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ENVIRONMENTAL PROTECTION TECHNOLOGIES OF THE AEROSPACE TECHNOLOGY MANUFACTURE

Tutorial textbook

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Викладено методологічні основи сучасної екології. Сформульовано основні поняття, терміни й принципи екології. Описано джерела впливу забруднювальних речовин під час виробництва аерокосмічної техніки. Подано заходи захисту атмосферного повітря, гідросфери й грунтів у межах території та повітряного басейну підприємства з виробництва аерокосмічної техніки.

Для студентів денної й заочної форм навчання англійською мовою за спеціальністю «Технологія виробництва літальних апаратів».

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The methodological foundations of modern ecology are described. The basic concepts, terms and principles of ecology are formulated. Main sources of the pollutants influence during the aerospace technology manufacturing are described. The measures of protection of atmospheric air, hydrosphere and lithosphere from polutants of enterprise for the aerospace technology production are given.

For full-time and part-time students studying in English, specializing in the field of aerospace technology manufacturing.

Fig. 7. Tab. 7. Bibliogr.: 22 titels

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CONTENTS

1. MODERN ECOLOGY AS A SCIENCE

For the first time the term "ecology" (*Gr. Oikos - house, logos - teaching*) was introduced into scientific use by the famous German biologist (follower of Charles Dickens) Ernst Haeckel in 1866. At present, there are many definitions of ecology. This is not only because environmental problems of human are coming to the foreground, but also because scientists of almost all scientific disciplines are engaged in solving them. Ecology as a science studies relationship between flora and fauna and their relationship with the environment, interaction between man and the biosphere as well as interactions of social production and the natural environment.

Because of human industrial activity, the nature has begun to experience human impacts becoming negative towards its own creator. This negative effect largely become apparent in the production of aerospace technical equipment (ATE). Therefore, modern ecology makes a person think about a fundamentally different behavior, and consider any activity from the point of view of nature laws.

1.1. The subject of ecology, basic concepts, terms and definitions

Life on Earth develops according to the strict nature laws. Species (including human beings) can exist and thrive only under certain conditions, which they are adapted to as a result of millennial evolution.

Human community (due to its activity) has to enter certain relationships with nature, i.e. to be engaged in nature management.

As a result, there are changes in natural systems under the influence of human activities.

Violation of nature laws may have dangerous and even tragic consequences for present and future generations.

To avoid this, you have to know the nature laws existence and development, how it interacts with the human community, which load the natural systems can withstand.

These questions are the subject of ecology.

Ecology faces numerous challenges.

The main one is (that based on the study of nature laws) to give evidence-based recommendations for the protection of nature, wildlife and reproduction of natural resources.

Ecology is a scientific basis of environmental protection.

Environmental protection can be defined as a field of knowledge that develops a complex of measures aimed at preventing harmful impact on the environment (including human beings). This complex includes the legislative, organizational, sanitary, engineering and other measures that prevent or reduce harmful effects of human activities on biological systems.

The competence of environmental protection as an area of knowledge and professional activity includes, for example, such issues as treatment of wastewater, air emissions, noise protection, radioactive substances burial, the creation of low-waste technologies, etc.

Assessing overall interaction between man and nature, we can draw the following conclusions:

1) any activity is potentially dangerous in terms of ecology;

2) in the process of environmental management is necessary to predict possible environmental effects of the use of new technologies, chemicals and new facilities;

3) The ecological crisis is not inevitable, correct natural management can prevent negative effects;

4) environment protection consists of correct nature management and minimization of need for special environmental protection measures by compensating possible adverse effects with appropriate recovery work.

V.I. Vernadsky defined the biosphere as the outer cover of the Earth, a place of life spreading. The biosphere includes all living organisms and elements of inanimate nature, which create a living environment. Thickness of the biosphere's is about 40 - 50 km. It includes the lower part of the atmosphere to the ozone layer (25 - 30 km), almost all of the hydro - and the lithosphere (to a depth of 3 km). In addition to living matter (plants, animals, microorganisms), the biosphere includes waste products of living organisms, products of decomposition and recycling of rocks by living organisms, water, radioactive substances.

Any environmental conditions which the body responds to by adjustment are called environmental factors. All environmental factors are divided into abiotic (non-living) and biotic (living).

Abiotic factors are:

- climate (light, temperature, air movement, humidity, pressure);
- edaphogenic (texture, density, moisture content, permeability of soil);
- orographic (terrain, altitude);
- chemical (gas composition of the air, salt composition of water, soil acidity).

Biotic factors are:

- phytogenic (influence of plants);
- zoogenic (influence of animals);
- microbiogenic (the influence of bacteria, fungi);
- anthropogenic (human activities).

A living organism can exist in a certain range of factors values. The wider the range, the greater the resistance of the organism. The totality of all the populations of different species living on the same territory with the inanimate environment is called an ecological system or ecosystem. Examples of ecosystems are a meadow, a forest, a lake, etc.

The term "biogeocoenosis" (from the "bio" - life, "geo" - land, "cenosis" - the company), whose an integral part is biocenosis, i.e. is the totality of living components was offered by Academician VN Sukachev.

Biogeocoenosis is a set on the Earth surface which consists of similar natural phenomena (atmospheric, rock, vegetation, fauna and microorganisms, soil, hydrological conditions, etc.) existing in continues motion and development.

This is a purely earthly formation.

At the same time biogeocoenosis is an ecosystem, i.e. the concept of "ecosystem" is broader than "biogeocenosis"

Biogeocenosis includes the following components:

• biotic (living community of plants and animals);
• abiotic (non-living set of environmental factors).
• microorganisms (microbiocenosis);
• representatives of fauna (phytocoenosis);
• wildlife (zoocenoses).

An important property of biogeocenosis (ecosystem) is its stability, balance of metabolism and energy between all the components, i.e. the dynamic equilibrium, or homeostasis (from "homeo" - the same as "stasis" - state).

Each ecosystem is always balanced, stable and homeostatic. Under certain conditions, this stability may be affected by various disturbances. A role of hindrances can be played by biotic or abiotic factors. The more complicated ecosystem is more stable in time and space. In the nature, a successive change of biocoenosis takes place under the influence of natural or human-induced factors, and it is called succession.

By its definition, succession is a directed and continuous sequence of changes in the species composition of organisms in a given habitat. There are several kind of successions: man-made succession (the influence of labour activity), pyrogenic (post-fire), zoogenic, phytogenic etc. Intervention in succession processes without taking into account these regularities could lead to the ecosystem collapse.

Primary organic matter on our planet is created mainly in plant tissues under the influence of solar energy. This process is called photosynthesis.

Photosynthesis occurs with absorption of heat. During this process free energy in organic matter increases, due to the conversion of solar energy into chemical one.

Plants absorb large amounts of carbon dioxide from the air (3.801011 t/year) and release free oxygen (501,011 tons / year).Plants build their bodies without intermediaries. Therefore they are called autotrophs, i.e. those who feed themselves. Autotrophs primary produce organic matter from inorganic. Organisms that cannot build their own material from mineral components and consume what is created by autotrophs are called heterotrophs. They make trophic (food) chains of varying complexity.

"Wastes" of organic character are created in the nutrition process at all trophic levels. During the nutrition process, destructors or destroyers (for example fungi, protozoa etc.) decompose these "wastes" to simple minerals. These organisms - destructors are called saprophytes. All substances on the planet are in the process of a biochemical cycle. There are two main cycles: large (geological) and small (biotic). The natural cycle of substances may be broken by human influence (fig. 1.1.).

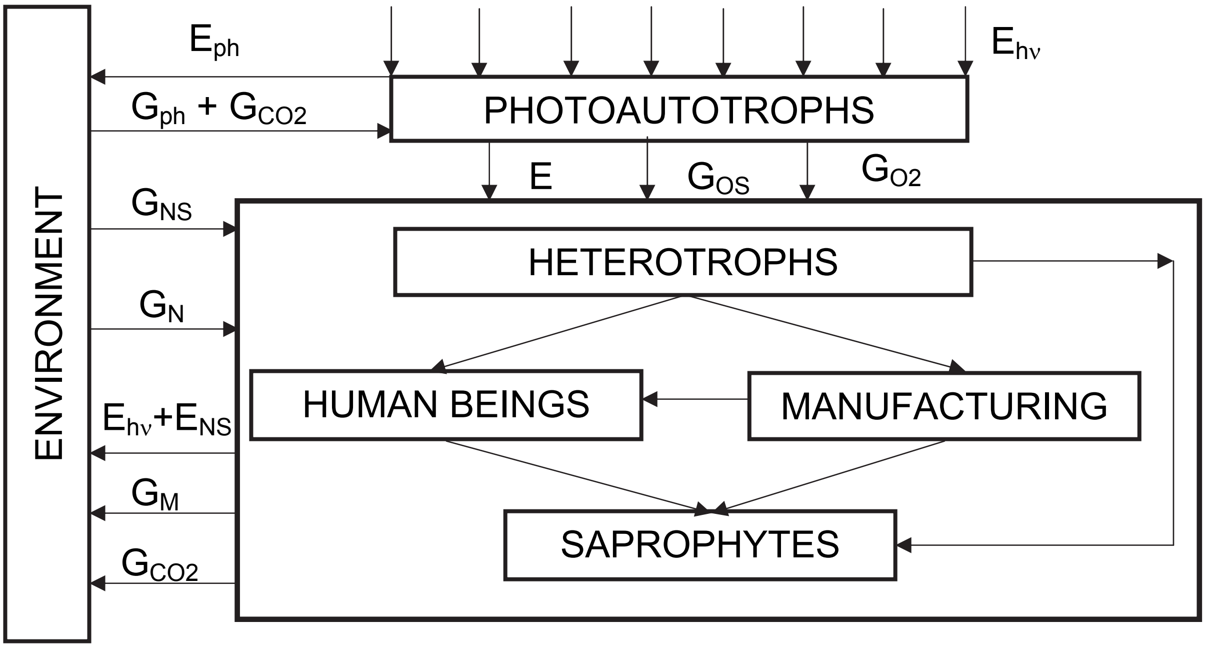

Fig. 1.1. Biotic cycle of matter in nature:
where $E_{h\nu}$ – is solar energy; E – is chemical bond energy; E_{ph} – is energy of photosynthesis; G_{OS} – is release of organic substances; G_{O2} – is oxygen emanation; G_{NS} – is release of nonorganic substances; G_{CO2} – is carbon dioxide emanation; G_N – is nitrogen emanation; G_M – is methane emanation; E_{NS} – is nonorgainc substance formation energy

Human beings close themselves to the biotic cycle of matter by polluting the air and water, using fuel, applying atmospheric nitrogen in food production, they have to take partial or full control over the chemistry of the environment.

1.2. Environmental laws, regulations and principles

Modern ecology has a set of laws, rules and principles. This book presents only the largest generalizations connected with the fundamental nature laws.

V.I. Vernadsky's Law of the constancy of the living substance amount: The amount of the biosphere living substance (for the given geological period) is constant.

Libih's Law of the minimum. It states that growth is dictated not by total resources available, but by the scarcest resource (limiting factor). The law has also been applied to biological populations and ecosystem models for factors such as sunlight or mineral nutrients.

The Law of the energy and information maximization: a system has the best opportunities for self-preservation only when it is more contributing to acquisition, production and efficient use of energy and information.

10% Rule (R. Lindeman's rule of pyramid energy). Only 10 per cent of the energy that enters the previous trophic level of the ecological pyramid moves to another higher trophic level.

Tolerance law (V.Shelford): the absence or impossibility of the ecosystem development is defined not only by shortage, but also by excess of any factors.

The law of competitive exclusion: two species occupying the same ecological niche cannot coexist in one place indefinitely long.

The law of limited resources: an increase in the number and weight of some organisms is due to the decrease in the number and weight of others.

The rule of ecological niche: an ecological niche is never empty; it is inevitably filled in a natural way.

Rule boomerang: whatever is extracted from the biosphere by human labor, it should be returned.

The principle of balanced nature usage: the development and placement of objects of material production in a particular area should be done according to its environmental resistance to man-made load.

The principle of distance events: the events, distant in time and space, psychologically seem to be insignificant and unimportant, but the proponents of this doom themselves to great danger.

Therefore, either humanity will be able to fit into the parameters of the existing biosphere and save it, or it will perish with it.

1.3. Legal foundation of environmental safety management

Protective environmental measures began to lag behind the negative changes in the biosphere at the present rate of increase in anthropogenic impact on the environment.

Therefore, in the 1980s, there appeared concept of an environmental management system that alerts the possibility of conflicts between society and nature was accepted.

The main objective of this concept is to develop a legal mechanism for the optimization and management of the harmonious development of local, regional and global socio-ecological system.

For the implementation of its main directions in the field of environmental protection, the following legislation was adopted:

- «On Environmental Protection" (1991);
- «On Air Protection" (1992);
- «On Nature Reserve Fund" (1992);

• «On Wildlife" (1993);
• «On Environmental Impact Assessment" (1995);
• «On Flora" (1999);
• «On Zone of Ecological Emergency" (2000);

The following laws were adopted to ensure the nuclear security of the population in 1995:

• «On Use of Nuclear Energy and Radiation Safety";
• «On Radioactive Waste Management";

Protection and use of certain natural resources of Ukraine is regulated by the following relevant Codes:

• «Forest Code" (1994);
• «Natural Resources Code" (1994);
• «Water Code" (1995);
• «Land Code" (2001).

The law of Ukraine "On Environmental Protection" is a fundamental piece of legislation regulating relations in the field of protection, reproduction and use of renewable natural resources, environmental safety, prevention and mitigation of the impact of economic and other activities on the environment. Supervision of compliance with environmental legislation is carried out by municipal environmental public prosecutor's office.

Among the whole environmental legislation the law of Ukraine "On Protection of Atmospheric Air» concerns to the greatest extent only legal regulation of urban problems because the sources of human impact on the air are located mainly within the boundaries of the city. The law of Ukraine established common standards for environmental safety of the air, which include the maximum permissible concentration (MPC) of pollutants in the atmospheric air and maximum permissible levels of acoustic, electromagnetic, ionizing and other kinds of harmful physical and biological impacts on the atmosphere.

The establishment of more stringent environmental standards for the air at health resort, therapeutic, recreational and other areas with increased demands for the air quality were provided.

For each stationary source emissions or exposure there should be established maximum permissible emissions (MPE) of pollutants into the air and maximum permissible harmful physical and biological impacts In order to limit the impact on the atmosphere and other objects. The procedure of development and approval of these standards was carried out. The standards of composition of pollutants in the exhaust gases and harmful physical impacts (noise, vibration, etc.) were set for all vehicles.

There was established the limitation the technological standards for formation of pollutants that are discharged into the air during operation process for equipment, individual buildings and facilities depending on the time of entry into service.

The procedure of development and approval of these standards was carried out.

Companies that have an impact on the atmosphere can operate only under permissions that specify the allowable emissions of pollutants (g / s or t / year) for each stationary source, as well as the levels of harmful physical effects. At aviation enterprises, measures to prevent environmental emergencies in case of accidents and adverse weather conditions (prolonged calm, fog) are provided. In accordance with the class of object's environmental hazard around it, a sanitary protection zone is set. The population should not reside and community facilities should not be located inside a sanitary protection zone.

Offenses in the field of air protection for any industry include:

• exceeding the limits of emissions;

• exceeding the maximum permissible levels of the harmful effects of physical and biological factors;

• Implementation of the illegal activity that adversely affects weather and climate;

• operation of vehicles, manufacturing equipment and other facilities that do not meet the requirements for the protection of atmospheric air;

• refusal to issue timely, complete and accurate information about the state of ambient air pollution sources, as well as the concealment or distortion of information about the environmental conditions prevailing as a result of air pollution.

In accordance with international agreements, Ukraine's enterprises have to cut and in the future to cease production and use of chemicals that have harmful effects on the ozone layer of the atmosphere.

Enterprises have to reduce emissions of carbon dioxide and other substances whose accumulation in the atmosphere can lead to negative climate change; reduce emissions of sulfur and other acidifying gases whose presence in the atmosphere will lead to acid rain.

"Water Code of Ukraine" legally regulates issues of water use.

It established the following guidelines on the use and protection of water:

• standards of environmental safety of water use (to assess the possibilities of using water from water bodies for the needs of the enterprise);

• ecological quality standard of water (to assess the environmental well-being, consisting of a general physical, biological, chemical and radiological indicators of pollution);

• standards of maximum permissible discharge (MPD) of pollutants;

• technological standards of formation of substances discharged into water bodies (MPC contain substances in wastewater, which are formed during the manufacturing process).

"Water Code of Ukraine" established the status for general and special water use. Common water use by citizens for the diversion capacity from water bodies without applying facility or technical devices.

Special water use is a water intake from water bodies with facilities and technical equipment or dump them in the waste (return) water.

Special water use provides the industry, transport, energy and other enterprises. Industrial enterprises should reduce the volume of water use through the establishment of a consistent system, recycling and closed water supply, as well as improving manufacturing processes and wastewater treatment in accordance with the MPD.

Not allowed commissioning of plants and other industrial enterprises without water treatment facilities to ensure wastewater treatment in accordance with the MPD.

1.4. Environmental monitoring

Over the past decades, ecologists of Ukraine have accumulated a lot of material about the natural environment changing. However, it does not contain the data in field of the development of processes dynamic. Thereby, it is necessary to organize the special observations of the state of the surrounding natural environment and its anthropogenic changes. Because of this, the permanent operational monitoring service is established, which will be able to assess, forecast and timely warn of possible adverse consequences [4].

The need for the systematic collection, storage and processing of data about the environment conditions was finally formed at the end of 1960s. Already in Stockholm (1972) at the environmental protection conference under the auspices of the United Nations, the concept of "monitoring" is explained as an integrated system for observing, assessing and forecasting changes in the state of the environment under the influence of anthropogenic factors. Now it means a set of geographically and chronologically organized observations of the biosphere components.

The monitoring includes the following main activities:

- observation of factors affecting the environment;
- monitoring the change in the state of the natural environment under the influence of these factors;
- assessment of the actual state of the natural environment;
- forecast for the development of the state of the natural environment and an assessment of this development.

Hereby the monitoring - is a system of observation, assessment and forecast of the environment state, that does not include environmental quality management, but provides the necessary information for such management and development of engineering methods of environmental protection [9].

Monitoring can cover both local areas and the terrestrial globe as a whole (global monitoring). To ensure an effective assessment and forecast, the monitoring should include observations of pollution sources, pollution of the environment and the consequences of this pollution. Therefore, the universal approach to determining the structure of anthropogenic change monitoring system is its division into the following stages: "Observation", "Assessment of the actual state", "Projection of the state", "Estimation of the forecasted state".

Data that characterize the state of the natural environment obtained as a result of observations or forecasts should be assessed depending on specially selected or developed criteria.

An assessment of the state of the environment implies that, on the one hand, it is necessary to determine the damage from external factors, and on the other - to choose the optimal conditions for human activity and to determine the existing environmental reserves.

The information system for monitoring anthropogenic change is an integral part of the overall system of management and interaction with the environment. To manage the state of the environment, it is necessary to collect, accumulate and analyze the information about changes in environmental parameters. Such information should be used as a basis for a set of measures for nature protection and be taken into account in the planning of economic development [4]. Fig. 1.2 shows the structure of monitoring in the management (regulation) system of the state of the environment. The scheme conditionally combines the energy (E) and information flows (H).

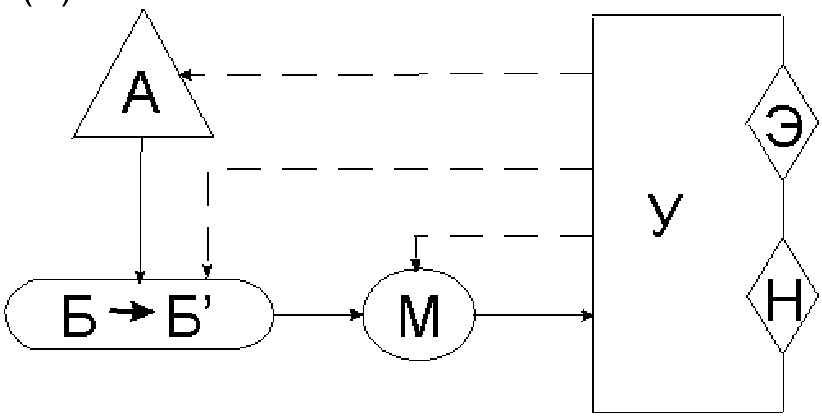

Fig. 1.2. Ecological monitoring diagram

An element of the biosphere with a level of state (B), being exposed to (A), changes its state (B → B '). The “photo picture” of this changed and, (if it is possible) the initial state is being created with help of the monitoring system (M). Then the data are summarized, the analysis and evaluation of the actual and predicted state are carried out. This information is transmitted to the control unit (Y) for making of necessary decision.

Protective measures for the limitation or stopping of anthropogenic impacts are based on the received information and depending on the level of scientific and technical developments (H) and economic opportunities (E), and take into account environmental and economic assessments. At the same time, measures for the preventive strengthening or subsequent restoration of this element of the biosphere [9] are being developed.

There are different approaches to the classification of monitoring, depending on the nature of the tasks to be solved, on the level of the organization, on the natural environments under observation, etc. The classification presented in fig. 1.3 covers all stages of environmental monitoring and observation of the abiotic component changing of the biosphere, as well as the response of ecosystems to these changes.

Thus, ecological (environmental) monitoring includes both geophysical and biological aspects, which determines a wide range of methods and methodic of research used in its conduct.

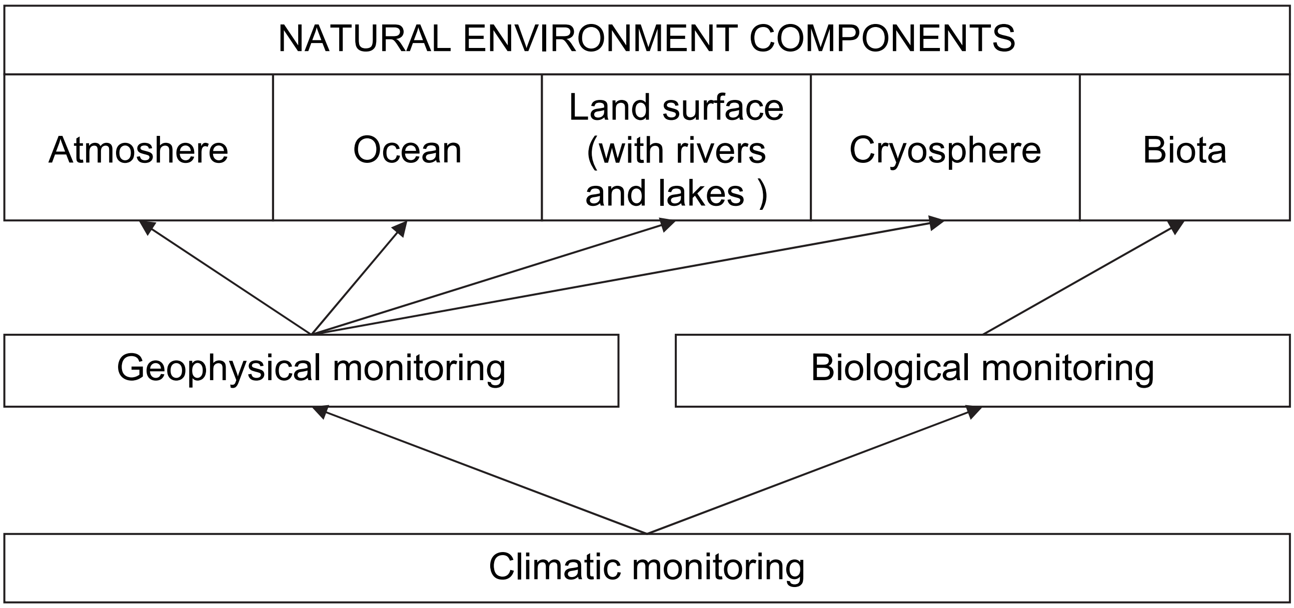

Fig. 1.3. Monitoring classification

Observations of the state of the natural environment should include the observations of sources and factors of influence (including sources of pollution, radiation, etc.). Observations of the state of the biosphere elements should include the observations of living organism's responses to the effect, the changes in their structural and functional indicators and factors [9].

1.4.1. Global environmental monitoring system

Today, the network of observations of the influence sources and the state of biosphere covers the entire globe. The Global Environmental Monitoring System (GEMS) was established by the joint efforts of the world community in 1974 at the first intergovernmental meeting on environmental monitoring [nine].

The organization of worldwide monitoring of the natural environment pollution and the factors causing its impact was recognized was the first priority. The system of environmental monitoring is implemented at several levels, to which specially designed programs correspond [9] in accordance with the classification of pollutants (table 1.1):

- impact (study of strong impacts on a local scale - I);
- regional (appearance of the migration problems and transformation of

pollutants, joint impact of various factors typical for the regional economy - R);
- background (based on biosphere reserves, where all economical activities are excluded - B).

Table 1.1

Classification of the main pollutants by priority classes in the GEMS system

Classes	Name of pollutant substance	Medium	Level of monitoring
1	Sulfur dioxide, suspended particles	Air	I, R, B
	Radionuclides	Food	I, R
2	Ozone	Air	I, B
	Organochlorine compounds and dioxides	Biota, man	I, R
	Cadmium	Food, water, man	I
3	Nitrates, nitrites	Water, Food	I
	Oxides of nitrogen	Air	I
4	Mercury	Food, water	I, R
	Lead	Air , Food	I
	Carbon dioxide	Air	B
5	Carbon monoxide	Air	I
	Hydrocarbons of oil	Sea water	R, B
6	Fluorides	Sweet water	I
7	Asbestos	Air	I
	Arsenic	Baking soda	I
8	Microbiological contamination	Food	I, R
	Reactive pollution	Air	I

The impact-monitoring program can be aimed, for example, at studying the dumping or emissions of a particular enterprise. The subject of regional monitoring, as its name implies, is the state of the environment within a given region. Background monitoring, carried out within the framework of the international program "Man and the Biosphere", aims to fix the background state of the environment, which is necessary for further assessments of the levels of anthropogenic impact.

Observation programs are formed according to the principle of selecting the priority pollutants (which are subject to priority determination) and integral characteristics (reflecting a group of phenomena, processes or substances). Classes of priority of pollutants (table 1.1), established expertly and adopted in the system GEMS.

The definition of priorities in the organization of the monitoring systems depends on the purpose and objectives of specific programs. On a territorial scale, the priority of state monitoring systems is given to cities, sources of drinking water and spawning grounds for fish; in point of environments observation, the atmospheric air and fresh water are primary importance [4].

Priority of ingredients is determined taking into account the criteria that reflect the toxic properties of pollutants, the amount of their entry into the environment, the features of their transformation, the frequency and magnitude of the impact on humans and biota, the possibility of organizing measurements and other factors.

The priorities chosen by public organizations in the development of monitoring programs can be formulated in different way, not repeating the ranking adopted in GEMS. This decision is justifiable, since regional and local priorities are closely related to the region's economy, with local sources of impact. Finally, the public monitoring program can be associated with a very specific problem (for example, recycling household garbage in Lviv in 2013-17), which will determine the priorities in this case.

1.4.2. Subjects of environmental monitoring in Ukraine

The system of ecological control includes various subjects of the monitoring system from ministries up to enterprises of all forms of ownership [9]. The Ministry of Ecology and Natural Resources monitors the state of atmospheric air, surface, groundwater and seawater and water objects within nature conservation areas. In addition, the Ministry of Ecology conducts monitoring studies of soils for various purposes, including in nature conservation areas, as well as various landscapes, sources of industrial emissions and discharges, radiation conditions, natural and dangerous natural phenomena, in particular, geological processes, floods, snow avalanches, mudflows etc. It also carries out the state ecological and geological mapping of the territory of Ukraine to assess the state of the geological environment and its changes under the influence of economic activity.

The Ministry of Emergency Situations monitors on the territories that are subordinate to the Administration of the exclusion zone and the zone of mandatory resettlement, as well as in other zones of radioactive contamination in consequence of the Chernobyl accident.

The Ministry of Health conducts the monitoring studies in places of residence and recreation of the population, in particular, in the natural areas of health resorts.

The Ministry of Agrarian Policy monitors the condition of soils for agricultural use, agricultural plants and animals, as well as products from them. Supervises the surface waters of agricultural purpose. The State Forest Resources Agency oversees the state of land soils.

The State Agency for Water Resources of Ukraine monitors the state of rivers, reservoirs, canals, irrigation systems and water objects within the frames of integrated water management systems, inter-industry and agricultural water supply systems. It conducts the monitoring studies of reservoirs in zones affected by nuclear power plants, surface waters in the border areas and their intensive production and economic use of irrigated and drained lands, oversees the flooding of rural settlements, coastal zones of reservoirs.

The State Agency for Land Resources conducts monitoring of the state of soils and landscapes, erosion and other exogenous processes, spatial contamination of land by industrial and agricultural production facilities, vegetation cover of lands, coastal rivers, seas, lakes, reservoirs, coastal lakes, bays, and hydraulic structures and buildings.

Enterprises, institutions and organizations, irrespective of their subordination and forms of ownership, whose activities result or may lead to environmental degradation, are obliged to carry out environmental monitoring of production processes and the condition of industrial zones. They are obliged to collect, store and gratuitously provide data and generalized information for its comprehensive processing. For this purpose, an agreement is concluded between the subjects of the monitoring system and the information provider, which is subject to registration with the Ministry of Natural Resources or its local authorities [9].

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1.4.3. Collection and processing of information about the state of the environment

The data obtained by monitoring systems and methods are used for modeling processes in the natural environment, for making scientific forecasts. Based on forecasts, practical recommendations for improving and improving the protection of nature are developed.

The methods of chemical and physicochemical analysis are used for determination the qualitative and quantitative composition of pollutants in the environment (in air, soil, water). The bio indication method is used for assessment the sustainability of natural ecosystems to different types of pollution. Bio indication is the detection and determination of anthropogenic loads by the reactions of living organisms and their communities to them. Bio indication allows defining ecological disturbances even at such levels of pollution that do not constitute a menace to the population living on the surrounding territory [9]. Therefore, the various concentrations of pollutants have been developed for determination the quality of the environment:

MPC – maximum permissible concentrations;

MPD – maximum permissible dose;

MPL – maximum permissible levels of pollutants.

MPC is the highest concentration of a substance in the environment and sources of biological consumption (air, water, soil, food), which, with prolonged influence on the human organism - contact, inhalation, and ingestion - has no effect on health and does not cause long-term effects (does not affect offspring etc.).

The system of environmental standards has been developed on base of normative concentrations [4]. Ecological standards - is a single and mandatory system of norms for all objects of this type and levels and requirements for the environment. There are international, state, industry and enterprise standards.

In accordance with the environmental standard, the following environmental observations are carried out on the territory of the aviation enterprise:

• air quality and the sources of contamination;

• the level of harmful physical and chemical agents;

• quality of water sources centralized drinking water supply;

• discharge of wastewater into the municipal sewage system.

During the observation of air pollution is monitored compliance with air emission limits with MPE and the composition of the air at the outer boundary of the sanitary protection zone.

Monitoring of sources of harmful physical and chemical effects is carried out by the regional sanitary and epidemiological stations. Noise levels, radiation, electromagnetic fields, vibration intensity and other physical effects are measured.

The results of measurement are compared with the standards of acceptable levels of exposure to physical factors. Control of discharge of industrial wastewater into the sewer is lead by urban sanitation service in accordance with the established limits. Aviation companies control themselves over their own work of local treatment facilities and determine the composition of the wastewater discharged into the municipal sewerage them.

The environmental inspection and sanitary and epidemiological stations in order of state control inspection carries out the check of operation of sewage treatment facility, the composition of wastewater discharged into water bodies and determines the impact on the state of water bodies - receivers of wastewater.

Metrological assurance measurements in the system of environmental monitoring is carried out by the organization of state standard of Ukraine.

State Standard in conjunction with the Ministry of Environmental Protection and Nuclear Safety, other ministries and departments of Ukraine, participating in the operation of environmental monitoring, provides the unification of methods of observation and laboratory tests, helps optimize the network of observation and improve the instrument base.

Collection, process, summarize and analyze information on the state of the environment and sources of influence on it is carried out by environmental safety organizations and local organizations of the State Committee on Statistics.

According to the results of the environmental monitoring of the Ministry of Environmental Protection and Nuclear Safety prepares and publishes an annual national report on the state of the environment in Ukraine.

1.4.4. Ecological audit and ecological expertize

The environmental inspection (i.e. an ecological audit) of an enterprise is conducted to establish the ecological condition of company, compliance with the requirements of environmental legislation or international standards and development of activities concerning production process at an enterprise in accordance with these requirements.

It is a management tool which covers all issues of the environmental assessment of the enterprise production process.

Ecological audit has the following main features:

- independence,
- confidentiality,
- objectivity,
- system,
- competence
- license,
- compliance with the objectives which are defined by the customer in the contract for the audit.

Ecological audit is organized on the initiative of the manager or the owner of the object and has the character of self-monitoring. It is carried out independently of the state ecological expertise.

Specialized auditing organizations that have the appropriate qualification certificate are involved in the process of ecological audit.

The sphere of activity of the ecological audit is the production area of the enterprise and the surrounding area at a distance of 5 km in perimeter, main and supporting processes, buildings and equipment.

Ecological audit is mandatory:

- in the privatization process of the enterprise;
- for environmental insurance;
- during formation of environmental action plans;
- when environmental funds provide financial assistance to companies;

• when a company applies for “green label”, the sign of a high environmental standard for products.

Ecological audit results are the basis for the development of advanced environmental issues, environmental action plans and the formation of environmental policy.

Expertise – is ecological study, analysis and assessment of existing or planned economic activity that has or may have a negative impact on the environment.

Environmental impact assessment is aimed at preventing the emergence of new sources, restriction or elimination of existing sources of negative impacts on the environment and human health. The environmental legislation of Ukraine identified the need and procedure for environmental impact assessment. There are State and public environmental expertises.

Additional independent environmental expertise can be carried out on the initiative of the stakeholders and organizations, as well as on the decision of central or local authorities.

State ecological expertize of objects of state and regional value is conducted by the Agency of Ecological Expertize of the Ministry of Environmental Protection and Nuclear Safety of Ukraine. For objects of local significance – by regional department of ecological expertise regional administration of environmental safety.

Organizations of public health surveillance and other relevant state organizations are involved in process of state ecological expertise.

Specialized research, training and design organizations, individual highly skilled experts from international organizations are involved in the preparation of conclusions of the state ecological expertise. Public ecological expertise is carried out to take into account a public opinion and social and environmental impacts caused by economic activity of the enterprise. It can be done for any field of activity, when requires the environmental justification. It is carried out on the initiative of social organizations created by voluntary eco-expert groups of public and independent experts, representatives of the mass media. The conclusion of the public environmental expertise covered in the media, is sent to the authorities conducting the state ecological expertise, local and central authorities.

1.5. Questions for self-check

1. What is the main criterion for evolutionary selection?
2. What is an ecosystem?
3. What is information and what is its main role in ecosystems?
4. What meaning in the laws of ecology: do the minimum and tolerance have?
5. What is the essence of the concept of rationial nature use?
6. Which laws regulate the protection and use of certain natural resources of Ukraine?

7. Which law of Ukraine sets the maximum allowable discharges of pollutants?

8. Which law of Ukraine establishes the maximum permissible emissions of pollutants?

9. What is the monitoring of the environment?

10. Which stages exist in the structure of the monitoring system of the anthropogenic changes?

11. What are the levels of specially designed environmental programs according to the classification of pollutants?

12. According to which criteria is the priority of pollutants determined in the tasks of individual environmental programs?

13. What subjects of the monitoring system are included in the system of environmental control?

14. Which are the concentration norms introduced to determine the quality of the environment?

15. What is the purpose of the ecological audit?

16. In what cases is the ecological audit mandatory for the enterprise?

17. What is the difference between the environmental expertise and the ecological audit?

2. ECOLOGY OF AIR ENVIRONMENT

Atmosphere is a layer of gases surrounding the Earth including mechanical mixture of various gases, water vapor and solid (aerosol) particles. It has a length of 1100 km. Atmospheric air is needed for breathing of living organisms. It is used in industrial processes of burning and melting raw material for the production of oxygen, nitrogen, inert gases, carbon monoxide.

The atmosphere is a gaseous medium for gas wastes of enterprises

Atmospheric air gets rid of impurities under the influence of atmospheric precipitation, solar radiation and transfer of air masses. This process is called self-purification of the atmosphere.

2.1. Composition, structure, properties and functions of the atmosphere

The composition of the atmosphere is in a state of dynamic equilibrium supported by such climatic factors as movement of air masses (wind and convection) and precipitation, vital activity of animal and plant worlds, especially forests and plankton of the oceans, as well as due to cosmic processes, geochemical phenomena and economic human activities.

The common name air is given to the atmospheric gases used in breathing and photosynthesis. By volume, dry air contains 78.09% nitrogen, 20.95% oxygen, 0.93% argon, 0.039% carbon dioxide, and small amounts of other gases. Air also contains a variable amount of water vapor, on average about 1% at sea level, and 0.4% over the entire atmosphere. Air composition and atmospheric pressure vary at different layers, and air suitable for the survival of terrestrial plants and terrestrial animals is found only in the Earth's troposphere and artificial atmospheres (table 2.1).

The atmosphere has a mass of about 5.15×10^{18} kg, three quarters of which is within about 11 km of the surface.

Table 2.1

Main atmosphere layers

Atmosphere layers	The upper and lower boundaries of the layer above the sea level (km)	Temperature, ^0C	
		lower boundary layer	upper boundary layer
Troposphere	0 – 11	+ 15	– 56
Stratosphere	11 – 50	– 56	– 2
Mesosphere	50 – 85	– 2	– 92
Exosphere	85 – 500	– 92	+ 1200

The composition of the atmosphere has a significant impact on the climate of the Earth. One of the first global problems is the increase in CO_2, it generates so-called greenhouse effect, because it prevents in-space dissipation of heat emitted by the Earth.

Economic and industrial activities cause increase in concentration of CO_2 released into the atmosphere primarily by burning huge amounts of fossil fuels. Over the past 20 years, the content of CO_2 in the atmosphere has increased by 15% as a result of anthropogenic influence, which can lead to global warming on the Earth and climate change.

The second global issue is reduction of the ozone layer, being possible due to anthropogenic air pollution, which is associated with the release of halogenated organic compounds - catalysts for the reaction of ozone depletion. Ozone depletion also accelerates emissions of nitrogen oxides in the stratosphere by jet engines during the flight of supersonic aircraft and by aerospace equipment.

Near-Earth space pollution is globally growing because of surface emissions from space satellites, launch vehicles and artificial satellites debris.

The anthropogenic impact on the environment is not limited to material contamination. We should also take into account the increasing heat flow, electromagnetic and ionizing radiation. There are many unregistered radio transmitters, radio noise, electromagnetic radiation from navigation equipment and air traffic control systems.

Nuclear plants, whose number in space is more than 50 units now, as well as accidents occurring at nuclear power plants, are the reason for air pollution by the ionizing radiation.

According to the "National Action Plan for the Conservation of the Environment", there were set of following main priorities of the air protection:

• restriction of activities of objects that pollute the air;
• improvement of ventilation system, cleaning and air conditioning indoor;
• improvement of regulatory framework.

For the implementation of "Plan ..." the following activities were offered:

• introduction of technological discipline in industry;
• restriction in the use of vehicles with poor performance;
• quality control of dust and gas cleaning facilities;
• improving the system of monitoring emissions into the air;
• inventory of emission sources;
• Introduction to the existing regulation of emissions into the atmosphere of technological standards that relate to the formation of pollutants during the manufacturing process.

The atmosphere has the following functions:

• it accumulates oxygen required for respiration of living organisms;
• it is a source of carbon dioxide for photosynthesis;
• it protects living organisms from cosmic radiation;
• it keeps the heat and regulates the Earth's climate;
• it transforms gaseous products of metabolism;
• it spreads water vapor over the planet;
• it is a habitat for the flying forms of organisms;
• it serves as a source of chemical raw materials and energy;
• it receives and transforms waste gases and dusts.

The upper boundary of the atmosphere is not clearly distinguished. It gradually goes into space. The average temperature of the atmosphere at mid-latitudes decreases linearly with height up to 11 km. The average temperature at sea level is taken equal to 288 K and at 11 km - 216.7 K

2.2. Rationing of air quality

Concept of concentration is used to quantify the content of impurities in the atmosphere - this amount of material contained in a volume unit of air transformed to normal conditions. Ambient air quality is a combination of its properties, which determines the impact of physical, chemical and biological factors on people, flora and fauna, as well as on materials, structures and the environment in general.

Air quality can be considered satisfactory, if the content of impurities in it does not exceed the maximum permissible concentration (MPC). Maximum permissible concentration (MPC) of a chemical substance is a level to which a worker can be exposed day after day during their working lifetime without adverse direct or indirect health effects.

Direct health effects on a person include temporary irritating effect actions, causing a sense of smell, cough, headache. Pathological changes of individual organs or the whole organism may occur with the accumulation of harmful substances in the body above a certain dose.

Indirect health effects include such changes in the environment, which impair normal living conditions without causing harmful effects on living organisms: do harm to green spaces, increase the number of foggy days, etc.

The main criterion for establishing standards for the MPC assessment of air quality is the impact of airborne contaminants on the human organism.

To evaluate the air quality there were set two categories of the MPC (table 2.2):

- the maximum single MPC_{ms};
- average daily MPC_{ad}.

MPC is the main characteristic of the dangers of harmful substances.

It is set to prevent reflex reactions in people (sense of smell, light sensitivity, the bioelectric activity of the brain) at short-term exposure to air pollutants.

Substances with smell or with influence on other human senses are examined according to this standard.

MPC_{ad} is set to prevent systemic toxicity, carcinogenicity, mutagenicity and other effects of the substance on the human body. Substances that are examined by this standard, have the ability of temporary or permanent accumulation in the human organism. By the beginning of 2010 MPC was applied to assess about 1,000 substances that can get into the air were estimated.

Table 2.2

MPC of most common substances

Name of pollutant	MPC_{ms}, mg/m^3	MPC_{ad}, mg/m^3
Nitrogen dioxide	0,085	0,04
Nitrogen oxide	0,4	0,06
Sulphurous anhydride	0,5	0,05
Ammonia	0,2	0,04
Benzopyrene	—	0,1
Suspended solids	0,5	0,15
Mercury	—	0,0003
Lead and its compounds	—	0,0003
Carbon monoxide	5	3
Formaldehyde	0,35	0,003

List of substances, the content of which is standardized in the air, is constantly updated. If the substance has harmful effects on the environment in lower concentrations than on human, then the normalization is carried out according to threshold action of this substance on the environment.

Effect of substances for which there are no MPC, is usually measured by the approximate safe level (ASL). ASL is a temporary health standard for air pollutants that is calculated for the design of industrial facilities. Limit values for the air should be the same for the whole territory of Ukraine. MPC that are established in other countries may vary up or down. For example, the US MPC for S02 is 0.75 mg / m3 and in Ukraine - 0.5 mg / m3. MPC is 20 % less for zones of sanitary protection of resorts, location of large resorts and holiday homes, as well as for recreation areas in cities than for residential areas.

Temporarily agreed emissions (ENE) is established in case when MPE values cannot be achieved (for objective reasons) for an enterprise or group of enterprises located in the same area.

Temporarily agreed emissions standard is established for the period of development and realization of air-protection measures to ensure the achievement of emission limits.

The validity of emission limits, as a rule, does not exceed 5 years.

The emission limits are subject to revision in case of building new production facilities, reconstruction of existing, changing the process or the type of raw materials used in other similar cases.

Citywide MPE, according to which the individual enterprise's MPE can be revised downwards, are developed for each city and based on the enterprise, is MPE and the background composition of the atmospheric air.

The computation of MPE is usually carried out with the help of specially developed software and approved by the Ministry of Environmental Protection and Nuclear Safety.

Compliance with air quality standards provides a favorable ecological condition in the region in accordance with the requirements of the law of Ukraine on protection of atmospheric air.

2.3. Basic laws of dispersion of pollutants in the atmosphere

The degree of air pollution by harmful substances at the earth surface is determined not only by the amount of pollutants emitted, but also by their distribution in space and time. Dilution of harmful impurities by air occurs due to the dispersion of industrial emissions in the atmosphere.

Dispersion of the impurity is usually understood as the combined action of the transfer and diffusion processes [5]. The transfer occurs in the direction from high atmospheric pressure to low one and depends on the wind speed. The movement of air masses in the atmosphere is accompanied by pulsations of wind speed and usually has a turbulent character. Gases are mixed in the atmosphere due to both pulsating velocities and turbulent diffusion. The pulsating rates of polluting emissions depend on many factors, such as

- wind speed;
- nature of the underlying surface, the lay of land;
- state and composition of the atmosphere, etc.

In addition, the nature of the temperature change – the temperature stratification of the atmosphere – affects the pulsation velocities and the shape of the emission flare. Under normal conditions, the temperature decreases with altitude increase.

To estimate the change in temperature stratification, we introduce the concept of a dry adiabatic temperature gradient corresponding to a change in the temperature of air particles, which moves vertically in a dry atmosphere without heat exchange with the surrounding medium. The dry adiabatic gradient is about 1 ° C per 100 m rise up. Under real conditions, a deviation from a given temperature gradient is observed due to the ability of the earth's surface to absorb and radiate heat [6].

The lay of land, as well as the presence of industrial buildings significantly affect the nature of the dispersion of harmful substances. This fact is connected with changes in the airflow and microclimate velocity fields in some areas. For example, stagnant, poorly ventilated areas are formed in low places, with a high concentration of harmful substances. From the windward sides of the hills there are large concentrations of harmful substances due to the formation of low-pressure zones behind the hills and the presence of reverse air currents. In the absence of wind, the additional initial rise of the impurity above the pipe cut reaches its maximum values and the surface concentrations are small.

As the wind speed increases, the initial rise of the impurity decreases and the surface concentrations increase. However, starting with a certain wind speed, the dissolving role of the atmosphere becomes the determining factor. This leads to a decrease in the levels of surface concentrations. Emissions from pipes can only be gas or include mixtures of gases and suspended particles. In general, the particle sizes range from 0.001 to 500 μm.

If the particle size were more than 20 μm, then they would have a significant subsidence rate. This causes increased concentrations of such particles near the earth surface not far from the pipe base compared to the concentrations of gases emitted simultaneously [7].

Pollutant emissions are subject to transformation, interaction, leaching, etc., which can lead to the formation of secondary components, possibly more dangerous than primary ones. These processes take place differently for suspended particles and gaseous impurities. The residence time ("life") of pollutants in the atmosphere depends on:

- atmosphere conditions;
- physical and chemical properties of released substances;
- height and diameter of the emission source;

• location of the source;

• lay of land.

The time of "life", for example, of sulfur dioxide can range from a few hours to several days.

The distribution of the pollutants concentration in the atmosphere from a point source torch is shown in fig. 2.1.

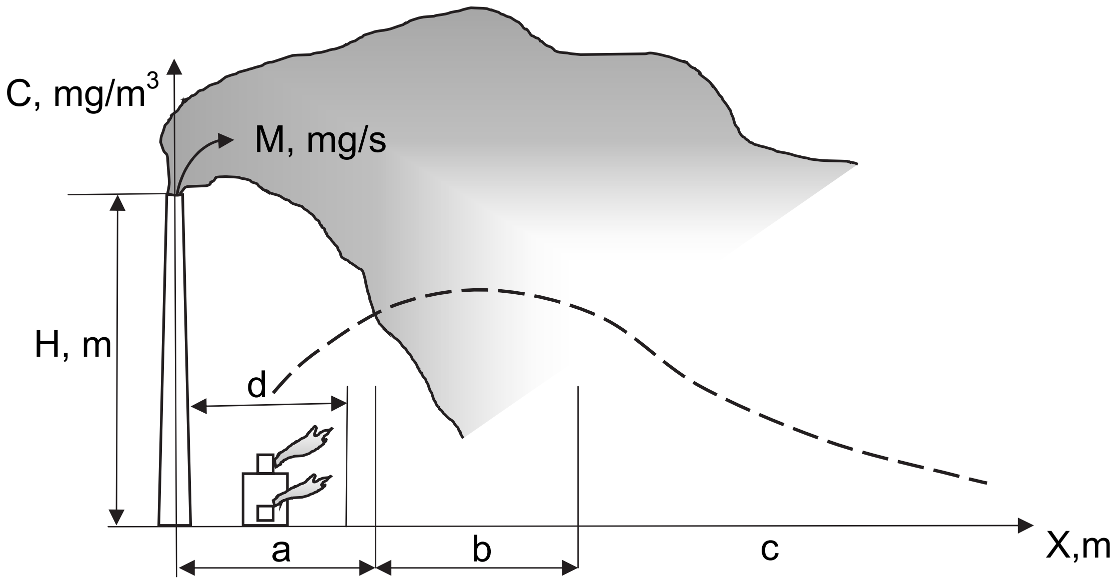

Fig. 2.1. The distribution of the concentration of pollutants in the atmosphere from the torch point source:
a - zone of torch transfer; b - zone of smoke; c - zone of progressive reduction of pollution; d - area pollution of unorganized emissions

Inside the zone of torch transfer (a) there is a high level of pollutants concentrations due to unorganized emissions. The zone of smoke (b) is a most dangerous and it should not include the residential areas. Dimensions of smoke zones could reach from 10 up to 50 of chimney height, depending on the weather conditions.

Ventilation of gaseous impurities and fining (diameter less than 10 microns), with small rate of sedimentation goes according to the same laws.

For larger particles of dust, this model does not work because of their sedimentation rate increase under gravity.

Weather conditions have a significant influence on transfer and dispersion of pollutants in the atmosphere.

The greatest influence is the one of wind and temperature conditions (temperature stratification), precipitation, fog, solar radiation.

A level of air pollution is determined by the highest concentration of the calculated value corresponding to the unfavorable weather conditions. Wind may have different effects on the process of admixtures dispersion depending on the type and characteristics of the emission source.

If the combustion gases are overheated relative to the ambient air, they have an initial lift height.

Because of this, a field of vertical velocity appears near the source. It provides the torch rise and impurities transfer upward.

This rise causes a decrease in the concentration of impurities near the ground.

The concentration decreases, and with very strong winds due to the rapid transfer of impurities in the horizontal direction. As a result, the highest concentration of impurities in the surface layer is formed at a certain speed, which is called "dangerous".

Effect of fog on the pollutant content in the atmosphere is manifested as follows. Fog droplets absorb the impurity, not only near the underlying surface, but also from the upper layer of contaminated air. Consequently, the impurity concentration is greatly increased in the layer of mist, and decreases above the fog. Dissolution of sulfur dioxide in the fog droplets leads to the formation of sulfuric acid. Precipitation clear the air of impurities well. High concentrations of pollutants in the atmosphere are practically not observed after long heavy rains. Solar radiation causes photochemical reactions in the atmosphere and forms various secondary products often having more toxic properties than the material coming from the emission source. For example, the oxidation of sulfur dioxide to form sulfate aerosols occurs in this way.

2.4. Methods of atmospheric air control

The gravimetric (weight) and optical methods are used to control the content of solid particles and aerosols in the air [8].

The gravimetric method consists in separating dust particles from a dust-gas flow by pumping it through a filter. This method makes it possible to obtain the dust concentration without taking into account its chemical and disperse composition.

The optical method is based on the determination of the opacity of the air when it is viewed through and then converting an optical signal into an electrical one.

Gas analyzers are the most common group of instruments for monitoring and analyzing impurities in the atmosphere. There are thermochemical, electrochemical, opto-acoustic, photocolorimetric, chemiluminescent, laser, etc gas analyzers. With their help it is possible to determine more than 100 names of combustible gases, vapors and their mixtures.

Chromotographs or mass spectrometers are used for the simultaneous of qualitative and quantitative analysis of gaseous admixtures. With their help it is possible to determine the content of any gases with a concentration of up to 10-6%. Chromotographs or mass spectrometers are devices of periodic action with an analysis time of 10-20 minutes.

Gas analyzers, on the other hand, make it possible to obtain time-continuous characteristics of air pollution and to detect the maximum concentrations of impurities that may not be fixed during periodic sampling of air several times per day.

At present, special attention is paid to the development and use of lasers for remote analysis of contamination by impurities and to determine the area of their spread. Such instruments, which are a combination of a laser and a locator, are called lidars. With their help, it is possible to study the spatial distribution of impurities in the air [8].

2.5. Questions for self-check

1. What factors support the composition of the atmosphere in a state of dynamical equilibrium?
2. What is the length of the atmosphere?
3. Which average chemical composition is in the lower atmosphere lay are?
4. Which global environmental problems are threatening the Earth as a result of anthropogenic contamination of the atmosphere?
5. Why is the atmosphere polluted by ionizing radiations?
6. Which atmosphere functions do you know?
7. Why is the concept of concentrations in the atmosphere used?
8. What is the difference between the maximum one-time and average daily maximum permissible concentration?
9. How can we assess the effect of substances, for which the maximum permissible concentration is not established?
10. Which factors determine the degree of air pollution by pollutants during production of aerospace technology?
11. What is the temperature stratification?
12. Which components of the air masses movement are affected by the atmosphere stratification?
13. What is the level of the dryadiabatic gradient when rising uphill every 100m?
14. What factors influence the pollutants lifetime?
15. What methods of atmospheric air quality management are used in aerospace production?
16. What is the advantage of using gas analyzers vs chromatographs?
17. Which devices are used to remotely analyze contaminants by impurities and determine the area of their distribution, and what are their features?

3. THE MAIN SOURCES OF AIR POLLUTANTS EMISSION DURING PRODUCTION OF AEROSPACE TECHNICAL EQUIPMENT

Sources of emissions into the atmosphere are divided into natural, caused by natural processes and anthropogenic which are the result of human activity. Production of aerospace technical equipment refers to the type of anthropogenic sources of emissions.

Total aerospace technology manufacturing process includes separate-specific processes of technological certain spare parts units, aggregates, compartments and the aircraft as a whole, as well as their monitoring and testing.

The technological process of manufacture and assembly of aircraft contains the following processes:

- manufacturing of the main elements of fuselage structures;
- production of truss and frame buildings;
- manufacturing of pipelines, automation elements, electric network, devices and other interior fittings;
- manufacturing of engines and steering systems;
- assembly of instrument, tail and fuselage sections and fairings;
- manufacture and assembly of fuel tanks;
- general assembly of the aircraft.

Anthropogenic sources of air pollution are numerous and have a wide variety of types.

The following pollutants are the most common in the manufacture of aerospace technology.

Carbon monoxide, carbon sulfide, ammonia, aniline, acetone, styrene, carbon monoxide, cyanides, chromic anhydride, phenol formaldehyde, hydrocarbons, dust, etc.

Carbon monoxide (CO) is the main part of the emissions produced during the combustion of fossil fuels (kerosene). CO content in vivo is from 0.01 to 0.2 mg / m^3. The CO increase in the atmosphere can lead to global warming.

Ammonia is a caustic and volatile substance of 4 class danger. Ammonia is used in heat treatment shops, it is used as combustible substances in aircraft engines test stations. Ammonia vapors cause irritation of the upper respiratory tract and lungs at concentrations greater than 20 mg / m^3 - cardiac arrest. At stations during engine, test the ammonia contact with oil can lead not only to inflammation, but also to explosion. The presence of ammonia lead to the destruction of aquatic ecosystems.

Aniline is applicable not only at aircraft engine testing stations, but also in shops of composite materials parts manufacturing. It is an aggressive, toxic substance of Hazard Class two. Aniline's vapor is released into the air ventilation system, causes general poisoning of animals and humans and possible destroys the Earth's ozone layer.

Acetone is used as a solvent in shops of manufacturing parts from composite materials, in paint shops, in aircraft engines test stations. Acetone in the atmosphere affects the central nervous system of people. Dropping precipitation affects vegetation, disrupting the rate of photosynthesis in plants.

Cyanide is used in almost all technological processes in the metal plating shops. The heated pickling and galvanic solutions rapidly evaporate, releasing cyanide. Exhaust ventilation system removes cyanide into the environment, which leads to secondary products formation, which have a significantly higher toxicity for the atmosphere and lithosphere.

Styrene and phenol formaldehyde are used in the manufacture of parts in the shops of composite materials, main components of which are the synthetic binder and fiberfill. The base of main binders is styrene and phenol formaldehyde. From the beginning of preparation of the binder and forming the finished product, the process is accompanied by increased release of phenol formaldehyde and styrene vapors into the atmosphere through the ventilation system of the shop. Binders vapors in the atmosphere leads to the problem of cancer disease of the population.

Manganese aerosols, silicon and copper, as well as fluoride and nitrogen oxides enter the atmosphere from the shops and sites of welding and soldering with manual and automatic plasma welding. Aerosol leads not only to mutagenic changes in human beings and animals, but possibly to the Earth ozone layer destruction.

Chromic anhydride is used in electroplating shops that use chemical and electrochemical methods of cleaning surface parts before coating in the paint shop. In the atmosphere, chromic anhydride leads to formation of acid rain and increases toxicity of soils.

The main source of hydrocarbons emissions during manufacture of aerospace technical equipment is aircraft engines test stations. The proportion of hydrocarbon emissions is about 50% of the total volume of aerospace production emissions. Emission of cyclic hydrocarbons (carcinogenic substances) occurs in case of incomplete combustion. Especially many carcinogen substances are contained in the soot emitted by the engine. Hydrocarbons may have a destructive effect on the ozone layer.

Dust is formed during processing and finishing of various materials, crushing, grinding, grinding, sieving the crushed substances, etc.

The main types of dust that are typical for aircraft production:

- mineral - sand and quartz, corundum, carborundum, cement formed during grinding and grinding work on the machine tools with abrasive wheels;
- metal - iron, steel, copper aluminum, magnesium, zinc, produced in different types of machining processes (chipping and punching shop, electroplating shop during preparation of surfaces for coating);
- wood it is contained in the emissions of woodworking shops in the processing of wood;

- formaldehyde it is formed during the machining of composite materials, stripping wood pieces glued with formaldehyde resins.

The size of dust particles has range from a few hundredths to a few tens of microns. The average particle size of dust in the atmospheric air is 7 - 8 microns.

Dust has an adverse effect on human beings, flora and fauna, absorbs solar radiation and thereby affects the thermal regime of the atmosphere and the Earth's surface. Dust particles serve as condensation nuclei during the formation of clouds and fog. Main quantity of dust is washed out of the atmosphere by precipitation. Emissions containing impurities in the form of dust, smoke, vapor or mist are called aerosols. The number of lands of atmosphere polluting aerosols reaches 300. Classification of air pollutants is conducted by the following features:

- the state of aggregation;
- chemical composition;
- particle size;
- mass flow rate of the emitted matter.

Air pollution can be global, regional, community and local. The extent of contamination is associated with the power of emission and the nature of the airflow. If these two factors have the same direction and time, dirt may be global, if not identical - regional, community or local.

According to the effects on the human, the pollution of the atmosphere is divided into physical and chemical. Physical pollutants are radioactive radiation, thermal effects, noise, low-frequency vibration, electromagnetic fields. Chemical pollutants are chemical substances and compounds. Pollutants are released into the atmosphere as a mixture of dust, smoke, fog, steam and gaseous substances.

3.1. Formation of pollutants in the manufacture of the basic elements of aircraft casing structures

The general scheme of the technological process of manufacturing structure membrane elements consists of blank cutting and edges stripping forming a flat blank into a curved, production of windows, rifts, drilling holes, final calibration of plating shape, final trimming and edging, plating control and coating application.

During machining process in the machining shops, the air is mainly polluted by aerosols of oils and coolants. "Dry" machining with abrasive tools is accompanied by the emission of abrasive metal powder of alloys of titanium, aluminum and magnesium alloys, heat-resistant steel, composite materials.

Electropulse machining leads to emission of oils, soot, aerosols, and iron oxides. Final steps of protective coatings application can cause emission of oxides of magnesium alloys, with anodized aluminum alloys aerosols.

Manufacturing of load-bearing elements, for example, stringers emits mainly dust titanium metal, aluminum-magnesium and heat resistant steels.

3.2. The formation of pollutants in production of truss and frame casings

The general scheme of making such casings includes manufacture of tubular or profiled parts. These operationns are carried out in the machining shop with emission of dust of metal alloys, aerosols cutting fluids or mineral oils into the air.

Manufacturing of power rings and fasteners with help of machines for cold metal processing is conducted in the same machining shops. Assembling of truss casings is carried out by welding. Welding with electrodes is accompanied by the evaporation of oxides of copper, aluminum and zinc, aerosols, manganese, silicon, and nitrogen oxides and fluorides.

The manual and automatic plasma welding of copper and its alloys cause release of copper oxides, iron, chromium dioxide, nitrogen oxides, manganese compound and fluorine. Soldering with tin-lead solder and rosin flux cause release of lead aerosols, combustion wire insulation. The final stage in the coating of metal aerosols cause nitrogen oxides and ozone emissions. After welding and annealing, the surface has to be machined by milling, grinding, and turning. These operations are accompanied by the above-described discharge of pollutants in the machining shop.

3.3. Formation of pollutants in the manufacturing of pipes, elements of automation, electric network, devices and other internal accessory

General scheme of manufacture of standard seamless pipes includes pipe sections, scraping and cleaning of pipes, cutting and stripping holes and welding of pipes and fittings, stripping after welding or soldering, testing, washing, drying and preservation.

After cutting pipes scraping cutting and stripping holes that are conducted manually, the process includes degreasing, etching in alkaline or acid bath.

The heated pickling and galvanic solutions rapidly evaporate releasing cyanide, nitrogen oxides, sulfur dioxide, hydrogen chloride, chromic anhydride, a pair of acids, alkalis, etc.

For special types of steel, it is necessary to use nitric, phosphoric and hydrofluoric acid. Spent solutions in electrolytic bath evaporate compounds of zinc, and hexavalent chromium, and ions of heavy metals. Heating and heat treatment in salt baths during the degassing and drying cause the emission of noxious gases into the atmosphere (carbon monoxide, nitrogen oxides, chlorine and fluorine compounds, hydrocarbons, and others.).Welding or soldering with tin-lead solder and rosin flux cause emission of lead aerosols and products of wire insulation combustion.

3.4. The formation of pollutants in the manufacture of engines and steering gear

Engine is the main element of engine's unit and consist of main components: combustion chamber and the nozzle head. Manufacture of the main elements of the engines and steering systems includes used machines for cold metal processing - the press, milling, drilling, grinding machines. During metal-cutting equipment work, the air is polluted with aerosols of oils and coolants. Electro pulse machining leads to emission of oils, soot, aerosols, and iron oxides. Abrading machining processes cause release of metal powders of titanium alloys, aluminum-magnesium and heat resistant steels.

3.5. Formation of pollutants during the manufacture and assembly of fuel tanks

Specific parts of standard fuel tanks can be divided into two groups. The first group is items that include load-bearing elements of the tank: shell, frames, stringers, etc. The second group is the parts of accessories: locking devices, liquid level sensors, valves, flanges, etc.

Hazardous emissions from industrial premises and shops to the environment occurs through ventilation skylights during manufacture process of the typical elements of the fuel tanks. Fiberglass impregnation with phenol-formaldehyde and epoxy resins at seven impregnating machines with production capacity of 26,000 m^3 / year cause emissions with 92 - 516 mg/m^3 of ethanol, 7 - 78 mg/m^3 of butanol, 11 - 40 mg/m^3 of toluene, 233 - 1638 mg/m^3 butyl acetate, 19 - 116 mg/m^3 of acetone 0 - 0.4 mg/m^3 of formaldehyde, etc.

Work in shops and sites of welding and soldering accompanied by the release of vapors of oxides of lead and zinc, aerosols of manganese, silicon and copper, as well as fluoride and nitrogen oxides. The manual and automatic plasma welding of copper and its alloys cause release of copper oxides, iron, chromium dioxide, nitrogen oxides, manganese compound and fluorine.

3.6. Formation of pollutants at the general assembling process

General assembling and tests are the final stages of aircraft manufacturing. General assembling is divided into direct assembling - connection of separate units and installation of equipment. Joining and assembling of units are carried out, as a rule, with the help of structural and technological connectors, welded or riveted joints. Thus, during the general assembling of aircraft there are no significant emissions of pollutants into the atmosphere.

3.7. Questions for self-check

1. Which main types of dust are typical for aerospace production?
2. According to which factors can the air pollution be global or regional?
3. Which classes of influence on the human body is the air pollution divided into?
4. What are the main sources of pollutants formation in the manufacture of main shell-type construction of aircraft elements?
5. What are the main sources of pollutant formation in the manufacture of stiffening components and fuselage frames?
6. What are the main sources of pollutant formation in the manufacture of pipelines, elements of automation, electrical network, devices and other aircrafts internal armature?
7. What are the main sources of pollutant formation in the manufacture of engines and steering devices?
8. What are the main sources of pollutant formation in the manufacture and assembly of fuel tanks?
9. What are the main sources of pollutant formation in the aircrafts general assembling?

4. ECOLOGY OF HYDROSPHERE

Three-quarters of our planet are covered by water.

The total volume of the hydrosphere is about 1.5 billion. Km3. The water itself is considered the main wealth of the biosphere. It is a universal solvent. Water has many anomalous phenomena: a boiling point (100 °), a solid phase of water (ice) is lighter than liquid, water molecules have a tendency to attraction. The main volume of the water (about 97%) is salted and not suitable for drinking, agricultural irrigation, domestic and industrial consumption. Fresh water is the most valuable element of the hydrosphere. The share of fresh water is about 3% of all the water, and 2% of them is encased in inaccessible ice. Among one of the most important issues of our time is the pollution of water resources. Aerospace manufacturing is characterized by the presence of a number of water-intensive production processes and, consequently, the creation of a significant number of industrial wastewater, polluting the hydrosphere.

4.1. Water quality indicators

The diversity of types of water use generates a variety of water requirements. Based on this, the concept of water quality should be linked to its use.

The water quality is a characteristic of the composition and properties of water that determines its suitability for a particular type of water use in accordance with the Water Code of Ukraine. Water quality assessment is based on a system of indicators. Water quality indicators are divided into physical, bacteriological, chemical and hydro-biological. Another form of classification of water quality indicators is their division into general and specific. General indicators include typical indicators for any water bodies. Presence in water of elements peculiar to the local geographical conditions, or presence of anthropogenic impacts on the water body, in particular the production of aerospace equipment are specific indicators.

The main physical indicators of water quality include:

Water temperature. In the aerospace industry, growing of water masses temperature depends on the heated water inputs during manufacture of basic elements of skin structures designs, interior fittings, etc. Temperature of water influences almost all processes that affect composition and properties of water.

Smell. Specific substances entering water create smell of water. Smell of water is measured in points.

Transparency. Transparency of water depends on a degree of dispersion of the sunlight in water by organic substances and mineral origin, located in water in suspension and colloidal. Condition transparency determines biochemical processes requiring the light (primary production, photolysis). Transporancy is measured in centimeters.

Chromaticity. The color of water depends on by the content of organic colored compounds. High color saturation reduces organoleptic properties of water and reduces concentration of dissolved oxygen. Color is measured in degrees.

The content of suspended particles. Suspended solids affect the depth of penetration of sunlight and degrade livelihoods aquatic organisms that lead to siltation of water bodies and cause their ecological aging (eutrophication). Suspended solids content is measured in g / m^3 (mg / l).

Bacteriological indicators characterize water contamination by pathogens. The most important bacteriological indicators include coli index - the quantity of coliform bacteria in one liter of water.

Hydro biological indicators make it possible to assess water quality according to animal population and vegetation water bodies. Changes in the species composition of aquatic ecosystems can occur at such a low contamination of water bodies, which is not detected by any other methods. Therefore, hydro biological indicators are the most sensitive. There are several approaches to the evaluation of hydro biological indicators of water quality.

Physical, bacteriological and hydro biological indicators are general indicators of water quality. Chemical indicators can be general and specific. The common chemical water quality indicators include dissolved oxygen and biochemical oxygen consumption. In the production of aerospace technical equipment, the most frequent specific indicators of water quality include the following substances.

Hydrogen index (pH). The water hardness index characterizes the quantitative content of calcium and magnesium in water, which are associated with both weak and strong acids.

Phenols. The content of phenols in water has a toxic effect on human beings and worsens organoleptic properties of water. 80% of all materials produced in aviation composite materials is based on phenols.

Petroleum products. They include petroleum fuel oil and some other products representing a mixture of hydrocarbons of various classes. The sources of petroleum products are oil leakage during transportation, during engine testing stations, cutting fluids during cold working of metals, etc.

Petroleum hydrocarbons are toxic and, to some degree, have a narcotic effect on living organisms, affecting the cardio - vascular and nervous system. Chemical indicators are measured in g / m^3, mg / dm^3 (mg / l).

Heavy metals. The most common heavy metals include lead, mercury, copper, zinc. Heavy metals have a mutagenic and toxic effect [6].

Thus, a radical change and deterioration of the entire hydro chemical regime of the hydrosphere can occur under the influence of wastewater. Be the composition of pollutants and the nature of their action, all wastewater is divided into four groups [4]:

1) containing inorganic impurities with specific toxic properties;
2) containing inorganic impurities without specific toxic properties;
3) containing organic impurities without specific toxic properties;
4) containing organic impurities with specific toxic properties.

An aerospace enterprise pollutes the hydrosphere with sewage from the first and fourth groups.

The main pollutants of the first group of wastewater are soluble and insoluble inorganic substances (salts, alkalis, acids, copper, lead and other heavy metals, hydrogen sulphide, sulfur compounds, oxides and metal hydroxides, etc.), many of which have toxic properties. Under the influence of such wastewater, water changes color, transparency, taste and smell. When sewage enters water bodies, the insoluble sedimentation is formed on the bottom, which complicates the development of the bottom fauna. Suspended substances clog and damage gills of fish, causing gill diseases. As a result, fish and their food objects living in water column (plankton) and in the ground (benthos) can completely disappear from a water.

The fourth group includes wastewater with pollutants similar to the drains of the first group, but they affect water objects more strongly. Benzene, toluene, oils, resins, phenols and some other substances are mineralized slowly, and therefore the pollution formed by them in the reservoir extends to tens or even hundreds of kilometers. The effect of such wastewater has a strong influence on physical properties of water in a reservoir. Water acquires color, an unpleasant phenolic medicinal odor and taste, becomes cloudy, covered with a fluorescent film that interferes with the natural course of biological processes and becomes unsuitable for the needs of the population.

Phenols and resins are toxic not only for human beings, but also for aquatic organisms, so rivers polluted with phenolic wastewater lose their fishing importance. Therefore, at present, the protection and prevention of pollution of the hydrosphere of Ukraine with industrial sewage water has acquired an important state significance [10].

The problem of protecting the hydrosphere from pollution can be fully resolved only after a whole range of different activities. Among these measures, it is very important to develop methods for wastewater treatment and to standardize their discharge into water bodies, i.e. to develop biological justifications and requirements for maximum permissible rates of wastewater treatment and neutralization and for conditions of their discharge into water bodies.

4.2. Protection against pollution of the hydrosphere

A combination of purification methods which would ensure the greatest effect at minimum costs (table 4.1) has to be used in connection with the huge diversity of pollutants in wastewater during manufacture of aerospace technology [4].

Table 4.1

Efficiency of different wastewater treatment methods

Wastewater treatment methods	Efficiency	
	By undissolved impurities	By biochemical oxygen demand
Mechanical (sedimentation, filtration, reverse osmosis)	60-90	30-40
Mechanis-and-chemical (coagulation, neutralization,)	80-85	40-50
Physical-and-chemical (ion exchange, sorption, flotation, rectification, crystallization, extraction, evaporation)	90	50-75
Thermal	90	-
Biochemical	90	80-90

In connection with taking into account the efficiency values from table 4.1, it is advisable to combine biochemical wastewater treatment with other purification methods. A sedimentation method is an essentials element in any combined purification scheme, being the very first step to remove the bulk of undissolved contaminants [10].

Biochemical methods are based on the ability of microorganisms to destroy and transform various compounds. Destruction occurs under the action of enzymes produced by microorganisms.

Mechanical methods of water purification include colation, settling, and separation of solid particles by the action of centrifugal forces and filtration, depending on solid particles properties, their concentration and solution.

Colation is designed to separate insoluble impurities of particles up to 2.5 mm in size from polluted sewage, as well as fibrous contaminants. Percolation is carried out by passing the wastewater through grids and fiber collectors. Such grids are made of metal rods or reinforcement with gaps between them of 0.5-2.0 mm and are installed at an angle of 60 °. The grids are cleaned most often mechanically with the help of swivel rakes or - manually. At the same time, impurities removed from the grate are crushed and discharged back into the polluted waters, thus deteriorating the quality of the air and water environment. Crusher grids are used for elimination of this drawback, which grind impurities without extracting them from contaminated water [10].

Settling is based on the peculiarity of solids sedimentation in a liquid. Purification of contaminated water is carried out in sand catchers and sedimentation tanks. Depending on the direction of movement of polluted water, the sand catchers can be horizontal with rectilinear and circular movement of water and aerated [6].

Filtration of contaminated wastewater is intended for cleaning them from fine dispersible solid impurities. For the purification of polluted waters, two kinds of filters are used: granular, in which the liquid flows through the porous material nozzles (sand), and micro filters, the elements of which are made of bonded porous materials.

Reverse osmosis (hyperactive filtration) is the separation of hydrated ions, molecules and other small particles from the drains by passing them under high pressure through membranes, the dimensions of the openings of which are smaller than the dimensions of the particles extracted from the water.

Purification of water from oil products is carried out by sedimentation, treatment in hydro cyclones, filtration and flotation depending on their composition and concentration.

The extraction and evaporation methods are the most widespread in the aerospace industry as regenerative purification methods for the recovery of valuable organic substances from wastewater with their subsequent disposal. During extraction the dissolved and emulsified substances are removed from the wastewater, with the aid of an extractant - a solvent stronger than water. Evaporation removes the volatiles with the help of water vapor [10].

The thermal treatment of wastewater actually completely wastewater and contamination in it, but in many cases it is not economically viable and very costly energetically and financially.

The cost of wastewater treatment only in some cases pay off the cost of the substances extracted from it and in most cases they are the overhead costs of production. Therefore, the fight against pollution should be carried out both by cleaning sewage, and by reducing the volume of sewage discharged into the city sewer.

Long-term observations on water bodies show that sewage and their components adversely affect aquatic organisms when their concentration in water exceeds a certain limit. The content of harmful substances below this limit sometimes creates even a favorable habitat for aquatic organisms. Consequently, it is sufficient only that the content of harmful substances does not exceed the maximum permissible concentration (MPC) (table 4.2) when sewage enters water bodies [10].

Table 4.2

MPC of the main harmful substances in water bodies

Ingredient	MPC g/m^3	Ingredient	MPC g/m^3
Lead	0,1	Ammonia	0,1
Arsenic	0,05	Ammonium salts	5,0
Copper	0,01	Tannins	Less than 10,0
Zinc	0,01	Sulphides	Absent
Nickel	0,01	Free chlorine	Absent
Cadmium	0,005	Phenols	0,001
Cyanides	0,05	Carbon disulphide	1,0
Magnesium	50,0		

4.3. Methods of water quality assessment

The main standard methods for monitoring the state of water pollution are the determination of chemical oxygen demand (COD) and biochemical oxygen demand (BOD).

COD is a value characterizing the total content of organic and inorganic reductants in contaminated water, which react with strong oxidants.

BOD is the amount of oxygen required to oxidize waterborne organic substances under aerobic conditions because of biological processes occurring in contaminated water.

When analyzing the composition of wastewater, "multicomponent" methods of analysis are increasingly being used, which make it possible to determine a wide range of chemical substances. These methods include atomic emission, X-ray and chromatographic methods [1].

There are one-time, indirect and complex methods of assessing water quality. One-time and indirect methods have already become traditional. The need for a more objective assessment of water has led to the development of a complex assessment method. Complex assessment of water quality is the idea of the water pollution extent or water quality expressed in parameters of one or other system of parameters, or via a limited set of characteristics of composition and properties of water, which are compared with the standards for a specific water use. Complex technique of assessing water quality must meet the following requirements:

1. Have a physical nature; be simple for determination and logically understandable;

2. Have a universal character and is suitable for water quality assessment for all water uses;

3. Have maximum information with the minimum number of parameters providing the most comprehensive and reliable assessment of water pollution;

4. Be automatable, processable and accumulatable.

The coefficients of water pollution are mostly abstract indicators that take into account the limited number of elements. The water pollution index (WPI) is considered to be the most informative.

WPI is a cumulative index and represents the average value of exceeding the MPC for a certain number of substances, and is calculated by the following formula:

$$WPI = \frac{1}{n} \cdot \sum_{i=1}^{n} \frac{C_i}{MPC_i} = \frac{1}{6} \cdot \sum_{i=1}^{6} \frac{C_i}{MPC_{w_i}},$$

where n is the number of indicators used to calculate the index;

C_i is concentration of a chemical substance in water, mg/l; MPC_i is the maximum permissible concentration of a substance in water, mg / l [4].

When determining the WPI for water bodies, the calculation is conducted based on the WPC_w values for the six components with the highest multiplicity of excess, i.e. n = 6. Among the six basic, so-called "defining" indicators, the concentration of dissolved oxygen and the value of BOD_5 are mandatory.

Depending on the size of the WPI, water bodies are subdivided according to the quality into seven classes presented in table 4.3 [10].

Table 4.3

Water quality classification

Water quality class	Name	WPI
I	Very clean	WPI < 0,3
II	Clean	0,3< WPI >1
III	Moderately polluted	1< WPI >2,5
IV	Polluted	2,5< WPI >4
V	Dirty	4< WPI >6
VI	Very dirty	6< WPI >10
VII	Extremely dirty	WPI >10

Determination of water quality class is carried out according to the procedures of relevant regulatory documents. Over a long period wastewater in the production of aerospace engineering has been one of the most significant causes of urban wastewater pollution (table 4.4).

Table 4.4

The approximate composition of the wastewater aerospace industry

Indicator	Concentration, g/m^3 (2000 year)	Concentration, g/m^3 (2013 year)
Suspended solids Phenols	100-200	50-100
Cyanides	200-300	80-100
Chrome	70-120	40-80
Acids	40-60	20-40
Petroleum products	70-100	30-70
Oils	25-40	10-25

Currently, environmental policy in Ukraine is aimed at limiting the discharge of industrial wastewater into water bodies, up to the prohibition of the untreated sewage discharge within the city territory, and has significantly changed the ratio between different sources of pollution. Concentration values of some indicators of harmful substances has reduced by a factor of three.

4.4. Questions for self-check

1. What factor is the concept of water quality?
2. What main indicators are the basic physical indicators of water quality?
3. What bacteriological indicators characterize water pollution?
4. Which water quality indicators are most sensitive?
5. Which groups do the chemical indicators of water quality belong to?
6. What substances are among the most commonly observed specific indicators of water quality in the production of aerospace technology?
7. Which group do the sewage of the aerospace enterprise belong to by composition of pollutants and the nature of their affect?
8. Which method of sewage treatment is a necessary element in any combined purification scheme, at the first stage?
9. What is reverse osmosis?
10. Which method of sewage treatment at aerospace enterprise is uneconomical, energy consuming and costly?

11. What are the effects of heavy metals on people?

12. Which method of sewage treatment in the production of aerospace technology uses water vapor?

13. Which multicomponent methods of sewage composition analysis allow to determine a wide range of chemicals?

14. What formula is used to determine the most informative hydrochemical index of water pollution (IPW)?

5. POLLUTION OF THE HYDROSPHERE DURING PRODUCTION OF AEROSPACE TECHNICAL EQUIPMENT

The main causes of surface water pollution is the discharge of untreated and inadequately treated industrial wastewater directly into the municipal sewage system. There is chemical, physical and biological water pollution.

Chemical contamination is caused increasing of inorganic and organic harmful impurities in water (mineral salts, acids, bases, and surface-active agents), etc.

Physical contamination is connected with a change in the physical parameters of the water environment and determined by thermal, mechanical, radioactive contamination.

Biological contamination consist in changing the properties of the aquatic environment as a result of an increase in its number of microorganisms, plants and animals (bacteria, fungi, worms), infused from outside.

Aerospace manufacturing is characterized by the presence of a number of water-intensive processes, and hence the creation of a significant amount of industrial wastewater. Waste of etching, electroplating, painting and machining shops and oil products, mainly contaminates wastewater of the aerospace manufacturing process.

5.1. The main types of wastewater pollution during manufacture of the basic elements of aircraft casing structures

The main elements of casings are boarding, shells, parts of the load-bearing elements and fasteners. Casing is made of aluminum, magnesium, titanium, steel alloys and composite materials.

The main types of wastewater contaminants in the manufacture of shells structures include sand, slag, dust, fluxes etc. The mass concentration of suspended solids in wastewater can reach 300 mg / l. The temperature of wastewater is from 30 up to 40 °C. After chemical milling, acid-alkaline, cyanides-containing and chromium-containing effluents are formed. After upholding of wastewater, metals are allocated according to their solubility. It is necessary to hold additional wastewater treatment for complete extraction of copper, nickel and zinc. There are oil phases, lubricoolant and oil in the sewage flows after machining of metal parts on CNC machines.

5.2. The main types of wastewater pollution in the production of truss and frame casings

The main parts of truss and frame casings are thrust racks, braces, supports, brackets, gussets, angles, frames, etc. Manufacture of these elements cause appearance 0.4-1 g / l of suspended substances and 0.01-0.06 g / l of mineral oils in sewage flows. After coating the major parts there are cyanide, chlorinated components as well as chrome, and hydrogen peroxide in the wastewater. The quantity of cyanides is 15 - 60 mg / l. The quantity of chlorine-containing components varies widely from 2 to 12 mg / l. Chrome plating electrolytes consist of the main components: chromic anhydride and sulfuric acid. Salts of hexavalent chromium that have greater toxicity are the main pollutants of wastewater. The flush water contains 600 mg/l, worn solutions up to several thousands. Sewage which includes petroleum products (gasoline, kerosene, lubricating oil, fuel oil, coolants) is created during the processing of parts, their washing and degreasing.

5.3. The main types of wastewater pollution in the manufacturing of pipes, automation elements, electric network, devices and other internal accessory

Pipelines are very important for fuel, air, oil and other systems of aircraft structures. Their manufacture and installation are very significant and complex. Leak testing is carried out in a water box. After checking and testing the pipes and bellows are cleaned, dried, degreased, both ends should be closed and sealed. Welding may cause possible presence of carbide sludge in wastewater. Press forming leads to presence of lubricoolant, oil phases and oil sewage.

5.4. The main types of wastewater pollution in the manufacture of engines and steering gear

The design of engines and steering gear has a number of standard elements:

- fuel tanks;
- a fuel feeding system from the tank to the combustion chamber via the turbo pump unit;
- combustion chambers;
- a gas generator;
- piping;
- a power frame;

• an electrical system.

Manufacture of metal casing of engines cause presence of lubricoolant, oil phases and oil in sewage flows. Manufacture of engine casing made of composite materials cause presence of sand, polyvinyl alcohols, etc. in sewage flows.

Oxides and oil residues, sulfuric or hydrochloric acid, and their mixtures go to sewage flows after etching and washing of metal products.

Treatment of special types of steel uses nitric, phosphoric and hydrofluoric acid. Sulfuric acid etching add into sewage flows from 0.5 to 4 g / l of sulfuric acid, from 0.5 to 8 g / L of ferrous sulfate and 300 mg / l of suspended solids (slag, sand, etc.).

5.5. The main types of wastewater pollution during general assembling process

The process of general assembling includes basing units relative to each other, their connection and fastening in various ways, installation and connection of communications holding adjustment operations of various systems, mechanisms and testing. Therefore, in all cases, there are high requirements for the preparation of chemically pure metal surfaces. Electrolytic degreasing, rinsing in alkaline baths and acid leads to presence in waste water from 0.5 to 4 g / l of sulfuric acid, from 0.5 to 8 g / L of ferrous sulfate and 300 mg / l of suspended solids.

5.6. Questions for self-check

1. What is chemical, physical or biological contamination of water?
2. Which work shops of aerospace production pollute the environment more than others?
3. What are the main types of sewage pollution during manufacture of the main shell-type structures of aircraft elements?
4. What are the main types of sewage pollution during manufacture of farm and frame skins?
5. What are the main types of sewage pollution during manufacture of stiffening components and fuselage frames?
6. What are the main types of sewage pollution during manufacture of engines and steering devices?
7. What are the main types of sewage pollution during the general assembly of an aircraft?
8. What contaminations containing crude oil come into wastewater?
9. What contaminants come into sewage during manufacture of composite housing?
10. Which metals reqire their for additional treatment of waste water is carried complete extraction?

6. ENVIRONMENTAL PROBLEMS OF SOIL

Soil is the an independent natural body which was formed on the surface of the rock, under the combined influence of animals, plants, micro-organisms, climate, water, relief, time and human activity. The thickness of the primer coating is from 15 - 20 cm to 2 - 3 meters. The overriding feature of soil is fertility, i.e. provision of plants with everything necessary for their growth and development. During the development of human civilization, the area of ecologically clean soil is continuously decreasing. One reason for this is land acquisition for the construction and operation of industrial facilities. Every year the earth surface loses 25 billion tons of fertile soil. The problem of soil pollution is that new, and microorganisms are substances uncharacteristic for soil found in soil. The main causes of soil degradation during production of aerospace technology is acidification and contamination of soil.

6.1. The main types of soil contamination

As an important link of the biological cycle of matter, soil produces basic food and energy material for other inhabitants of the planet. At the same time, it performs the function of the regulator which maintains the natural composition of the atmosphere through the conversion of dying biota and human food production activities. It is this aspect of soil participation in the biological cycle of substances that makes it the most important component of the ecosystem. In urban areas soil exposed to pollution, which can be divided into mechanical, chemical and biological. Mechanical contamination is contamination of soil by macro fragmental material in the form of industrial, construction debris and other relatively inert waste. This has an adverse effect on the mechanical properties of soils. Chemical contamination of soils is caused by penetration of substances that alter the natural concentration of chemical elements to a level above normal, resulting in the change of physical and chemical properties of soils. This type of pollution is the most typical for the production of aerospace equipment, durable and dangerous. Biological contamination is caused by introducing organisms and breeding being dangerous to human into the soil environment. Bacteriological, helminthological and entomological indicators of soil determine the level of epidemiological risk.

6.2. Soil contamination in production of aerospace technical equipment

There are many factors of soil degradation. The main factors among them are the following:

• improper use of land, which leads to disappearance of fertile soil;
• disappearance of ecosystems, where this type of soil was formed;
• changes in climatic factors, primarily hydrological conditions;
• pollution by industrial waste.

Accumulation of heavy metals is dangerous for soil. By their origin, heavy metals are divided into three groups:
• lithogenic - included in the rocks;
• pedogenic - a part of soil;
• anthropogenic - get into the ground as a result of industrial activity.

The last group is of the greatest threat; aerospace manufacturing causes soil contamination by the metals of this group. The most toxic to soils are hazard class 1 substances used in aircraft manufacture. These substances include mercury, lead, cadmium, cobalt, chromium, nickel, tin, manganese, copper, chlorine, etc. Most of these substances are concentrated in the food chain. Moreover, at higher concentrations they are biologically dangerous to all living organisms.

6.3. Methods of control in soil monitoring

Soil cover accumulates information about the processes and changes that occur, i.e. soil is a kind of indicator not only of the momentary state of the environment, but it also reflects past processes. Therefore, soil monitoring is more general and opens up great opportunities for solving environmental problems. The main indicators that are evaluated in the monitoring process are acidity, loss of humus, salinity, pollution with oil products [8].

The acidity of soils is estimated from the value of the hydrogen exponent (pH) in the water extracts of the soil. The pH value is measured by means of a pH meter or potentiometer. Optimum pH ranges for plants from 5.0 to 7.5. If the acidity is less than five, then soil limiting is carried out; at a pH of more than 7.5-8, chemicals are used to reduce pH.

The humus content is determined by oxidability of organic matter. In this case, organic matter which is part of humus, is oxidized to CO_2 and H_2O. The amount of spent oxidizer is determined either by titration or by a spectrophotometric method. Knowing the amount of oxidizer, we determine the amount of organic matter. Recently, carbon analyzers have been used in which dry combustion of organic matter takes place in an oxygen flow followed by determination of the released CO_2.

Anthropogenic salinization of soils is manifested in an increase in the content of readily soluble salts in soils and soil solutions - NaCl, Na_2SO_4, $MgCl_2$, and $MgSO_2$. The simplest method of detecting salinity is based on the measurement of electrical conductivity. Determination of electrical conductivity of soil suspensions of aqueous extracts, soil solutions, and directly soils is applied. This process is controlled by determining the specific electrical conductivity of aqueous suspensions with the help of special saltmeters.

When monitoring pollution of soils with oil products, it is usually necessary to determine the extent of pollution, assess the degree of pollution, and identify toxic and carcinogenic contaminants [16].

The first two problems are solved by remote methods which include the aerospace measurement of spectral reflectivity of soils. By changing the color or density of blackening in aerial photographs, it is possible to determine the size of the contaminated area and the configuration of the contamination area, and by the reflection coefficient decrease it is possible to estimate the degree of contamination.

6.4. Protection of soils from pollution

In order to protect the soil from degradation, the following environmental protection measures are used:

- protection of soils from water and wind erosion;
- remediation of disturbed soil cover;
- protection of soils from dehumification, soil exhaustion and depletion;
- protection of soils from salinization, solonetization and slimming;
- protection of soils from pollution by products of technogenesis (heavy metals, radionuclides, etc.).

Protection of soils from water and wind erosion includes organizational and economic, agrotechnical, forest melioration and hydrotechnical measures [10].

Organizational and economic measures are justification and preparation of an anti-erosion measures: plan of and ensuring of its implementation (rational distribution of land, soil-protection crop rotation, farming by strips, regulation of grazing, etc.)

Agrotechnical measures include methods of phytomelioration, erosion control of soil (horizontal processing of soil, "contour" farming, chipping and moling of soils, dumping, subsurface tillage), snow retention and regulation of snow melting (forest strips and wings, plowing of snow, packing).

Forest remediation measures are based on the creation of forest protective plantations (wind protection and near-ravine forest belts, shelter forest and shrubbery across the slopes, etc.).

Hydrotechnical measures are used in those cases when other methods are not able to prevent erosion and are based on the creation of hydraulic structures ensuring the containment or regulation of slope flows (terracing slopes, rafting ravines with bulldozers, fastening slopes of ravines) (rotation with perennial grasses, replacement of clean vapors by occupied, green manure and backstage).

Remediation of land is measures to restore and optimize disturbed landscapes. It includes a complex of mining, melioration, agricultural, forestry and engineering and construction operations aimed at restoring the damaged fertility of land. Agricultural lands, forest plantations, water bodies, recreation areas, residential and industrial buildings, etc. are created in the restored territory [6].

Remediation of the land consists of three stages: preparatory, mining and technical remediation and biological remediation [4].

Stage 1 (preparatory) involves the examination of disturbed areas: determine the direction of remediation, make a feasibility study and a remediation project.

Stage two (mining remediation) includes chemical remediation, if necessary. Mining and technical remediation is carried out by enterprises that are mine minerals.

Stage three (biological remediation) is aimed at restoring the fertility of the lands prepared in the process of mining and remediation and turning them into full-fledged forest or agricultural lands. Afforestation is the cheapest type of development of reclaimed areas. Lupine, sweet clover, or alfalfa are planted before planting trees, followed by plowing for improvement of the properties of the upper layer of the dumps, for accumulation of organic matter and nitrogen in it.

The protection of soils from dehumification, soil depletion and depletion includes the following measures:

1. Application of organic fertilizers,
2. Liming of acidic soils,
3. Use of perennial grasses in the rotation,
4. Regulation of the ratio in crop rotations of tilled crops and crops of solid sowing,
5. Use of gentle soil treatment (facilitating machines, minimizing processing).

Protection of soils from salinization and fusion includes the following measures: chemical land remediation (application of gypsum), application of physiologically acidic and calcium-containing fertilizers, and inclusion of perennial grasses in crop rotation.

Protection of soils from pollution by products of technogenesis (heavy metals, oil, oil products, radionuclides, etc.) is carried out in two directions.

The first direction is to prevent contaminants from entering the soil. Application of closed-cycle technologies.

The second is to clean the soil of pollution, which has already occurred. Cleansing is carried out by removing the upper contaminated soil layer, then it is washed and only then, to extract pollutants (heavy metals and radionuclides) the soil is sown with perennial grasses in order to reduce the content of harmful substances with their help.

Another approach to protection from contamination by products of technogenesis is based on fixing atoms of toxic elements in the soil, in order to prevent them from entering adjacent environments and living organisms. For this purpose, organic matter, phosphoric mineral fertilizers, ion-exchange resins and natural zeolites, brown coal, liming of soil, etc. are applied to the soil [6].

6.5. Questions for self-check

1. What are the main causes of soil degradation during production of aerospace technology?
2. What is the problem of soil contamination?
3. What kind of soil contamination is most typical for the aerospace equipment production ?
4. What are the main indicators of the soil monitoring process?
5. According to which indicators is soil pollution by oil products estimated?
6. What are the environmental protection measures used to protect soil from degradation?
7. What is the difference between phytomelioration and anti-erosion treatment of land?
8. Which the environmental protection measures are used to prevent soil contamination when producing aerospace equipment?
9. Which stages are included in land remediation?
10. What is dehumification?

7. ECOLOGY AND PROTECTION OF THE BIOSPHERE

7.1. Anthropogenic disturbances in the biosphere and public health

A human organism can exist only at constant interaction with nature and self-repair as a result of such interaction [1].

The complex indicator of the state of the human population is the health of its representatives. Health is a natural state of the body, characterized by a certain balance with the biosphere and the absence of any painful changes [6].

According to the definition of the World Health Organization, health is a state of complete physical, spiritual and social well-being. Factors that affect the level of human health include: lifestyle (50%), genetic factor (30%), environmental factors and medical factors (20%). Assuming that the genetic factor is highly dependent on the state of the environment, we can assume that human health is 50% dependent on anthropogenic impact on the environment [7].

In the 21st century, production activities have caused an increase in physical, chemical and biological pressures on the biosphere. The reserves of all natural resources are correspondingly decreasing because of the growing population of the planet.

Deep genetic changes and pathological phenomena in the human organism are caused by energy, chemical and radioactive contamination of air, water, soil and food. Due to water pollution, about 20 thousand people die in the world every day [1].

Along with the deficit of sunlight and clean water, urban residents are also adversely affected by stressful situations, caused by the intense pace of life, population accumulation, and lack of green spaces. The Chernobyl disaster led to an increase in the overall incidence rate, the incidence of hypertrophy of the thyroid gland, endocrine system diseases, and digestive and metabolic disorders [7].

Significant anxiety in Ukraine is caused by pathologies that are most dependent on the state of the environment, these are allergic diseases. In addition, an unfavorable ecological situation provokes the spread of chronic diseases that reach maximum before the reproductive period, forming a closed cycle - sick parents - sick fetus - a sick child - a sick teenager - sick parents. The duration of such a cycle is 20-25 years.

This situation worsens the demographic situation in Ukraine, especially in the highly urbanized regions of Donetsk, Dnipro, Kharkiv and Sumy regions. The decline in the birth rate and the increase in mortality lead to depopulation process deepening. In recent years, the natural increase in the population of Ukraine is negative, when mortality prevails over fertility.

Raw material supply for the production volume of many industries, (including aerospace) is highly dependent on the biosphere resources formed in the course of ecological processes. Economics, not taking into account the negative impact of technology on all life, has led to modern technogenesis. Technogenesis is creation of techniques and technologies, increasingly sophisticated tools and devices for influence on environment with the purpose of production and consumption of civilization benefits. An important feature of modern technogenesis is the use of chemicals in all sectors of the economy including the aerospace industry. Over the last decade the production of plastics, synthesized fiber, synthesized detergents, etc. has increased manyfold. Technogenesis has a strong influence on the ecology of the biosphere, displacing natural ecological systems and processes. The extent of contamination with industrial waste primarily affects the state of the atmosphere, hydrosphere and soils.

There is a need for environment protection which would include a set of technical and administrative measures aimed at eleminating or reducing the increasing anthropogenic pollution.

Development of series of environmental measures is necessary for protection of the natural environment from influence of aerospace industry.

Engineering and environmental activities include three groups:

1) engineering activities,
2) environmental activities,
3) organizational activities.

The first group is used to improve the existing and develop of new technological schemes and processes, machines, tools and materials in order to avoid or mitigate negative impacts on the natural environment. Engineering activities are divided into technological and technical. As a result of technological measures, parameters and characteristics of sources of influence are changed. Technical measures are aimed at reducing the impact on the natural and human environment or elimination of pollution sources.

The second group is based on the use of natural physical and chemical processes occurring in the lithosphere, hydrosphere and atmosphere, which allow reducing the risk of impact or mitigating its consequences. The group of organizational activities is related to the management of the structure and functioning of natural and industrial systems being created or already existing. Organizational activities are divided into planned and urgent.

7.2. Technology and technical means of emissions clearing

In the aerospace manufacturing introduction of non-waste and low-waste technology is the most promising measure which allow reducing the air pollution level radically. At aviation enterprises, devices and apparatuses are usually placed in the upper tiers of the shop space. Substances removed from dust and gas emissions are typically either finished product or recycled materials. In the aerospace industry the following emission purification technology are used to purity gases from solid and liquid particles:

- dry inertial gas cleaning;
- wet scrubbing;
- filtering.

Absorption, adsorption, thermal and thermo catalytic purification and biochemical reactors are widely used to purity gases from gas and vapor components. Basic requirements for dust and gas cleaning devices are:

- high efficiency;
- operational reliability.

Gas treatment unit, generally do not provide a direct profit. A possibility to use a treatment product covers only a small part of cost. A most widely used machines of dry inertial gas cleaning in practice. The operating principle of these devices is the deposition of dust due to changes in the direction and velocity of cleaned gas stream and hitting dust particles against a wall and transverse barriers. These devices are easy to design and manufacture. The most popular dry inertial gas arresters are cyclones. Design and function of the cyclone are shown in fig. 7.1.

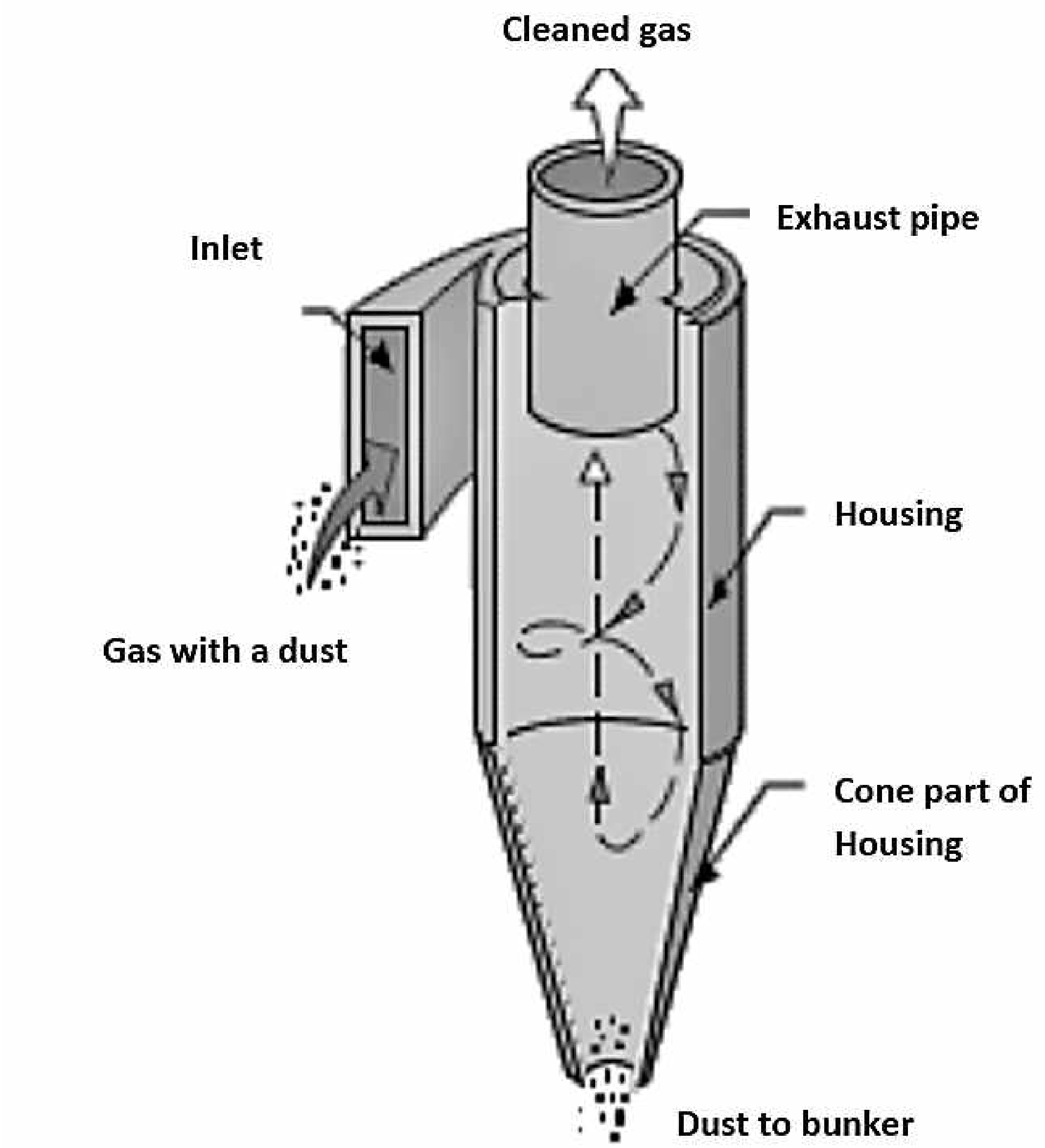

Fig. 7.1. Cyclone

Wet cleaning of emissions is one of the most effective and widely used methods for dust arresting. During this process, there is a high degree of extraction of solid, liquid and gaseous impurities. The basis of the process of scrubbing is a deposition of dust particles on drops or a liquid layer.

The scrubbing liquid is usually water. Sometimes, depending on a particular composition of treated emissions, water can be basified or acidified. Wet gas cleaning devices have a simple design and operation, and relatively low cost. They can clean emissions of any moisture, as well as fire and explosive mixtures. The disadvantages of wet-gas cleaning dust include:

• formation of waste water and sludge, which require further processing;

• corrosion of equipment when exposed to corrosive gases and liquids;
• relatively high specific consumption of electricity.

The simplest machine of emissions scrubbing is a venturi scrubber. It is intended to capture particles greater than 10-15 micron, as to cool and humidity treated emissions. Venturi Scrubber (fig. 7.2) is a cylindrical container with pipes for inlet and outlet of purified air. A rotating disc produces liquid spray in the mechanical venturi scrubber.

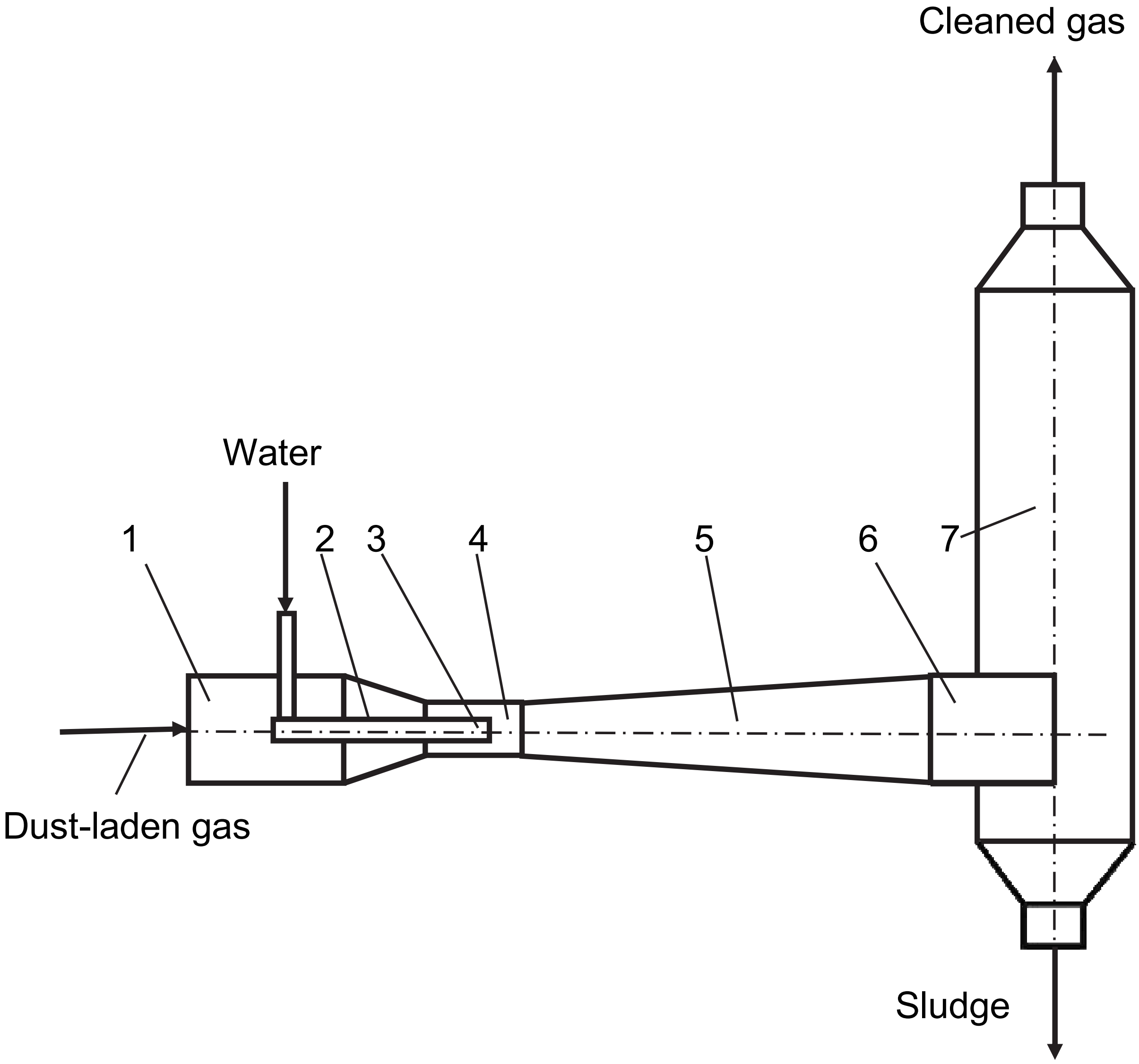

Fig. 7.2. Venturi scrubber
Venturi pipe (1) convergent pipe (2) sprayer (3) mouth 4 diffuser (5), drop catcher (6) casing (7)

High-performance gas cleaning technologies include filters.

Operation of all kinds of filters consists in dust-laden air filtering through the porous partition when gas-suspended dust particles are retained in partition walls, and gas smoothly passes through.

Porous walls may be made of tissue paper, fiber materials, ceramics, metal mesh, granular layers; they may have sufficient effectiveness to detain particles of any size. Filters to capture dust particles smaller than 5 microns are the most advisable to be use. Pressure drop in the porous wall determines the filtering process speed. The most common type is a fabric filter baghouse in fig. 7.3.

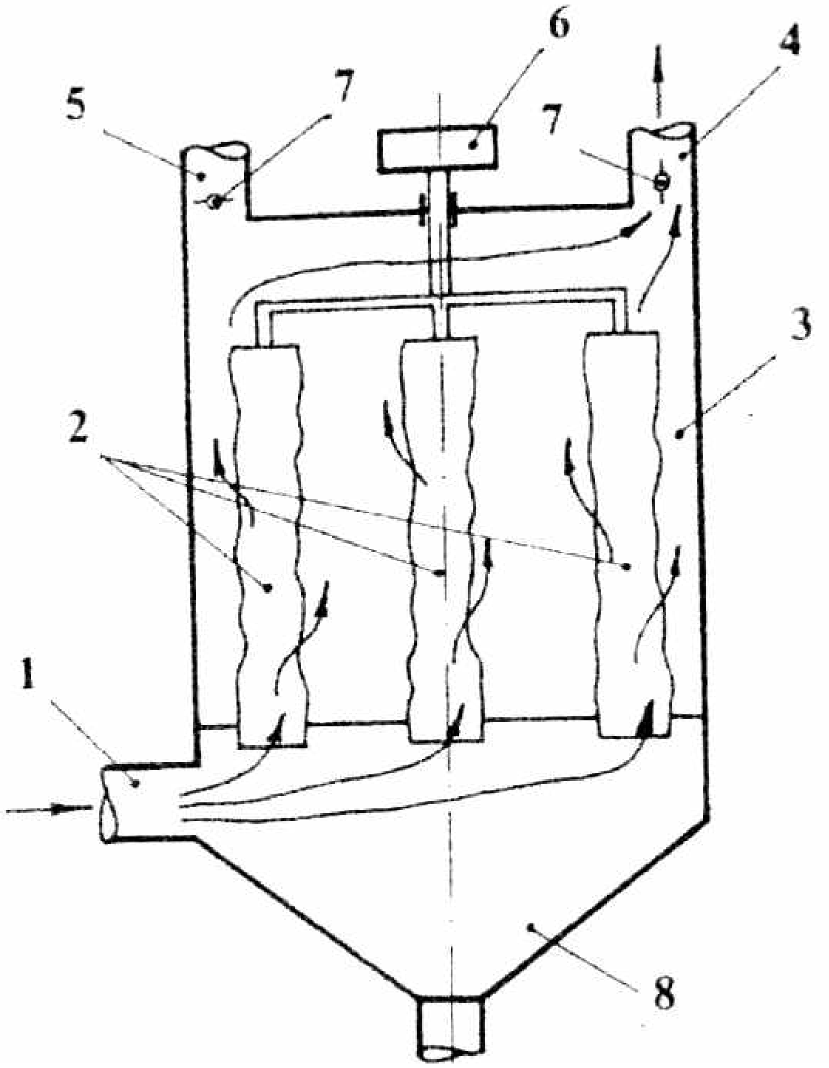

Fig. 7.3. Baghouse filter:
1 - input dusty gas; 2 – hoses; 3 - the filter housing; 4 - clean gas duct;
5 - purging air duct; 6 - shaking mechanism; 7 - valves;
8 – bunker for collecting the dust

After the end of the service life, the exhaust filter material is usually replaced with a new one. Fibrous filters use both natural and special manufactured fiber with thickness of 0.01 to 100 microns. The degree of purification of fine dust can be up to 99%. Granular filters are used in the purification of gases with high temperatures (up to 500-800 ° C) in aggressive environment with sharp changes in pressure and temperature. They represent a vessel filled with a filter material which may be sand, slag, dust, grit ore, coal, graphite, plastics and the like. As a filtering granular, layer filters use bulk materials. Granular filters are used for collecting abrasive and sticky dust in cases where the use of apparatuses of other types is complicated. A variant of granular filters are filters of sorption purification, where the filtering material includes catalysts and sorbents. Sorption filters are designed to capture gaseous impurities [6].

7.3. Techniques for treating industrial waste water

Physical and chemical methods of sewage treatment are the most common methods at aerospace industry enterprises. They include:

- flotation;
- sorption;
- neutralization;
- electrochemical treatment;
- heat treatment;
- ozonization.

The flotation process is based on molecular adhesion of the particles of impurities and air bubbles. Reagents entering the sewage can modify wettability of particles. Enhancing of air bubbles stability is achieved by introducing reagents - frothers.

Flotation is used to remove undissolved contaminants, particularly petroleum and mechanical particles from wastewater. During sorption wastewater cleaning occurs due to extracting organic substances with sorbents. The most effective sorbent is activated carbon of various grades. By using highly efficient sorbents, it is possible to purify water from pollutants to almost zero residual concentrations. Industrial cleaning is carried out by passing the wastewater through a layer of sorbent.

Neutralization is a reaction between ions of hydrogen ions and hydroxide, resulting in the formation of undissociated molecules of water. Neutralization of acids can be made by any alkalis. Correspondently, acids any bases are used to neutralize most industrial wastewater contains not only with acids, but also metal cations, which upon neutralization may precipitate as correspondently hydroxides. Oxidation is the main process of electrochemical cleaning of wastewater. When wastewater goes through a constant electric current between electrodes, hydrogen gas is released on the cathode to form precipitations of corresponding metals. On the anode, there is a process of production of oxygen and halogens, and organic substances are oxidized. Consequently, the electrolysis of wastewater is a series of different physical and chemical processes that cause the effect of wastewater cleaning from dissolved and dispersed impurities. Heat treatment is the burning of waste liquid petroleum and other fuels in furnaces and burners of various design. Wastewater to be incinerated should have a high oil content, usually not less than 30%. For this purpose, wastewater is collected in a tank for accumulation and precipitation. The layer of oil is passed to combustion. The combustion zone temperature is maintained at 800 - 1200 °C and there is an excess of oxygen. In the combustion of organic compounds, reactions are of a redox type. Substances that are not capable of further combustion; CO_2; H_2O appear in the process of complete combustion. In case of incomplete combustion, we can get H_2S, NH_3; etc. Ozonization occurs by passing the wastewater through a layer of an ozone-air mixture. Ozone disintegrates organic substances into harmless products. Biochemical oxidation of industrial wastewater can be used in addition to physical and chemical cleaning methods. Mechanical cleaning is used when suspended impurities are present in industrial wastewater. For this purpose, it is possible to use sedimentation, filtration, and sedimentation in a centrifugal field, etc. Three main types of treatment facilities are used for purification of industrial wastewater:

- local (shop);
- general (factory);
- district (city).

The enterprises of the aerospace industry mainly use local and general treatment facilities. In some cases, after cleaning in the factory wastewater is to be sent for purification in district or municipal facilities.

7.4. Soil remediation technologies

Remediation of soils is a complex of operations aimed at upgrading the productivity and economic value of the damaged land. The process of soils remediation consists of three stages. The first stage is called preparatory or design-and-search. At this stage, we study the structure of soils and ability of being biologically remediated, and simultaneously develop technical and environmental justifications. The second stage is mining-and-technical and it includes smoothing the surface of the earth, filling up the careers and pits for chemical remediation of soil, filling up of fertile soil layer, carrying out remediation activities. The third stage is called biological. This step is restoration of soil fertility.

Multilateral techno genic impact on the natural landscape and the different response of ecosystems does not uniquely allow addressing the issue of remediation of any territory. Therefore, the restoration of previous systems that were before the violation of the natural environment is not always appropriate. However, after the completion of all the work remediated land and surrounding areas should become a land scape which is organized and resistant to the effects of anthropogenic impact.

The value of remediated land and soil must not be lower than what it was before their violation. Land remediation has to be the final stage of production processes that lead to disruption of soil lithogenic bases or territory. Drafting of remediation should be carried out simultaneously with the design of the main production facility and consider a full range of natural, economic, social and sanitary factors. They determine a choice of remediation direction.

For a long time humanity has sought to increase fertility of soils. However, basically, this task was solved with the help of chemical fertilizers, thus causing a negative impact on the environment and human health. An alternative land remediation was required, which would have a system character.

In modern agriculture, alternative remediation consists of three systems: organic, biological and biodynamic.

The organic system assumes an increase in fertility due to the introduction of organic substances into the soil (humus, compost, bone meal, chalk, algae, etc.)

The biological system involves application of natural methods for protecting plants from pests and diseases (collecting harmful insects, spraying plant infusions, etc.).

The biodynamic system consists in taking into account the terrestrial, solar and lunar rhythms during the cultivation soils.

For three decades, soil scientists of Ukraine have been developing new soil protection systems to increase soil fertility, relying on scientific developments of foreign and domestic scientists.

The main ways of greening and restraining the degradation of fertile soils, as well as reducing their dependence on the techno sphere is to provide the following conditions for their environmentally and economically balanced development:

- cultivation of ecological clean products;
- introduction of lightweight agricultural equipment which does not compact soil,
- introduction of biological methods of pest and plant diseases control;
- introduction of new efficient farming technologies, etc. [1].

7.5. Questions for self-check

1. What is a complex indicator of the human population condition?
2. What is the main feature of modern technogenesis?
3. What engineering and environmental measures are carried out to protect the environment from the impact of aerospace production?
4. What technologies of emissions treatment are used in the production of aerospace equipment for cleaning gases from solid and liquid particles?
5. What are the main requirements for dust and gas cleaning machines?
6. Describe the operation of a dry inertial gas cleaning apparatus such as a cyclone?
7. What is the main difference between the operation of the cyclone and the Venturi scrubber?
8. What principle is filter operation based on?
9. What does the filtering process speed depend on?
10. In which cases are granular filters are used for purification of gases in the production of aerospace machinery ?
11. Which physical-and-chemical methods of sewage treatment are used at enterprises of the aerospace industry?
12. Which type do treatment facilities for purification of industrial waste water in the production of aerospace machinery belong to?

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ТЕХНОЛОГІЇ ЗАХИСТУ НАВКОЛИШНЬОГО СЕРЕДОВИЩА ПРИ ВИРОБНИЦТВІ АЕРОКОСМІЧНОЇ ТЕХНІКИ

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