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Theme 2
ENVIRONMENT AND THE SAFETY OF HUMAN LIFE

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2.1. Introduction

The study of man, his environment evolves constantly. Recently discovered scientific facts give rise to new views on the safety of human life and protection of the environment. These studies have a practical focus as well: protecting human life and making it more comfortable.

The twentieth and twenty-first century saw significant positive changes in the economy and power industry, an increase in industrial and agricultural production, labor productivity, power-to-weight ratio of people.

At the same time, however, there are new negative phenomena affecting the life-sustaining activity of people. With increasing industrial production, rising energy production, rapid development of chemical industry, metallurgy, transport, construction, there is an increase in emissions and discharge of harmful pollutants into the biosphere.

Intensification of agriculture, excessive use of fertilizers and pesticides with the aim of improving soil fertility and pest control led to negative consequences for the human and his environment.

The technosphere itself has become a source of danger. The humankind is facing an urgent task of creating an environment that is not only of quality, but

also safe. In this connection, it is important to know and identify hazards affecting the person, to develop ways and methods of minimizing or eliminating the causes of these hazards and the harm inflicted by them.

2.2. Brief overview of the interaction between human and environment

Humans interacting with their environment form a continuously operating man/environment system, and it is in this process that people satisfy their physiological and social needs.

A habitat is an environmental area composed of a combination of physical, chemical, biological, informational, and social factors which can have a direct or indirect, immediate or distant impact on human activity, health and offspring.

In modern world humans have two diametrically opposed types of habitat: the natural habitat in the biosphere, and man-made habitat, the environment of industry, urban and domestic life.

The biosphere is the global ecological system integrating all living beings and their relationships, including their interaction with the elements of the lithosphere, geosphere, hydrosphere, and atmosphere.

The technosphere is the part of the biosphere transformed by man with the help of technical means for social and economic purposes. The technosphere includes domestic, urban, industrial environment as well as the areas of culture, education, health care, etc. The technosphere was built over a long period of time, but its most intensive development occurred in the nineteenth and twentieth centuries.

Human interaction with the environment is based on transmission of flow of substances and their compounds, energies of all kinds as well as information between the elements of the system.

These flows are needed to meet people's needs for food, water, air, solar energy, information about the environment and to release flows of mechanical and intellectual energy, biological waste, flow of thermal energy into the living space. The most typical flows of substance, energy and information in the living space are as follows.

Flows in the natural environment:

- solar radiation, radiation of stars and planets;
- cosmic rays, dust, asteroids;
- electric and magnetic fields of the Earth;
- cycles of different elements in the biosphere, ecosystems, biogeocenoses;
- flows associated with atmospheric, hydrospheric and lithospheric events.

Flows in the technosphere:
- flows of raw materials and energy;
- flows of industry produce and waste;
- information;
- transport;
- light (artificial lighting);
- flows due to technogenic accidents and other.

Flows in the social environment:
- information (education, public administration, international cooperation, etc.);
- human flows (population explosion, urbanization);
- flows of drugs, alcohol and others.

Flows consumed and emitted by humans in the process of life:
- flows of oxygen, water, food and other substances (alcohol, tobacco, drugs, etc.);
- the flow of energy (mechanical, thermal, solar, etc.);
- information;
- waste.

Flows can be acceptable if they do not harm the matter receiving them, and unacceptable, if harm is inflicted. The body's ability to bear an adverse impact of any factor is called tolerance.

Effects of flows on humans in the environment:
- comfortable exposure: flows correspond to the optimal conditions of exposure, ensuring protection of human health and integrity of the environment;
- acceptable exposure: flows lead to discomfort reducing the effectiveness of human activity and can initiate negative processes in the environment;
- dangerous exposure: flows exceed permitted levels producing adverse effects on human health and the environment;
- extremely dangerous exposure causing harm to the extent of death and destruction of habitat.

Man is daily exposed to a complex of many environmental factors, and some of them have a constant impact, others periodically, and almost none of them works in isolation. Therefore, it is important to assess the full range of factors with the goal of solving practical problems in the prevention of disease, improvement of the environment.

2.3. Impact of negative environmental factors on humans

When assessing the impact of negative factors one should consider the degree of their influence on human health and life, the extent and nature of

changes in the functional state and capacity of the body, its dormant reserves, adaptive capacity and the possibility to develop the latter.

Negative environmental factors can lead to an increase in common diseases, whose development and course is triggered by adverse environmental effects. These include respiratory allergic diseases of the respiratory system, diseases of the cardiovascular system, infectious diseases, congenital malformations, reduced sexual function in men, growing incidence of neoplasm cases.

The human body can safely bear certain effect as long as they do not exceed the limits of adaptation.

To rule out irreversible biological effects, the impact should be limited to the maximum permissible levels (MPL) or maximum allowed concentrations (MACs).

Maximum level or maximum allowed concentration is the maximum value of a factor affecting a person (either alone or in combination with other factors) that does not cause any biological changes and even latent or temporarily compensated conditions. That is to say, diseases, changes in reactivity, in adaptive and compensatory ability, immunological reactions, disorders of physiological cycles and psychological disorders (impaired intellectual and emotional ability, mental health).

MAC and MPL values are set for manufacturing and environmental areas. They are worked out according to the following principles:

- priority of medical and biological indications over all other approaches in establishing sanitary regulations;
- threshold values of adverse factors;
- development and implementation of preventive measures should outstrip the emergence of dangerous and harmful factors.

2.3.1. Impact of negative technosphere factors

In the process of life people are exposed to negative factors of the technosphere. The negative impact of the technosphere can be divided into three levels:

A. Impact on man

Household, urban and industrial technosphere can be dangerous to humans when permissible levels are exceeded. Studies show that 18% of employees work in unsafe conditions in Russia. The most common occupational diseases include respiratory disorders (35%), vibration disease (25%), hearing disease (12%), musculoskeletal lesions (12%). Compared with other developed countries Russia has high rates of occupational injuries, child injury, mortality in fires and man-made emergencies.

B. Impact on urban population

The most typical negative factors are industrial and domestic household waste. Compared to the countryside, cities and industrial centers show a high level of air pollution.

There is a huge negative impact on the hydrosphere and the condition of soil in cities. Regarding certain substances the extent of water pollution exceeds permissible values tenfold. Contamination of groundwater reduces the resources of drinking water. The task of disposing of solid waste, toxic and radioactive waste has become an intractable problem. A direct consequence of these problems is deterioration of air quality, drinking water, and food.

The negative impact of the technosphere on nature and humans can be in the form of short intense exposure such as explosions and fires at potentially dangerous facilities.

C. Global effects

Human activity has a negative impact on the environment, and it can lead to large-scale planetary phenomena posing a threat to the entire civilization. Addressing such global problems requires integration of efforts of the entire global community. In today's world there is an increase in the number of existing threats while new ones are emerging, too. The most significant global problem of today is the destruction of the ozone layer in the upper atmosphere, global warming, shortage of drinking water and food, depletion of non-renewable natural resources, major accidents and disasters.

Negative factors of the technosphere include

- harmful substances;
- vibration;
- acoustic oscillations (noise, ultrasound, infrasound);
- shock wave;
- electromagnetic fields (RF, microwave, etc.);
- ionizing radiation;
- high and low temperature;
- high and low atmospheric pressure, and other.

The most dangerous factor in the technosphere is exposure to harmful substances. Currently, there are about 7 million chemical substances and compounds; 600,000 of them can be put to use. From 500 to 1000 new chemical compounds and mixtures arrive on the global market annually.

A substance is called harmful when contact with it can cause injury, illness, or disturbance in health detected by modern methods both upon immediate contact, and in the long term, in present and future generations.

Classification of harmful substances:

- toxic: causing poisoning of the entire body or affecting certain systems;
- irritant;
- sensitizing, acting as an allergen;
- mutagenic, resulting in disruption of the genetic code;
- carcinogenic, usually causing malignant newgrowth;
- affecting the reproductive function.

Vibration refers to factors with high biological activity. The power of oscillation in the contact area, and the time of contact are the main parameters that determine the development of vibration-induced abnormality, the extent of which depends on the frequency and amplitude of the oscillations, duration of exposure, point of contact and the axis direction of vibration exposure, and other conditions.

Individuals exposed to vibration are more likely to develop cardiovascular and nervous disease; they usually present many complaints of somatic nature.

Noise affects the entire human body. The impact of noise depresses the central nervous system, affects the rate of respiration and heart rate, promotes metabolic disorders, development of cardiovascular disease, hypertension, and can lead to occupational disease (hearing impairment, etc.)

Noise causes hypofunction of protective systems and of the overall resistance of the body to external influence.

Shock wave can affect humans and animals. It arises as a result of exposure to excessive pressure and velocity of air pressure. Due to the small size of the human body, the shock wave covers a human within a few seconds. The sudden pressure increase is perceived by a living body as a sharp blow. The extent of the shock wave depends on the power of the explosion, distance, weather conditions, location and position of the person (lying, sitting, upright) and is characterized by mild, moderate, severe and extremely severe injuries.

Long-term effects of **electromagnetic fields** (EMF) leads to disorders that present as subjective complaints of a headache in the temporal and occipital region, lethargy, sleep disorders, memory loss, irritability, pain in the heart. Chronic exposure to power-frequency EMFs leads to cardiac rhythm disturbance and slowing down of the heart rate, disorders of the nervous system. Individuals working with electromagnetic fields of industrial frequency (50 Hz) can develop functional disorders of the central nervous system and cardiovascular system, changes in blood composition. It is therefore necessary to limit the time of human presence in the area of the electromagnetic field.

Upon exposure **ionizing radiation** causes a chain of reversible and irreversible changes. The trigger mechanism of action is the process of ionization and excitation of atoms and molecules in the tissue. Dissociation of complex molecules upon breaking of chemical bonds is the direct effect of radiation.

As a result, metabolic processes are disrupted, growth of tissues slows down and ceases, new atypical chemical compounds are formed. This leads to disruption of individual functions and body systems. Ionizing radiation can cause two types of effects which clinical medicine relates to diseases: deterministic threshold effects (radiation sickness, radiation burns, radiation cataract, radiation infertility, abnormalities in fetal development, and other) and stochastic (probabilistic) threshold-free effects (malignant newgrowth, leukemia, and hereditary disease).

An upward or downward change of air pressure has a significant impact on the human body. The effect of high pressure is due to the mechanical, physical and chemical action of the gaseous medium. Optimal diffusion of oxygen into the blood from the gas mixture in the lungs is carried out at an atmospheric pressure of about 760 mm Hg. Elevated oxygen and other gases in the blood can cause a stupefacient reaction. Low pressure exerts an even more pronounced effect, and can lead to disorder of vital functions and loss of consciousness.

2.3.2. Impact of environmental factors on human health

Biosphere is becoming more and more saturated with human-made substances that are harmful to living organisms. Billions of tons of these substances released into the atmosphere, discharged into water, accumulate in the waste. Air flow, river and sea currents carry pollutants over long distances and damage human health, nature and assets. Changes in the human environment due to pollution of the environment are leading to a rising incidence of environmentally induced conditions. The greatest influence on environmental pollution comes from c**hemical, biological and physical factors.**

Chemical environmental factors may be of natural and anthropogenic origin. A significant role in the chemical pollution belongs transport: land, water, air means of transport using petroleum as energy source. The amount of chemicals is extremely large. Currently, there is evidence of almost 8 million different chemical compounds, and tens of thousands of them are widely used in diverse spheres of life and are constantly used by people. The most dangerous chemical pollutants include heavy metals, pesticides, carcinogens and radioactive substances.

Chemicals can cause pollution of water (through sewage and storm water), drinking water, soil, air and food products and be the cause of adverse environmental conditions.

In cities and regions with unfavorable environment children show functional abnormalities in the immune system and blood, disturbed compensatory-adaptive mechanisms. The impact of air pollution on children's health is noted in all age groups. The greatest impact is the increase in the incidence of respiratory diseases in children aged 1–2 and 3–6 years. Cities that are on the list with the highest level of air pollution show significantly higher infant mortality than other cities.

Another morbidity risk is **drinking water contaminated** by chemicals. The presence of heavy metals salts and organochlorine compounds public water supply systems, as well as low barrier capacity of wastewater treatment plants is a serious threat to public health. Regions of Russia characterized by persistent deterioration of water quality tend to increase the incidence of bacterial and viral intestinal infections of bacterial and viral nature.

Soil contamination can occur as a result of application of fertilizers, pesticides, irrigation of fields with wastewater containing various chemical compounds; soil contamination can also stem from dumps of industrial and household waste.

Chemicals can get into **food** due to treatment of fields with mineral fertilizers, pesticides, during transportation, upon using chemical additives to improve the appearance and other properties of commodity products.

Biohazards refer to biological substances that pose a threat to the health of living organisms, primarily of humans. They can be both natural and man-made, occurring in all environments — water, air, soil, food, in industrial and household settings. Biological pollutants are extremely numerous and varied.

The main components of the biological factor are:

- macro-organisms;
- microorganisms;
- products of microbiological synthesis (enzymes, antibiotics, toxins, amino acids, protein and vitamin concentrates, and so on).

According to the World Health Organization, food and water carry numerous pathogens, including *Salmonella*, *Vibrio cholerae*, staphylococcus, streptococcus, *Rickettsia*, viruses. Over 20% of all human infectious diseases are air-borne.

Physical environmental factors acting people are diverse and are quite numerous. Regarding their origin they may be natural or anthropogenic. Some of these factors can be beneficial, necessary for human life and health, and others are harmful, depending on the nature and intensity of their impact.

2.4. Environmental protection

Currently, there is a growing interest in various aspects of environmental protection from depletion, pollution and degradation.

The main cause is an intensive alteration of the environment under the influence of anthropogenic, sociogenic activity: rapid development of industry, power economy and transport, use of chemicals in agriculture and in everyday life, urbanization, urban growth, which leads to an increase in waste from industry, agriculture, transport, household. This has a direct and indirect impact on the health and morbidity of the population, the conditions of work, life and recreation.

For most part, man alters the environment quite consciously, in order to achieve specific purposes. An analysis of environmental consequences of human activity allows distinguishing positive and negative outcomes.

Positive outcomes include reproduction of natural resources, land reclamation on the site of development of mineral resources, reforestation, restoration of damaged ecosystems in local natural areas, and other.

The most common type of negative human impact on the biosphere is pollution (physical, chemical, biological and other types of pollution).

Thus, anthroposociogenic exposure has a significant impact on the functioning of the man-environment system and suggests necessity to work out environmental safety measures.

2.4.1. Brief description of global problems in modern world

Considering global and most pressing issues problems of modern age, our leading scientists and politicians always highlighted, as a priority, issues related to relationships between humans and environmental protection (energy and raw materials, environment, food supply, space exploration, etc.). Global environmental problems are in the focus of attention, because they have a significant impact on the functioning of the man-environment system. The most important modern environmental problems are as follows:

- greenhouse effect;
- destruction of the ozone layer of the Earth;
- acid rain;
- environmental pollution;
- destruction of the soil and restoring its fertility;
- climate change;
- preservation and protection of biological resources;
- disposal of domestic, industrial and toxic waste;
- deficiency of clean drinking water, its purification.

The atmosphere is almost entirely permeable for solar radiation, but because of the greenhouse gas in the atmosphere (which includes carbon dioxide, methane, Freon, and nitrogen oxide) there is a significant delay in inverse thermal radiation of the earth surface. Greenhouse gases form a sort of greenhouse glass roof over the planet, and a lot of the heat radiated by the Earth returns back. The increase in thermal energy storage in the surface layers of the atmosphere is linked to greater concentrations of greenhouse gases, and this is the essence of the greenhouse effect.

Increasing of the greenhouse effect leads to an increase in rainfall, variations in wind direction, ocean currents, reducing size of glaciers, rise in temperature on the surface of the Earth and warming of the climate. For thousands of years the average global temperature held at +15 °C. Over the past 100 years, the temperature at the Earth's surface has increased by 0.5–0.6 °C, and continues to grow rapidly and can reach +18 °C. This can lead to a significant climate change in many areas of our planet.

The highest concentration of ozone in the atmosphere is observed at an altitude of 20–25 km. The total mass of ozone is less than one millionth of the mass of the entire atmosphere. However, the ozone layer not only protects all life on the planet from immediate destruction by ultraviolet radiation, but also prevents dangerous mutation of living organisms. Over 99% of UV light is absorbed by the ozone layer in the stratosphere at about 25 km. 1% ozone depletion entails a 1.5% increase in UV. The temperature behavior in the atmosphere and its dynamics are largely determined by the ability of ozone to absorb the ultraviolet rays. As intensity of ultraviolet radiation grows, scientists have linked to it the increasing in eye disease and cancer incidence in humans, immunity impairment, and occurrence of mutations (ultraviolet rays destroy the DNA molecule).

Acidic precipitation includes any type od precipitation like rain, fog, snow, whose acidity is higher than normal. The problem of acid rain emerged in the early 1970s. Most importantly, it manifested itself in the countries of Scandinavia, where the lakes are being depleted of fish, micro-organisms, but the water remains clean visually. The acid properties of the environment are determined by hydrogen ions. The greater the concentration of hydrogen ions in solution, the higher acidity of this solution.

The problem of environmental pollution is an urgent one nowadays. When we use modern equipment and technologies, no more than 10% of raw materials from the subsoil and from the planet's surface is converted into finished goods, and 90% goes to waste, polluting the biosphere. Every year, Russia pro-

duces about 7 bln. tons of waste, of which only 2 billion. tons, or 28.6% is put to actual use. Waste pollutes the air, soil, vegetation, groundwater and surface water. This waste is divided into household and industrial types, and can exist in the solid, liquid and gaseous state. Accumulation of toxic waste is most dangerous, as it often contains carcinogens. This situation poses a real threat to human health.

One of the problems facing people on Earth is to provision of fresh water suitable for drinking, irrigation, water supply, public utilities. Currently, humanity uses 3.8 thousand km^3 of water annually. Each individual consumes an average of 650 thousand km^3 of water per year (1780 liters) while 2.5–3 liters per day, or about 1 m^3 per year are quite enough to meet the physiological needs. A large amount of water is required for agriculture needs (69%); 23% of water consumption is accountable to industries; 6% is spent at households. Currently, one-third of the world's population experiences a lack of drinking water.

Environmental evaluation implies a comparison between its current condition and certain standards. The parameters of natural, undisturbed state of natural complexes, background environment settings can serve as criteria in this comparison. Scientists are in the process of developing the statutory rate of standards that would characterize the rate of human impact on the environment. The statutory rate is established on the basis of special studies, or as a result of expert estimates.

Since the economy and technology cannot function without emission of harmful substances into the environment, the notion of maximum permissible concentration (MPC) of harmful substances was introduced.

2.4.2. Environment protection measures

The qualitative condition of the man-environment system depends largely on timely implementation of environment protection measures, as well as on compliance with environmental safety requirements.

Protection of natural environment means a system of international, governmental and public measures aimed to ensure a harmonious interaction between society and nature, based on conservation and restoration of natural resources, sustainable use of natural resources, improvement of the quality of the environment.

Environmental safety can be quantified as the degree of environmental risk. This can be achieved by a set of measures aimed to reduce the negative anthropogenic impact on the environment. It depends on how effective environmental protection measures are.

Environmental protection includes the following measures:

- legal protection, which provides scientific ecological principles in the form of legally binding laws;
- financial incentives;
- environmental engineering techniques including environment-friendly and resource-saving technology and equipment.

In accordance with the Russian law On Environmental Protection (2002), the following items should be protected:

- natural ecological systems, the ozone layer;
- land, its mineral resources, surface and ground water, air, forest and other vegetation, fauna, microorganisms, gene pool, natural landscapes.

The basic principles of environmental protection are:

- ensuring favorable environmental conditions for life, work and recreation of people as a priority;
- scientifically proven combination of environmental and economic interests of society;
- taking into consideration the laws of nature and self-recovering and self-purification capacity of its resources;
- avoiding irreversible consequences for the environment and human health;
- inevitable responsibility for violating environmental legislation;
- international cooperation in the field of environmental protection.

In this country, the requirement for protection and use of natural resources is stated in the Constitution. There are about two hundred legal documents relating to environmental management. One of the most important is the complex of the Russian Federation law On Environmental Protection adopted in 2002.

It contains the following provisions:

- the right of the citizens to a healthy and favorable environment;
- economy-driven mechanism of environmental protection;
- governmental environmental assessment;
- environmental emergencies;
- liability for environmental offenses;
- environmental control system consisting of the civil service monitoring the state of the environment, governmental, industrial and public control.

The problem of environment protection is a global one, and the future of our civilization depends on addressing this problem.

Key questions for self-control:

1. What is a habitat?
2. The main factors of the technosphere and its effects on humans.
3. Characteristics of flows in the habitat.
4. Types of exposure in the environment.
5. Characteristics of global environmental problems.
6. Natural threats and their characteristics.
7. Anthropogenic threats and their characteristics.
8. Technogenic threats and their characteristics.
9. Environmental protection, its fundamental principles and goals.
10. Legal basis for environmental protection.