more dangerous as they can lead to diverse diseases by entering human cells.

One of the most prominent representatives of aerosol pollution in the atmosphere is organic dust, containing aliphatic and aromatic hydrocarbons and acid salts. It is formed during the combustion of residual oil products and in processes like pyrolysis in refineries, petrochemical, and similar facilities.

Aerosol pollution in the atmosphere can also manifest as smoke, fog, haze, or smog under certain weather conditions. Smog, in particular, is highly hazardous to the respiratory and circulatory systems.

Radiation contamination is another specific atmospheric pollutant caused by radioactive aerosols entering the atmosphere due to nuclear explosions, accidents in nuclear facilities, disposal, and recycling of spent nuclear fuel, or military conflicts. Subsequently, atmospheric radiation is absorbed into the soil, water solutions, and living organisms, causing cancer and genetic damage in humans.

Noise pollution in the atmosphere is a form of wave-related, physical pollution that the human body cannot adapt to. The intensity of noise pollution (pressure) is measured in decibels (dB). Noise levels between 30-80 dB do not harm the human body. However, noise intensities of 85 dB and above can lead to physiological and psychological negative effects on the nervous system, sleep, emotions, and work capacity [10].

Electromagnetic pollution is particularly noticeable in urban settlements, where the level of electromagnetic fields is hundreds of times higher than natural fields. An electromagnetic field intensity of 1000 V/m can have adverse effects on the human body, resulting in disruptions to the nervous system, endocrine system, and metabolic processes.

Throughout its existence, humanity has been closely connected with nature. However, since the emergence of highly industrialized societies, we have increasingly interfered with its functioning. At the current stage, this interference threatens the complete destruction of nature. Non-renewable resources are constantly being depleted, and the number of arable lands is drastically reduced due to the construction of new cities and industrial plants. Humans have started to interfere with the functioning of the biosphere, the part of our planet where life exists. Additionally, the atmospheric ecological condition has significantly deteriorated, leading to changes in air composition and the emergence of various diseases caused by harmful substances in the air we breathe.

The atmospheric air in populated areas is constantly polluted, and it differs fundamentally from clean, natural air that stimulates biological processes. People living in areas with highly polluted air experience changes in their immune status. For drivers and bus passengers, their cognitive and physical performance is affected.

Air pollution can have both local and general effects on the human body. Local effects can lead to acute respiratory and lung diseases. General effects mainly affect metabolic processes. Often, general effects are preceded by local effects, so they should always be considered together. Some diseases related to air pollution are typical metabolic disorders caused by air pollutants.

The most prevalent harmful air pollutant is carbon monoxide (CO). Inhaling this gas leads to rapid fatigue, headaches, dizziness, sleep disturbances, mood instability, memory impairment, and disruptions in the cardiovascular system and other organ systems. Carbon monoxide II forms a stable compound with hemoglobin in the blood, called carboxyhemoglobin, which blocks oxygen transport in the body.

The concentration of benzopyrene in the air has a direct link with lung cancer mortality. Generally, the mortality rate from lung cancer among urban dwellers is twice that of rural inhabitants. Besides benzopyrene, molybdenum, arsenic, zinc, vanadium, and cadmium contribute to the occurrence of lung cancer. In gas-polluted areas, ten times more people die from lung cancer compared to remote suburbs. Lead is also present in vehicle exhaust gases, and the amount found in the blood of drivers and passengers is harmful to health. The higher the lead concentration in the air, the more it accumulates in the blood, leading to a decrease in enzyme activity involved in oxygen saturation of the blood and metabolic disorders in the body.

In cities, the number of cases of conjunctivitis, eczema, pharyngitis, and laryngitis increases due to air pollution from carbon oxides, nitrogen oxides, ammonia, hydrocarbons, sulfur dioxide, formaldehyde, fluorides, sulfuric acid aerosols, surface-active substances, etc. These pollutants cause poisoning and reduce the immune properties of the body [11].

Nitrogen oxides cause irritation of the upper respiratory tract mucous membranes, and in severe cases, it can lead to death due to lung edema. Incidences of pneumonia, myocardial infarction, and allergic diseases, including bronchial asthma, are also associated with air pollution. The negative impact of environmental factors on the human body can manifest as inflammation, dystrophic changes, allergic conditions, developmental impairments in fetuses, and damage to the cell's genetic apparatus. Approximately 70-80% of all cancer cases are caused by exposure to chemical carcinogens. Currently, about 4% of newborns already exhibit genetic defects that can lead to significant hereditary diseases.

Air pollution contributes to an increased prevalence of inflammatory diseases of the respiratory system and eyes, cardiovascular diseases, infectious diseases, and lung cancer. People residing in areas with significant atmospheric emissions often have low body weight, physical development levels, and functional deviations in the cardiovascular and respiratory systems. The morbidity rate of respiratory diseases accounts for an average of 73.5% of the total morbidity.

Due to the scientific and technological revolution and urbanization of our planet, the environment is steadily deteriorating under the impact of anthropogenic activities that subject it to increasing physical, chemical, and biological loads. Humans are no longer able to adapt to these rapid and global changes. Furthermore, the problem of a demographic explosion and the limitation of natural resources and living space on Earth has emerged.

As a result of the catastrophic deterioration of the environment, the overall health level of the Ukrainian population has sharply declined in recent years. Mortality rates have exceeded birth rates, and genetic processes have been disrupted, leading to an increase in births of children with various hereditary diseases by 2-4

times. Ukraine ranks first globally in terms of child mortality rates. Life expectancy has decreased by 6 years, and the rate of primary disability has increased [12].

The increased air pollution has led to a significant rise in the incidence of cardiovascular diseases, especially myocardial infarction and ischemic heart disease, cerebrovascular diseases, cancer, bronchial asthma, diabetes mellitus, allergic diseases, and gastrointestinal disorders.

Discussion. Based on the research conducted on two sections of the roadway in Boyarka, it was found that automobiles are the main air polluters in the selected areas. The number of vehicles is increasing over time, posing a growing threat to the environment.

Among different types of vehicles, passenger cars contribute the most to harmful emissions, accounting for nearly half of the total emissions released into the atmosphere.

The level of air pollution varies depending on the traffic load on the streets. The main road, Vulytsia Bilohorodska, being the primary transportation artery of the city, has the highest number of vehicles. On the other hand, Vulytsia B. Khmelnytskoho, though not as large in size, has approximately four times less traffic.

During the research period, the amount of harmful emissions into the atmosphere increased. On Vulytsia Bilohorodska, it rose by an average of 3.7%, and on Vulytsia B. Khmelnytskoho, it increased by an average of 5.4%. The rise in the number of passenger cars on Vulytsia B. Khmelnytskoho during the study period contributed to the increased volume of air required to dilute harmful substances, thus ensuring acceptable environmental conditions.

Another well-known method to assess air pollution is by observing the same-sized lichens of a specific species (such as Parmelia, Cetraria, Cladonia, etc.) on tree trunks [13].

It is known that lichens are highly sensitive to air pollution, especially sulfur dioxide gas, which at concentrations of 0.08-0.1 mg/m3 suppresses most lichens, and at a concentration of 0.5 mg/m3 is harmful to virtually all species. It has been observed that with increased air pollution levels, foliose lichens disappear first, then fruticose lichens, and finally, the most resistant species - crustose lichens. Based on these observations, lichen zones can be identified, which provide insights into the degree of air pollution.

For the investigation of air pollution based on changes in the sizes, shapes, and colors of lichens, a territory bounded by Bilohorodska Street and Bohdan Khmelnytskyi Street was selected.

Observations were conducted at a distance of 800 meters from the intersection of the chosen streets, with regular intervals, and as close as possible to the roadways.

During the study, the presence of lichens on the territory was examined, and photographs were taken, which clearly demonstrate the differences in their size, color, and shape (Appendices 1-3).

All trees located closest to the roadways completely lack lichens (Appendix 1). This indicates that this area is polluted with harmful emissions, making it inhospitable for lichens. Lichens serve as indicators of clean air, and the absence of

lichens entirely suggests that the roadway area in the city of Boyarka is extremely hazardous and unfavorable.

At a short distance from the road (10-20 meters), lichens start to appear, but their quantity is limited, and the most resilient forms are crustose lichens (Appendix 2). They have a gray-green color, smaller in size and height. On this territory, the variety of lichen forms cannot be observed, as foliose lichens are absent entirely. This absence is attributed to the close proximity to the road and exposure to automotive emissions from the roadways. The high concentration of harmful gas pollutants directly affects the composition of the air and prevents the growth of less sulfur dioxide-resistant lichen forms [14].

In less polluted areas, located at a greater distance from the roads (beyond 20 meters), different forms of lichens appear, and their quantity, variety of forms, and vegetation density increase. Only in the forest park near the stadium can almost all species of lichens with diverse shapes, colors, and appearances be found. However, even in such unpolluted places like the park, foliose lichens are absent, and fruticose forms are scarce compared to crustose lichens (Appendix 3). This illustrates the ability of the natural environment to self-regulate. The trees in the forest park are currently capable of absorbing the level of harmful emissions into the air and restoring the city's air balance.

Based on the observations, three pollution zones can be identified:

1. Lichen desert - complete absence of lichens, the most unfavorable areas near the roadways.

2. Competition zone - poor lichen flora.

3. Normal zone - peripheral parts of the city, parks, and forest parks.

As a result of this study, a map outlining the air pollution zones was created (Appendix 4). The conclusions drawn from the research provide evidence of the correlation between the existence of lichen flora and the cleanliness of the air and the quantity of gas emissions pollutants.

Automotive emissions directly influence the presence and size of lichens in the city. As the number of vehicles increases, the amount of harmful gas emissions into the air also rises. This relationship was observed in the previous study. The pollution is reflected in the lichen population in the form of reduced size, quantity, and height, disappearance of foliose forms, and decreased fruticose forms. The presence of park and forest park zones significantly affects the ecological environment. Where streets are bordered by densely planted trees, the lichen desert zone is almost absent. This is characteristic of Bohdan Khmelnytskyi Street. Conversely, the lichen desert along Bilohorodska Street exists and has considerable dimensions.

Our city faces a severe air pollution problem, primarily due to the increasing number of vehicles. It can be confidently said that this problem affects every city resident.

To address this issue, the reduction of harmful emissions from vehicles is necessary. This can be achieved through:

1. Installing catalytic converters on engines to neutralize exhaust gases.

2. Switching to gas mixtures as an alternative fuel.

3. Implementing energy-saving technologies.
4. Reducing the number of automobiles on the road.
5. Transitioning to alternative fuel sources.
6. Increasing the number of green spaces, parks, and forested areas both within the city and its surroundings.
7. Prohibiting the indiscriminate felling of trees in and around the city [15].

Conclusion. The possibilities of human impact on nature are constantly growing and have already reached a level where humans can destroy the planet, annihilate all living beings, and completely alter climatic conditions. The Earth's atmospheric envelope is one of the most crucial conditions for life. Without food, a person can survive for a month; without water, a week; but without air, only a few minutes.

The atmosphere has great ecological significance. It protects living organisms from harmful cosmic radiation and meteorite impacts, and serves as a carrier of heat and moisture. Through the atmosphere, photosynthesis and the exchange of energy and information take place - fundamental processes in the biosphere. The presence of the atmosphere on the planet determines a series of complex exogenous processes such as the weathering of rocks, the movement of air masses, and natural water activities. For some organisms like bacteria, flying insects, birds, and others, the atmosphere is their primary living environment.

The development of automotive transport has led to the pollution of the atmosphere in cities and transport routes with heavy metals and toxic hydrocarbons. The widespread use of mineral fertilizers and chemical plant protection agents has resulted in the presence of chemical pollutants in the atmosphere, soils, and natural waters, contaminating bodies of water, watercourses, and agricultural products with harmful elements like nitrates and pesticides. The operation of chemical plants and thermal power stations also generates massive amounts of solid waste (residue, slag, ashes), which is deposited on large areas and has a negative impact on the atmosphere, surface and underground waters, and soil cover (due to dust generation, gas emissions, etc.). Within Ukraine's territory, there are 877 chemically hazardous objects and 287,000 objects that use highly toxic substances or their derivatives in production processes (located in 140 cities and 46 settlements).

Human activities disrupt the balance in nature, leading to the emergence of ecological problems. Among them, we can mention the greenhouse effect, ozone holes in the atmosphere, smog, acid rain, air pollution, and more. The problem of air pollution is no longer confined to individual countries; it is a problem faced by every city and every individual. We cannot ignore the gradual deterioration of the chemical composition of the air and the negative impact of various harmful pollutants on our bodies.

Achieving the desired air purity can only be accomplished through a comprehensive approach that involves legislative, technological, planning, and sanitary measures implemented at the state level, requiring significant financial and material resources. However, an essential role in this endeavor is also played by raising the cultural level and awareness of the population in Ukraine. Effective means of preserving the cleanliness of the atmospheric air include replacing harmful

substances in industrial processes with less toxic alternatives, creating new closed-loop technological lines that operate without emissions into the atmosphere, practicing waste-free utilization of natural resources, and implementing efficient filtering systems.

The problem of reducing air pollution can be solved only in close cooperation of public organizations and state institutions, and on a global scale - only on the basis of international cooperation and joint efforts of all countries.

Among the system of measures aimed at preventing atmospheric pollution, several main groups are distinguished: the first group includes measures aimed at reducing gross emissions of pollutants into the atmosphere. These are measures of a technical, economic and legal nature: improvement of technological processes of industrial enterprises; focus on environmentally safe sources of electricity production (wind, solar, tidal, hydropower plants); improvement of fuel carburetion, transition of vehicles to environmentally safe types of fuel.

In order to protect the atmospheric air from pollution by motor vehicles, the planning and development of urban settlements are of great importance. In particular, greening of highways, zoning of residential areas, creation of multi-level traffic junctions, ring roads, use of underground space for parking lots, garages, creation of expressways, sanitary protection zones.

Measures of an economic nature aimed at reducing emissions into the atmosphere include: establishment of economic sanctions (fees for emissions, fees for excessive emissions, fines for causing damage to the environment); formation of ecological exchanges, within which it is possible to buy or sell the right to additional emissions of pollutants into the atmosphere; development of measures to stimulate the introduction of new technological processes.

A group of measures of a legal nature is represented by legislative acts on the protection and use of atmospheric air. These include the UN international convention on climate change, as well as a number of state-level legislative acts: the Law of Ukraine "On Atmospheric Air", Regulations on the Procedure for Issuing Permits for Emissions of Pollutants into the Atmosphere (Decree of the CM of Ukraine), Instructions on the Procedure for Development, Installation, and Review and proving the limits of emissions of polluting substances into the atmospheric air (Order of the Ministry of Safety and Security of Ukraine).

The second group of measures consists of those aimed at reducing the concentration of pollutants in the boundaries of industrial nodes, centers, and agglomerations. They include measures for planning the dispersion and deconcentration of harmful industries on the territory [16].

The third group of measures to prevent atmospheric pollution includes environmental education and environmental education. The formation of the components of the ecological culture of the population allows to regulate household pollution of the air environment, to relate with understanding to the introduction of air cleaning measures in workplaces, institutions, organizations and enterprises.

Author contributions. The authors contributed equally.

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References:

1. Savina L., I know the world, K., "School" 2002.
2. Rudzitis G. E. Feldman F. G. Inorganic chemistry, K., "Soviet school" D990.
3. I.M. Voloshyn Methods of researching nature management problems. - Lviv: LDU, 1997. - 160 p.
4. Ecological dictionary: Education. manual /V.V. Prezhko et al. - Kharkiv: KhDAMG, 1999. - 416 p.
6. Zlobin Yu.A. Principles of Ecology. - K.: Libra, 1999. - 249.
7. Korsak K.V., Plahotnik O.V. Fundamentals of ecology, - K.: MAUP, 2000. - 238 p.
8. Curly V.P. Ecology, - Lviv: World, - 500 p.
9. Bilyavskyi G.O., Padun M.M., Furduy R.S. Basics of general ecology. - K.: Lybid. 1995 - 368 p.
10. Bilyavskyi G.O., Furduy R.S. Workshop on general ecology. // Education manual - K.: Lybid, 1997. - 160 p.
11. Burynska N.M. Chemical Engineering, "Perun", Irpin, 2001
12. Kopilevich V.A. Chemistry, NAU Publishing Center, K., 2005.
13. Dombrovsky A.V. Organic chemistry 10-11th grade, "Education", K., 1998
14. Aleksandrova M.P. Chemistry: Handbook. - D., Stalker, 1998-512p
15. Vasilega M.D. Interesting chemistry, "Soviet school", K. - 1989
16. Shandala M.G., Zvyniatkovskyi Y.Y. Environment and health of the population, - K.: Nauk, Dumka, 1988.