Content

Theme 1 – Ecology as a science

At more than six billion, the number of people inhabiting the planet is the largest in history. Their presence leaves an indelible mark on the planet and sets off changes with unknown consequences. Deforestation, the destruction of ecosystems, air pollution, water pollution, and changes to the land, such as the building of dams and reservoirs, appear to be culminating in the phenomenon of global warming, which is affecting the Earth and foretells a truly difficult and complicated future.

(10.08.2016) came another record day for the Earth. Mankind has absorbed more natural resources than the planet is able to produce in a single calendar year. And it happened on the eighth day of the eighth month.

According to the Global Footprint Network, we cut down the forests, fish caught and released so much carbon dioxide for 220 days a year, as it can make the whole planet for 365 days. In other words, we still have another 145 days, the resources that we take "credit" in the next year.

In early times of human history no one thought about the environment. Today the Ecology has become one of the most important disciplines. It helps to understand the main principles of ecosystem functioning, to predict the effects of human activities on the environment.

Ecology as a science is relatively new. The word "ecology" was invented in 1866 by the German scientist **Ernst Haeckel** (1834–1919).

Soon after Charles Darwin wrote his revolutionary book, "The Origin of Species" in 1859, ecological thoughts began to hover upon the minds of biologists. In 1870 German biologist Ernst Haeckel coined the word Oekologie using two Greek words oikos meaning "home" and logos meaning "science". From Oekologie arose the word Ecology and it was first used in 1892.

In the beginning Ecology was only a branch of biology. But afterwards it has developed in multidisciplinary science and today is associated with all areas of human activity.

Ecology today is an applied science. It aims to unravel the complex relationships between animals and plants and each animal species and with each plant species and also the complex relationships which exist between each species and their non-living environments such as, soil water, light, heat and air etc. Hence Ecology has to draw upon various relatively pure sciences such as, morphology, taxonomy, behavior, embryology, physiology, genetics, chemistry, physics, mathematics, geology, geography and meteorology etc.

There are many subcategories of ecology, such as ecosystem ecology, animal ecology, and plant ecology, which look at the differences and similarities of various plants in various climates and habitats. In addition, physiological ecology, or ecophysiology, studies the responses of the individual organism to the environment, while population ecology looks at the similarities and dissimilarities of populations and how they replace each other over time.

Finally, it is important to note that ecology is not synonymous with environment, environmentalism, natural history, or environmental science. It is also different from, though closely related to, the studies of evolutionary biology, genetics, and ethology.

Ecology is the scientific study of the distributions, abundance and relations of organisms and their interactions with the environment.

Ecology includes the study of plant and animal populations, plant and animal communities and ecosystems. Ecosystems describe the web or network of relations among organisms at different scales of organization. Since ecology refers to any form of biodiversity, ecologists research everything from tiny bacteria's role in nutrient recycling to the effects of tropical rain forest on the Earth's atmosphere.

Global Ecology studies the biosphere as the global ecosystem—the sum of all the planet's ecosystems and landscapes. Global ecology examines how the regional exchange of energy and materials influences the functioning and distribution of organisms across the biosphere.

Landscape Ecology A landscape (or seascape) is a mosaic of connected ecosystems. Research in landscape ecology focuses on the factors controlling exchanges of energy, materials, and organisms across multiple ecosystems.

Ecosystem Ecology An ecosystem is the community of organisms in an area and the physical factors with which those organisms interact. Ecosystem ecology emphasizes energy flow and chemical cycling between organisms and the environment

Community Ecology A community is a group of populations of different species in an area. Community ecology examines how species interactions, such as predation and competition, affect community structure and organization.

Population Ecology A population is a group of individuals of the same species living in an area. Population ecology analyzes factors that affect population size and how and why it changes through time.

Organismal Ecology Organismal ecology, which includes the subdisciplines of physiological, evolutionary, and behavioral ecology, is concerned with how an organism’s structure, physiology, and behavior meet the challenges posed by its environment.

Industrial Ecology: The design of the industrial infrastructure such that it consists of a series of interlocking "technological ecosystems" interfacing with global natural ecosystems. Industrial ecology takes the pattern and processes of natural ecosystems as a design for sustainability. It represents a shift in paradigm from conquering nature to becoming nature.

Ecological Engineering: Unlike industrial ecology, the focus of Ecological Engineering is on the manipulation of natural ecosystems by humans for our purposes, using small amounts of supplemental energy to control systems in which the main energy drives are still coming from non-human sources. It is the design of new ecosystems for human purposes, using the self-organizing principles of natural ecosystems.

Ecological Economics: Integrating ecology and economics in such a way that economic and environmental policies are reinforcing rather than mutually destructive.

Urban ecology: For ecologists, urban ecology is the study of ecology in urban areas, specifically the relationships, interactions, types and numbers of species found in urban habitats. Also, the design of sustainable cities, urban design programs that incorporate political, infrastructure and economic considerations.

Conservation Biology: The application of diverse fields and disciplines to the conservation of biological diversity.

Restoration Biology: Application of ecosystem ecology to the restoration of deteriorated landscapes in an attempt to bring it back to its original state as much as possible. Example, prairie grass.

All these disciplines require an understanding of the "organizing principles" of ecosystems, i.e., their ecology. This involves the detailed study of the structure and function of ecosystems in their undisturbed state, and using their designs to:

− determine the resilience of ecosystem functions to human activities.

− design ecosystems which function in the service of human beings with minimal fossil energy input (ideally none) and minimal waste.

− design the industrial infrastructure.

− integrate the value of "goods and services" of natural ecosystems into the global economic system.

Like many of the natural sciences, a conceptual understanding of ecology is found in the broader details of study, including:

- life processes explaining adaptations
- distribution and abundance of organisms
- the movement of materials and energy through living communities

- the successional development of ecosystems

- the abundance and distribution of biodiversity in context of the environment.

In Ecology there is known three great branches:

- **Autecology**, also called Species Ecology, the study of the interactions of an individual organism or a single species with the living and nonliving factors of its environment. Autecology is primarily experimental and deals with easily measured variables such as light, humidity, and available nutrients in an effort to understand the needs, life history, and behavior of the organism or species.

- **Synecology** is the study of group of organisms of different species which are associated together as a unit in form of a community. Also known as community ecology.

Autecology helps us to understand the relationships between individual plants and environment. Synecology helps us to understand the relationships between communities and environment.

Synecology is further subdivided into aquatic and terrestrial ecology. The aquatic ecology includes fresh water ecology, estuarine ecology and marine ecology. Terrestrial ecology is further subdivided into forest ecology, grassland ecology, cropland ecology and desert ecology.

- **Demecology** is that branch of biology which deals with the ecology of populations.

Scientists-ecologists and biologists have identified several **levels of organization of living matter**

Biosphere: The largest known ecosystem

↓ Biome: Large scale areas of similar vegetation and climatic characteristics.

↓ Ecosystem: Set of organisms and abiotic components connected by the exchange of matter and energy (forest, lake, coastal ocean). Or, “the smallest units that can sustain life in isolation from all but atmospheric surroundings.”

↓ Community: Interacting populations which significantly affect each other’s distributions and abundance (intertidal, hot spring, wetland).

↓ Population: Group of interacting and interbreeding organisms

↓ Cell/Organism → Organelle → Molecule → Atom

Questions:

1. Name 5 applied ecology disciplines.
2. The scientist, who has invented word «Ecology».
3. ___________ the study of the interactions of an individual organism or a single species with the living and nonliving factors of its environment.

4. Make the list of the levels of living matter organization.

5. __________ is the study of group of organisms of different species which are associated together as a unit in form of a community.

6. ___________ is that branch of biology which deals with the ecology of populations.

Theme 2. The Planet Earth

Atmosphere

The Earth's atmosphere consists mainly with next gases:

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.

Based on the variation of temperature with height, the atmosphere can be divided to different layers.

Troposphere:

The lowest major atmospheric layer is the troposphere, extending from the Earth's surface to the tropopause. The thickness of the troposphere varies with latitude, but in generally it is about from 10-18 km.

Troposphere contains about 80% of total mass of the atmosphere, nearly all water vapour and dust particles can be found here. Almost all weather phenomena and cloud formation take place in this layer. The troposphere is heated from below by the Earth's surface. Incoming solar radiation first warms the surface, which radiates heat into the atmosphere. The warmer air in the near surface layer generates turbulent vertical motions, which transfer water vapour and other tracers to higher altitudes.

Temperature decreases with increasing height in the troposphere to away from the warming surface. The changing rate of temperature with height is called "lapse rate". Tropospheric air temperature is generally proportional with distance from surface and lapse rate is fairly uniform, it is about 6,5 °C / 1000 m, but this rate is affected by water vapour content.

However, in the lower troposphere, the atmospheric stratification can differ from normal, and temperature can increase with height in the function of time of day and weather condition. This situation is called inversion. This is unpleasant for us, because it prevents the normal circulation of air masses and leads to stagnation of pollutants in the lower layers.

Stratosphere:

It is located at a height of up to 50 km.

In this layer temperature increases with height. Temperature increase in the stratosphere is due to the relatively high concentration of ozone. Ozone strongly absorbs uv radiation from the Sun. This absorption by the ozone is the primary cause of temperature increase in the stratosphere.

The ozone layer is situated at height from 20 to 30 km

Stratosphere holds about 19% of total mass of the atmosphere, and it contains only a very small amount of water vapour. stratosphere is a stable layer and the mixing of air masses is weak. Particles that reach the stratosphere from the troposphere (e.g. from a large volcanic eruption) can stay a long time (many years) in the stratosphere without removing from it.

The stratosphere is bounded above by the stratopause at about 50 km height, where the average temperature is generally just below 0 °C.

Mesosphere:

Over the stratopause, the next layer is the mesosphere from about 50 km to 85–100 km above the Earth's surface. Air density is tow low to absorb solar radiation, thus the mesosphere is warmed from below by the stratosphere and hence the temperature decreases with increasing height. However the atmosphere is still thick enough to slow down meteoroids enter to the atmosphere. The upper boundary of mesosphere is the mesopause, which is the coldest region of Earth's atmosphere, where the temperature is around –100 °C.

Thermosphere:

It is located at height from 100 till 500 km above the Earth's surface

In the thermosphere, over the mesopause, temperature rise continually with increasing height due to the direct absorption of high energy solar radiation by atmospheric gases. Temperatures are highly dependent on solar activity, and can rise well beyond to 1000 °C. However, this value is not comparable to those of the lower part of the atmosphere, as the air density is extremely low in this layer.

Over about 500–1000 km above the Earth's surface (depending on solar activity), the collisions between atmospheric constituent become negligible. This layer is often called as exosphere, which gradually merge into interplanetary space.

The energy that reaches the earth comes from the sun, and the absorption and loss of radiation from the earth and its atmosphere determine our climate. If the earth had no atmosphere, the mean surface temperature would be 255 K, well below the freezing point of water. The atmosphere serves to retain heat near the surface and the earth is thereby made habitable. This accounting for incoming and outgoing energy is called the global energy balance and could potentially be upset by any significant changes to the earth's atmosphere.

The boundary of the biosphere in the atmosphere is at a height of 20 km.

Hydrosphere

Hydrosphere is the combined mass of water found on, under, and above the surface of a planet (table1).

Table 1

Table of water distribution in the Earth's hydrosphere

Parts of the hydrosphere	**% of the total volume**
The world ocean	93,96
Underground waters	4,12
Glaciers	1,65
Lakes	0,019
River waters	0,0001

The surface area of the hydrosphere is 70.8% of the surface area of the globe, while its volume - only about 0.1% of the planet. Thickness uniformly distributed over the Earth's surface of the film is only 0.03% of its diameter.

Water is chemically and physically a substance with unusual properties.

Studied on its own, the water molecule is deceptively simple. It is shaped like a wide V, with its two hydrogen atoms joined to the oxygen atom by single polar covalent bonds. This make it a polar molecule, meaning that its overall charge is unevenly distributed.

The properties of water arise from attractions between oppositely charged atoms of different water molecules: The slightly positive hydrogen of one molecule is attracted to the slightly negative oxygen of a nearby molecule. The two molecules are thus held together by a hydrogen bond. When water is in its liquid form, its hydrogen bonds are very fragile. The hydrogen bonds form, break, and re-form with great frequency. Each lasts only a few trillionths of a second, but the molecules are constantly forming new hydrogen bonds. Therefore, at any instant, most of the water molecules are hydrogen-bonded to their neighbors. The extraordinary properties of water emerge from this hydrogen bonding, which organizes water molecules into a higher level of structural order.

Collectively, the hydrogen bonds hold the substance together, a phenomenon called cohesion. Cohesion due to hydrogen bonding contributes to the transport of water and dissolved nutrients against gravity in plants. Water from the roots reaches the leaves through a network of water-conducting cells. As water evaporates from a leaf, hydrogen bonds cause water molecules leaving the veins to tug on molecules farther down, and the upward pull is transmitted through the water-conducting cells all the way to the roots.

Adhesion, the clinging of one substance to another, also plays a role. Adhesion of water by hydrogen bonds to the molecules of cell walls helps counter the downward pull of gravity. Related to cohesion is surface tension, a measure of how difficult it is to stretch or break the surface of a liquid. At the interface between water and air is an ordered arrangement of water molecules, hydrogen-bonded to one another and to the water below. This gives water an unusually high surface tension, making it behave as though it were coated with an invisible film.

Water moderates air temperature by absorbing heat from air that is warmer and releasing the stored heat to air that is cooler. Water is effective as a heat bank because it can absorb or release a relatively large amount of heat with only a slight change in its own temperature.

Compared with most other substances, water has an unusually high specific heat. Because of the high specific heat of water relative to other materials, water will change its temperature less than other liquids when it absorbs or loses a given amount of heat. Specific heat can be thought of as a measure of how well a substance resists changing its temperature when it absorbs or releases heat. Water resists changing its temperature; when it does change its temperature, it absorbs or loses a relatively large quantity of heat for each degree of change.

What is the relevance of water's high specific heat to life on Earth? A large body of water can absorb and store a huge amount of heat from the sun in the daytime and during summer while warming up only a few degrees. At night and during winter, the gradually cooling water can warm the air. This capability of water serves to moderate air temperatures in coastal areas. The high specific heat of water also tends to stabilize ocean temperatures, creating a favorable environment for marine life. Thus, because of its high specific heat, the water that covers most of Earth keeps temperature fluctuations on land and in water within limits that permit life. Also, because organisms are made primarily of water, they are better able to resist changes in their own temperature than if they were made of a liquid with a lower specific heat.

Water is one of the few substances that are less dense as a solid than as a liquid. In other words, ice floats on liquid water. While other materials contract and become denser when they solidify, water expands. The cause of this exotic behavior is, once again, hydrogen bonding. At temperatures above 4°C, water behaves like other liquids, expanding as it warms and contracting as it cools. As the temperature falls from 4°C to 0°C, water begins to freeze because more and more of its molecules are moving too slowly to break hydrogen bonds. At 0°C, the molecules become locked into a crystalline lattice, each water molecule hydrogen-bonded to four partners.

The hydrogen bonds keep the molecules at "arm's length," far enough apart to make ice about 10% less dense (10% fewer molecules for the same volume) than liquid water at 4°C. When ice absorbs enough heat for its temperature to rise above 0°C, hydrogen bonds between molecules are disrupted. As the crystal collapses, the ice melts, and molecules are free to slip closer together. Water reaches its greatest density at 4°C and then begins to expand as the molecules move faster.

The ability of ice to float due to its lower density is an important factor in the suitability of the environment for life. If ice sank, then eventually all ponds, lakes, and even oceans would freeze solid, making life as we know it impossible on Earth.

Water is an excellent solvent. It is extremely polar and can dissolve a wider range of solutes and in greater amounts than any other substance. Water has a very high dielectric constant, a measure of the solvent's ability to keep apart oppositely charged ions.

The term **salinity** is a measure of the salt content of seawater, a typical value for oceanic waters being 35 g kg/1. In an oceanographic context, the most important consequence of the addition of salt to water is the effect on density. However, many of the characteristics outlined above are also altered.

Dissolved compounds play an important role in the ecosystem. Thus, for example, sea water have the ability to maintain a constant pH (пи эйч) (buffering properties) and to some extent neutralize incoming contaminants. Of course, in every ecosystem may occur the limit, when it can not compensate for the negative impacts and begins to break down.

The water cycle in nature has a very important function - it prevents the stagnation of water in natural reservoirs, renewing it. However, in various media update occurs at different rates. The water contained in living organisms, updated every few hours. Updating the Arctic glaciers and depth of groundwater occurs no more often than once in 10 000 years.

Border of Life in the hydrosphere limited in depth of just over 11 km (depth of the deepest depressions in the ocean - the Mariana).

The Lithosphere

Lithosphere - solid shell of the Earth, including the Earth's crust and upper mantle of the planet, has a thickness of 50 to 75 km on the continents and 5-10 km below the ocean floor. The upper layers of the lithosphere (2-3 km) sometimes called litobiosfphere.

The inner structure of the planet consists from: crust, mantle, outer core, inner core (figure 1).

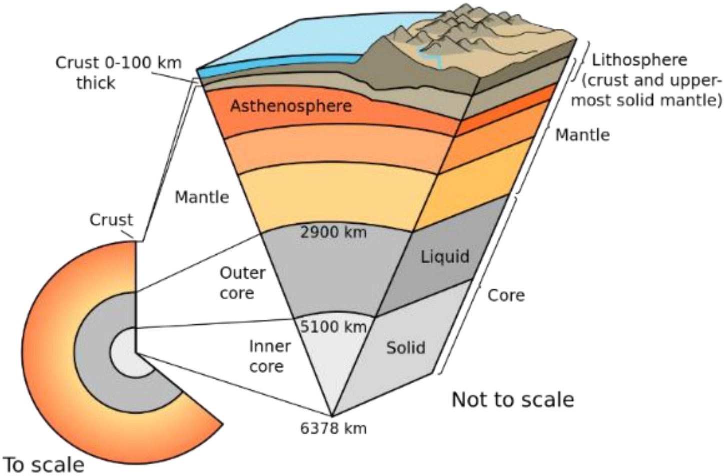


Fig.1 – The inner structure of the Earth

It should be noted that all the current data on the structure of the planet were obtained indirectly, because we cannot get inside the planet deeper than 10-12 km.

According to modern scientific ideas core of our planet is composed of metals that are in liquid form.

The earth’s lithosphere is made up of about a dozen giant and several smaller sections called plates, and these move in various directions in processes known collectively as plate tectonics.

Average speed of movement of about 5 centimeters per year.

The chemical composition of the lithosphere is mainly represented by only eight elements (table 2). This oxygen, silicon, hydrogen, aluminum, iron, magnesium, calcium and sodium. Together, these elements account for about 99.5% of the material of the Earth's crust.

One of the lithosphere differences from other objects in the world around us is the fact that it is a permanent human dwelling place, and therefore its the most exposed to human impacts (including exploitation of the surface layer and the interior of the Earth). therefore, from all parts of the world soil is exposed to the maximum contamination.

Table 2

The chemical composition of the Earth's crust at depths of 10 - 20 km.

Element	**Mass fraction,%**
Oxygen	49,13
Magnesium	2,35
Iron	4,20
Carbon	0,35
Potassium	2,35
Aluminum	26,00
Sodium	2,40
Silicon	26,00
Hydrogen	1,00
Calcium	3,25

Soil is the complex biogeochemical material which forms at the interface between the earth's crust and the atmosphere, and differs markedly in physical, chemical, and biological properties from the underlying weathered rock from which it has developed.

Soil comprises a matrix of mineral particles and organic material, often bound together as aggregates, and populated by a wide range of micro-organisms, soil animals, and plant roots. The spaces between particles and aggregates form a system of pores, which are filled with aqueous soil solution and gases. The physical, chemical, and biological properties of soils are highly relevant to considerations of contaminated land and its reclamation.

The type of soil that forms at any site is determined by climate, the nature of the parent rock material on which it forms, the landscape (especially whether it is a free-draining or water collecting site), the vegetation, and the time period over which the soil has been forming. These factors control the intensity and type of pedogenic processes operating at any site and determine the nature of the soil profile that develops.

The presence of organic matter and living organisms is a characteristic of soil and helps distinguish it from regolith (weathered rock). All soils, in the pedological sense of the word, contain organic matter in their surface horizons but the amount and type may vary considerably.

The organic matter present in soils can be classified as either humic or non-humic. Humic compounds are highly polymerized, colloidal, products of microbial decomposition of plant material, especially lignins. Non-humic material includes undecomposed or partially decomposed fragments of plant tissues and soil organisms. These latter include a wide range of species of bacteria, fungi, protozoa, actinomycetes, and algae, and many species of mesofauna, such as earthworms, which fill an important ecological niche in the comminution of plant litter and its incorporation into the soil. Although organic matter only tends to form a small percentage of the mass of the soil (usually less than 10%), it has a very great influence on soil chemical and physical properties especially with regard to the behaviour of contaminants.

Soil has a number of important properties

The Soil has fertility - an essential property for the existence of plants

The soil has a significant impact on the composition and properties of the surface and underground waters and the entire hydrosphere of the Earth. Filtering through layers of soil water extracts the specific set of chemical elements

Soil is the main regulator of the composition of the Earth's atmosphere. This occurs due to the activity of soil microorganisms producing a variety of large scale of gases - nitrogen and its oxides, oxygen, carbon dioxide and monoxide, methane and other hydrocarbons and a number of other gases.

One of the most important in ecology is the concept of the **ecosystem.**

Ecosystem - a dimensionless stable system of living and non-living components in which takes place external and internal circulation of substance and energy. (Example: forest ecosystems, soil, hydrosphere).

The largest ecosystem, known to us, is the Biosphere.

Biosphere - active shell of the Earth, which includes all the living organisms of the Earth.

It is in conjunction with the non-living environment (chemical and physical) of our planet, with which they are integrated (figure 2).

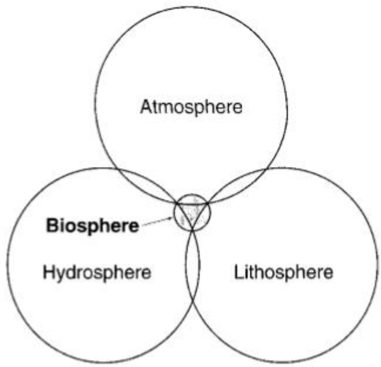


Fig.2 – The biosphere

Questions:

1. Describe the troposphere and the stratosphere
2. Which two the most important kinds of chemical bonds are presented in water?
3. Which specific properties of water you do know?
4. What means the term salinity? What value of it is typical for oceanic waters?
5. Describe the structure of the lithosphere.
6. Name 3 the most common chemical elements in the lithosphere.

7. Name 3 the most common chemical elements in the atmosphere.
8. What factors influence soil formation?
What specific properties of soil you do know?
9. Borders of the biosphere on our planet.

Theme 3. The circulation of energy and matter in the Biosphere

The mutual communication within biogeocenose is supported in the cycle of nutrients.

The whole cycle of organic and inorganic matter form the basis of the biosphere and the basic condition for the maintenance of life in it.

In the continuous cycle of living matter it provides the formation of new living matter, which not only replaces the death of its mass but also obtain a new quality in the process of evolution.

Biocenosis - the interacting organisms living together in a habitat (biotope).

Biotope is an area of uniform environmental conditions providing a living place for different species of plants and animals.

Together they form **ecosystem -** A natural complex, which is formed by living organisms and their environment. The trunk of a dead tree, forest, lake, ocean, biosphere – are examples of different scale ecosystems. The largest of the known ecosystem is the biosphere

Biocenosis and biotope communicate with each other and with the environment of substances, energy and information (signals).

In the implementation of the biosphere's functions to ensure the organisms activity the decisive role belongs to the cycle of matter, which is achieved due to the dynamic equilibrium and the stability of the biosphere as a whole and its individual parts.

At the same time in a single cycle, the large geological cycle takes place as a result of abiotic factors, as well as the small biotic cycling of matter in the solid, liquid and gaseous phases occurring with the participation of living organisms.

The **great geological cycle** takes place over hundreds of thousands or millions of years. As a result: the rocks are destroyed, weathered and eventually washed away by streams of water in the oceans. There they are deposited on the bottom, forming sediments, and partially back to land with organisms extracted from water for human or other animals.

It is found out that in the oceans 12 km3 annually imposed mineral substances, bringing with continents surface layer is removed by an average of about 0.08 mm thick.

At this rate, all the continents would be destroyed for 10-11 million years. However, this does not happen, as opposed to the process of destruction of the continents of the active substance recovery process from the depths of the Earth's mantle. Large slow geotectonic changes, the lowering process of continents and raising the sea floor, moving oceans and seas lead to the fact that the marine sediments returned and the process begins again.

The **small biotic circulation** is the part of the large one. The process flow speed is much higher. The single biotic cycle involves all kinds of living organisms inhabiting the planet. If we look at this cycle as a single closed circuit, any plants, animals, microorganisms make up the individual links of the chain. The contact of the individual units is expressed in the fact that the matter and energy acquired by each preceding link are then consumed and processed in the following link. This occurs as long as the material balances are returned to the original link.

Plants may be treated as complex organic machines performing photosynthesis (the process of organic substances formation using such starting components required, such as water and carbon dioxide, with the evolution of oxygen).

Part of the chemical energy is stored by green plants, then is absorbed by herbivores, and then carnivores eat herbivores. The remains of dead organic matter formed after the death of living organisms or their metabolic process (e.g., dead branches, leaves, etc.) are destroyed by the destructors (especially microorganisms) and come with a certain speed to the soil, water, air, and are again included into the biotic circulation. At this stage the substance is excluded from the biotic turnover, and with the help of geochemical processes fixed in sediments or transferred to the ocean.

Materials in ecosystem, do not get lost but recycle again and again. Materials locked up in living bodies return to the abiotic environment after the death of the living beings. These materials are again picked up by plants to produce new biomaterials. This cyclic passage of inorganic materials from the abiotic environment into the biotic bodies and return from these to the abiotic environment again is known as Bio-Geo Cycle of Chemicals. This process is repeated again and again in nature as an unending cycle

Biogenic elements

Living organisms are made up of chemicals based mostly on the element carbon. Carbon enters the biosphere through the action of plants and other photosynthetic organisms. Plants use solar energy to transform atmospheric CO2 into the molecules of life, which are then taken in by plant-eating animals. Of all the chemical elements, carbon is unparalleled in its ability to form molecules that are large, complex, and varied, making possible the diversity of organisms that have evolved on Earth. Proteins, DNA, carbohydrates, and other molecules that distinguish living matter from inanimate material are all composed of carbon atoms bonded to one another and to atoms of other elements. Hydrogen (H), oxygen (O), nitrogen (N), sulfur (S), and phosphorus (P) are other common ingredients of these compounds, but it is the element carbon (C) that accounts for the enormous variety of biological molecules.

Macroelements are elements found in almost all of Earth`s living systems. There are 11 of them. Six are colled organogens ore major biogenic elements. The content of them is 97% in the organism.

Major Biogenic Elements or Organogens: Carbon, Hydrogen, Oxygen, Nitrogen, Sulfur, Phosphorous.

Minor Biogenic Elements: Sodium, Potassium, Magnesium, Calcium, Chlorine.

Microelements are essential elements necessary only in very small quantities to maintain the chemical reaction on which life depends. These are **Biogenic Trace Elements**: Manganese, Iron, Cobalt, Copper, Zinc, Boron, Aluminum, Vanadium, Molybdenum, Iodine, Silicon, Nickel, Bromine.

Water cycle

Water is a major content of the bodies of living beings Water contents ranges from 50% or so in hardwoods to 95% or more in jelly fishes. Without water life would not be possible.

The journey of water from the living to the non-living and back to living takes the following route. Water comes out from the living systems through respiration, transpiration, perspiration, metabolism and decomposition after death. Water from these evaporate, go into the atmosphere and form part of the cloud formations. In the meantime simultaneously due to solar radiation, water constantly evaporates from sea, land, rivers, lakes etc. to form the bulk of the clouds. These cloud masses are carried along with wind currents and when situation favors (mainly due to drop of temperature) condense into water droplets and come down to earth either as rain or snow. Rainwater moistens the earth.

From moist soil, plants take in water and other nutrients so that biosynthesis continues. Not all clouds rain on lands. In fact most clouds rain on seas, some only on lands and the remaining come down as snows on mountain tops, polar regions and cold temperate zones. Mountain snows melt in summer and feed the rivers. Part of the water from snow leaks into the soil and nourish the ground water. Not all rainwater that falls on land enters the plants. Most of it however enters the soil to recharge the ground water system or aquifers and some evaporate to feed the clouds and the rest feed the rivers. Ultimately all the ground water flows into seas. Thus gradually with time, all water in the clouds find their way back into the seas. From sea the cycle starts again.

When we sink deep tube wells and suck out large quantities of water for housing projects in towns and intensive agriculture, we deplete the aquifers more than the normal recharging during the monsoons and consequently the water table gets lowered. Unless we recharge the aquifers adequately during monsoon with proper water management, the groundwater will be further depleted with consequent havocs in various areas and countries. India is already suffering for neglecting the above principle.

The amount of energy involved in the changing state of water is very large indeed. Energy used in changes of state plays an important role in the global circulation of energy, which drives the Earth’s climate. The energy source which drives the hydrological cycle is solar radiation. Over the temperature range found across much of the Earth’s surface, water can exist freely in liquid and vapour states. As water is relatively plentiful in the biosphere, the changes of state which characterise the hydrological cycle function might seem to have more significance for climatic and geomorphic systems than for ecosystems. But this is not so. Apart from the fact that climate and land forms are a major element in the abiotic environment of ecosystems, water in terrestrial environments is often relatively scarce. Without a rapid and effective cycling system most parts of the land surface of the planet would be unable to support any autotrophic plants, and thus would be devoid of life. Therefore the ambient temperature of the Earth’s surface is critical, by allowing water to be moved quickly from the world ocean to land surfaces through the processes of evaporation and condensation. Water in the world ocean contains about 3.5 per cent of dissolved salts, mainly sodium chloride. Although marine plants are fully adapted to use this type of water, terrestrial plants require and receive much purer water. The process of evaporation affects only pure water, leaving behind soluble salts. Rain-water picks up some dissolved material and solid particulate aerosol material, such as dust, in its passage through the atmosphere. However, compared with sea water it is relatively chemically pure. This is the condition required by nearly all land plants.

Carbon cycle

The cycling of carbon is closely linked to energy flow through ecosystems. Indeed, we sometimes refer to life on Earth as being carbon based, because the organization of energy upon which life depends is done, to a large extent, through the combination and breakdown of carbon compounds. The carbon cycle has four types of pools; like the hydrological cycle, these are of very different sizes.

The lowest part of the atmosphere, the troposphere, is a fairly constant mixture of gases, of which carbon dioxide comprises 0.039%. However, this is quite sufficient to sustain terrestrial plant productivity, and other limiting factors, such as water or nutrient supply, normally act as controls on production rates. Carbon dioxide is soluble in water, and makes carbonic acid, which is very weak and dissociate to form bicarbonate (HCO_3^-) and hydrogen (H^+).

Most of the carbon in the world ocean is in the form of carbonates. Some of this is converted into carbon dioxide, and respiration by marine organisms contributes carbon dioxide to the atmosphere too. Marine photosynthesis uses dissolved carbon dioxide obtained directly from water, so that the gas form is the available state for both land and aquatic autotrophs. A large part of the oceanic carbonate is converted into sediment over geological time scales. Such sediments include limestone and chalk, which through the long-term evolution of the Earth’s crust may be raised and weathered, thereby releasing carbon dioxide into the atmosphere. Very large quantities of carbon are locked in carbohydrate-rich organic material which has been converted by geological processes into sediments or trapped fluid residues. These are the fossil fuels. The global pool of coal, oil and natural gas accounts for more than 20 per cent of the biosphere and near lithosphere total of carbon. Under normal circumstances release of this material, which is located in the upper part of the Earth’s crust beneath both land and sea surfaces, is very slow. However, human use of these materials has accelerated at such a rate over the past 200 years that the almost instantaneous return of carbon dioxide to the atmosphere by combustion is having a significant effect on the carbon cycle, and thus upon environmental conditions in general. Burning fossil fuels releases the energy which had been fixed by plants in bygone geological times. It also decomposes geologically altered carbohydrates into carbon dioxide, water and some residual compounds. The resultant increase in atmospheric carbon dioxide causes increasing temperature in the troposphere due to the infra-red energy capture properties of CO_2. As levels of carbon dioxide can be measured with some precision, we know that atmospheric content has increased about 15 per cent in the past 200 years.

The final pool in the carbon cycle is the carbon content in current organic matter.

Nitrogen cycle

Nitrogen is an important component of all proteins, and thus is vital to all plant and animal life. Just as plants are vital because of their ability to convert carbon dioxide and water into plant organic matter (food for animals) in the carbon cycle, they are also vital because of their ability to convert inorganic nitrogen in the soil into organic nitrogen (plant proteins).

Nitrogen has many valence states available and can exist in the environment in a number of forms, depending upon the oxidizing ability of the environment. The oxides of nitrogen represent the most oxidized and least thermodynamically stable forms. These exist only in the atmosphere. Ammonia can exist in gaseous form in the atmosphere but rather rapidly returns to the soil and waters as ammonium, NH_4^+ . Fixation of atmospheric N_2 by leguminous plants leads to ammonia, NH_3. In aerobic soils and aquatic systems NH_3 are progressively oxidized by micro-organisms via nitrite to nitrate. The latter is taken up by some biota and used as a nitrogen source in synthesizing amino acids and proteins, the most thermodynamically stable form of nitrogen. After the death of the organism, microbiological processes will convert organic nitrogen to ammonium (ammonification) which is then available for oxidation or use by plants. Conversion of ammonia to nitrate is termed nitrification, whilst denitrification involves conversion of nitrate to N_2.

It is interesting to note that substances involving relatively small fluxes and burdens can have a major impact upon people. Thus nitrogen oxides, NO, NO_2, and N_2O are very minor constituents relative to N_2 but play major roles in photochemical air pollution (NO_2), acid rain (HNO_3 from NO_2), and stratospheric ozone depletion (N_2O).

Many human activities have a significant impact on the nitrogen cycle. Burning fossil fuels, application of nitrogen-based fertilizers, and other activities can dramatically increase the amount of biologically available nitrogen in an ecosystem. And because nitrogen availability often limits the primary productivity of many ecosystems, large changes in the availability of nitrogen can lead to severe alterations of the nitrogen cycle in both aquatic and terrestrial ecosystems.

In terrestrial ecosystems, the addition of nitrogen can lead to nutrient imbalance in trees, changes in forest health, and declines in biodiversity. With increased nitrogen availability there is often a change in carbon storage, thus impacting more processes than just the nitrogen cycle. In agricultural systems, fertilizers are used extensively to increase plant production, but unused nitrogen, usually in the form of nitrate, can leach out of the soil, enter streams and rivers, and ultimately make its way into our drinking water.

Much of the nitrogen applied to agricultural and urban areas ultimately enters rivers and nearshore coastal systems. In nearshore marine systems, increases in nitrogen can often lead to anoxia (no oxygen) or hypoxia (low oxygen), altered biodiversity, changes in food-web structure, and general habitat degradation. One common consequence of increased nitrogen is an increase in harmful algal blooms (sometimes called eutrophication). Toxic blooms of certain types of dinoflagellates have been associated with high fish and shellfish mortality in some areas. Even without such economically catastrophic effects, the addition of nitrogen can lead to changes in biodiversity and species composition that may lead to changes in overall ecosystem function. Some have even suggested that alterations to the nitrogen cycle may lead to an increased risk of parasitic and infectious diseases among humans and wildlife. Additionally, increases in nitrogen in aquatic systems can lead to increased acidification in freshwater ecosystems.

The phosphorus cycle

Phosphorus is an essential nutrient for animals and plants. It plays a critical role in cell development and is a key component of molecules that store energy, such as ATP (adenosine triphosphate), DNA and lipids (fats and oils). Insufficient phosphorus in the soil can result in a decreased crop yield.

Unlike other elements cycle in nature, there is no phosphorus in gaseous form. Another feature of the phosphorus cycle is that the natural compounds of this element slightly soluble or near insoluble.

Phosphorus moves in a cycle through rocks, water, soil and sediments and organisms.

Here are the key steps of the phosphorus cycle:

- Over time, rain and weathering cause rocks to release phosphate ions and other minerals. This inorganic phosphate is then distributed in soils and water.
- Plants take up inorganic phosphate from the soil. The plants may then be consumed by animals. Once in the plant or animal, the phosphate is incorporated into organic molecules such as DNA. When the plant or animal dies, it decays, and the organic phosphate is returned to the soil.
- Within the soil, organic forms of phosphate can be made available to plants by bacteria that break down organic matter to inorganic forms of phosphorus. This process is known as mineralization.
- Phosphorus in soil can end up in waterways and eventually oceans. Once there, it can be incorporated into sediments over time.

The phosphorous cycle is affected by human activities. Although phosphorous is normally a limiting nutrient, most agricultural fertilizers contain phosphorous. Run-off and drainage from farms can flood aquatic ecosystems with excess phosphorus. Artificial phosphorous can cause over growth of algae and plants in aquatic ecosytems. When the excess plant material is broken down, the decomposing bacteria can use up all the oxygen in the water causing dead zones.

The energy balance

All substances conversion processes during cycles require energy. Living organisms for its existence must also constantly consume and replenish energy. None of organism is capable to produce energy, it may only be obtained from the outside. The primary source of energy used by the biosphere, is the sun.

From the Sun Earth receives about 99% of its energy, and this amount is about $4 * 10^{-9}$ of the total energy emitted by the sun.

On average about 30% of the radiation which has reached the planet dissipates in the atmosphere. About 20% is absorbed by the atmosphere. About 50% of the solar radiation, which reached the planet, reaches the land surface and the oceans. Part of this radiation is reflected directly back into space.

During photosynthesis flowing in green plant cells, it binds only about 0.02% of the energy received from the sun. More than half of the energy associated with photosynthesis, immediately consumed during respiration of the plants themselves.

And this tiny amount of energy received from the Sun, it is sufficient for the existence of our entire biosphere.

There is a one-way flow of energy in an ecosystem: During photosynthesis, plants convert energy from sunlight to chemical energy (stored in food molecules such as sugars), which is used by plants and other organisms to do work and is eventually lost from the ecosystem as heat.

Light is a form of energy known as electromagnetic energy, also called electromagnetic radiation. Although the sun radiates the full spectrum of electromagnetic energy, the atmosphere acts like a selective window, allowing visible light to pass through while screening out a substantial fraction of other radiation. The part of the spectrum we can see—visible light—is also the radiation that drives photosynthesis.

The properties of energy can be understood by following the basic laws of thermodynamics.

The First Law of Thermodynamics states that energy can neither be created nor destroyed; it can only change from one state to another.

The Second Law states that at every step of conversion Id Est change from one state to another some energy will be invariably lost (or dissipated) into the environment. Consequently energy will always flows from a higher level to a lower level

The Third Law states that Nature if left to herself tends to lose energy and thus gradually sink to more and more disorder. In thermodynamics this is known as entropy. In short, third law implies that without constant input of energy order tends to disorder.

The decay of bodies after death can be easily understood through this third law. To remain alive a living being requires constant input of energy. This energy is obtained through respiration followed by several subsequent metabolic processes. If the respiration is stopped then, soon the animal dies. The same thing happens with waterlogging of plant roots. After death when no longer energy could be supplied hence decay Id Est breakdown of tissues take over. So death simply means cessation of energy input.

Photosynthesis is a process used by plants and other organisms to convert light energy into chemical energy that can later be released to fuel the organisms' activities

We can write the overall reaction of this process as:

$$6H_2O + 6CO_2 \rightarrow C_6H_{12}O_6 + 6O_2$$

Along with photosynthesis of higher plants and algae, followed by release of O_2, in the nature of bacterial photosynthesis is carried out, wherein the oxidizable substrate is not water but other compounds having a more pronounced reducing properties, for example sulfur dioxide and hydrogen sulfide. Oxygen in bacterial photosynthesis is not allocated, for example:

$$2H_2S + CO_2 \rightarrow 2S + [CH_2O] + H_2O$$

Thus, in the process of photosynthesis radiation energy is converted into chemical energy of carbon compounds.

In the future, these high-energy compounds are cleaved again to form carbon dioxide and water with release of energy. The processes of organic compounds oxidation by oxygen in the air are called breathing. Respiration - a source of energy consumed by the cell for all its needs. Plants also breathe, and breathe day and night, while the photosynthesis occurs only in the daytime.

Breathing and combustion have the same nature. Fuel, or oxidizing agents, interact with oxygen consumed by the body from the air and burns to form carbon dioxide and water:

$$\text{Organic matter (food)} + O_2 \rightarrow C0_2 + H_2O + \text{energy}$$

Released energy is converted into chemical energy which is then used in all physico-chemical processes occurring in the living body, - the processes of synthesis of proteins and nucleic acids, transport agents and direct the movement and operation of the muscles.

Thus, photosynthesis and respiration **-** are two opposite processes in the natural environment, which form the basis of energy processes in the biosphere.

The energy synthesized and stored by autotrophs (or. green plants) during photosynthesis, gradually passes through various heterotrophs (i.e. herbivores and carnivores) i.e. secondary and tertiary producers and so on till the entire quantity of solar energy trapped by the plants is released back into the environment. This particular pathway of stored energy through an ecosystem is called Energy Circuit or Energy Pathway

The transfer of energy contained in the plants through a series of other organisms as a result of eating each other, called the **food chain.**

Several food chains, connected with each other called food web.

More complex food webs form a more stable ecosystem, because with the disappearance of one species its place in the food chain take the others and the ecosystem continues to function.

According to the trophic relations of all organisms are divided into three groups:

- producers – which produce the primary organic matter;

- consumers (1 level and 2 level), who consume organic compounds;

- decomposers - transform dead organic matter into inorganic compounds.

The transfer of solar energy from plants to animals however, is always partial, the unused energy being lost to atmosphere as heat. As a matter of fact in all such cases of transfers of energy from one form into another (here from plants to animals) are always accompanied with some loss of energy in the form of heat.

This progressive attrition of energy captured by plants, during its passage from plants through others such as herbivores, carnivores etc. till the energy is completely dissipitated, has led to the emergence of a very useful concept known as Pyramid of Life (or Ecological Pyramid). It can be 3 types (figure 3).

If we measure the amounts of energy fixed by one producer against another, preceeding or succeeding, according to a descending order i.e. parent producers occupying the lower rungs and the consumers the upper, we shall get an usual conical structure i.e a conical tetrahedron— the pyramid of energy. This means the base would be widest with the upper tiers successively narrower (figure 4). While the pyramids of energy of any ecosystem will always look normal i.e. base wide and the tip narrow, but other types of ecological pyramids of the same ecosystem such as, pyramid of biomass and pyramid of number may not always look so.

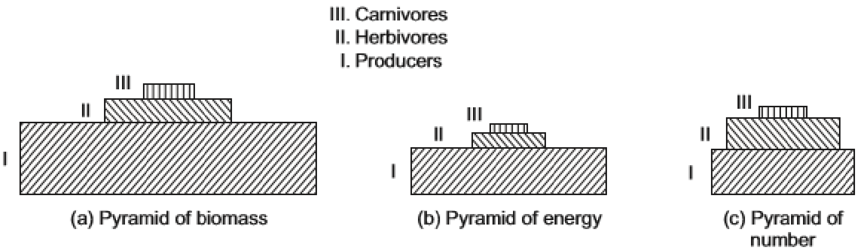


Fig.3 - Ecological pyramids, a- biomass, b- energy, c - number

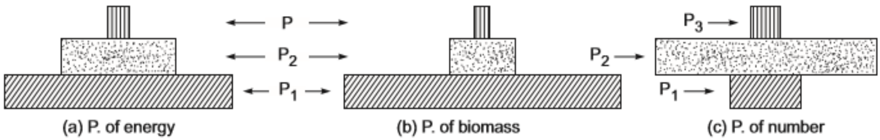


Fig. 4 - Ecological pyramids of the same ecosystem–i.e. a tropical rainforest but using three different parameters—a. energy, b. biomass and c. number.

In this ecosystem (tropical rainforest) P1 are trees, P2 are insects and P3 are birds. While the pyramid of energy (a) for any ecosystem will look normal i.e. like a conical tetrahedron but the pyramids of biomass (b) or number (c) however may not look normal for all ecosystems. For example here the ecosystem being a forest the P1 are trees, P2 are insects (mostly) P3 are birds mainly. So here necessarily the pyramid of number (c) is an inverted one. In another type of ecosystem say, the Afrikan savanna the P1 mainly consists of grasses and a few trees, P2 of deers, wildebeests and zebras and P3 of Lions, Cheetahs and Hyenas. Here the Pyramids (a), (b) and (c) all look normal i.e. will have a normal pyramidal shape (conical tetrahedron). Therefore it should be remembered that for a comparative study of one ecosystem with another, the pyramids of energy are most reliable.

Each food chain within a food web is usually only a few links long. In fact, most food webs studied to date have chains consisting of five or fewer links. The most common explanation, the energetic hypothesis, suggests that the length of a food chain is limited by the inefficiency of energy transfer along the chain. Only about 10% of the energy stored in the organic matter of each trophic level is converted to organic matter at the next trophic level . Thus, a producer level consisting of 100 kg of plant material can support about 10 kg of herbivore biomass and 1 kg of carnivore biomass.

Another factor that may limit food chain length is that carnivores in a food chain tend to be larger at successive trophic levels. The size of a carnivore and its feeding mechanism put some upper limit on the size of food it can take into its mouth. And except in a few cases, large carnivores cannot live on very small food items because they cannot obtain enough food in a given time to meet their metabolic needs.

Questions:

1. What are the biocenocis, biotope?
2. What are the Minor Biogenic Elements?
3. What are the Major Biogenic Elements or Organogens?
4. Draw schematically the water cycle.
5. Draw schematically the carbon cycle.
6. Draw schematically the Nitrogen cycle.
7. Draw schematically the phosphorus cycle.
8. Write the reaction of photosynthesis for the green plants.
9. Write the reaction for bacterial photosynthesis.
10. What is a food chain?
11. How can be divided all organisms according to the trophic relations?
12. Which 3 types of the ecologic pyramids do you know?

Theme 4. Change of natural communities

A variety of natural conditions on our planet leads to different types of ecosystems formation in different regions.

Since the earth's surface is differentiated there are developed more or less separated complex of relationships between organisms and environmental factors.

Biomes are very large ecological areas on the earth's surface, with fauna and flora (animals and plants) adapting to their environment. Biomes are often defined by abiotic factors such as climate, relief, geology, soils and vegetation. A biome is not an ecosystem, although in a way it can look like a massive ecosystem. If you take a closer look, you will notice that plants or animals in any of the biomes have special adaptations that make it possible for them to exist in that area. You may find many units of ecosystems within one biome.

Biomes are defined as "the world's major communities, classified according to the predominant vegetation and characterized by adaptations of organisms to that particular environment".

There are five major categories of biomes on the Earth.

The Desert Biomes: They are the Hot and Dry Deserts, Semi Arid Deserts, Coastal Deserts and Cold Deserts.

The Aquatic Biomes: Aquatic biomes are grouped into two, Freshwater Biomes (lakes and ponds, rivers and streams, wetlands) and Marine Biomes (oceans, coral reefs and estuaries).

The Forest Biomes: There are three main biomes that make up Forest Biomes. These are the Tropical Rainforest, Temperate and Boreal Forests (also called the Taiga)

The Grassland Biomes: There are two main types of grassland biomes: the Savanna Grasslands and the Temperate Grasslands.

The Tundra Biomes: There are two major tundra biomes—The Artic Tundra and the Alpine Tundra.

It should be noted that in addition to the main types of biomes there are exist many transition forms

Ecosystem lives and develops as a single unit. In nature less stable ecosystem eventually replaced by more stable. Their change is determined by three factors:

1. An orderly process of the ecosystem development - the establishment of stable relationships between species in it;
2. Changes in climatic conditions;
3. Changes in the physical environment under the influence of organismal activity.

Ecological succession, is the process by which the structure of a biological community evolves over time. Two different types of succession—primary and secondary—have been distinguished.

Primary succession occurs in essentially lifeless areas—regions in which the soil is incapable of sustaining life as a result of such factors as lava flows, newly formed sand dunes, or rocks left from a retreating glacier. Secondary succession occurs in areas where a community that previously existed has been removed; it is typified by smaller-scale disturbances that do not eliminate all life and nutrients from the environment.

During primary succession, the only life-forms initially present are often prokaryotes and protists. Lichens and mosses, which grow from windblown spores, are commonly the first macroscopic photosynthesizers to colonize such areas. Soil develops gradually as rocks weather and organic matter accumulates from the decomposed remains of the early colonizers. Once soil is present, the lichens and mosses are usually overgrown by grasses, shrubs, and trees that sprout from seeds blown in from nearby areas or carried in by animals. Eventually, an area is colonized by plants that become the community's dominant form of vegetation. Producing such a community through primary succession may take hundreds or thousands of years. Early-arriving species and later-arriving ones may be linked by one of three key processes. The early arrivals may facilitate the appearance of the later species by making the environment more favorable—for example, by increasing the fertility of the soil. Alternatively, the early species may inhibit establishment of the later species, so that successful colonization by later species occurs in spite of, rather than because of, the activities of the early species. Finally, the early species may be completely independent of the later species, which tolerate conditions created early in succession but are neither helped nor hindered by early species.

An example of **Secondary Succession** by stages:

1. A stable deciduous forest community
2. A disturbance, such as a wild fire, destroys the forest
3. The fire burns the forest to the ground
4. The fire leaves behind empty, but not destroyed, soil
5. Grasses and other herbaceous plants grow back first
6. Small bushes and trees begin to colonize the area
7. Fast growing evergreen trees develop to their fullest, while shade-tolerant trees develop in the understory
8. The short-lived and shade intolerant evergreen trees die as the larger deciduous trees overtop them. The ecosystem is now back to a similar state to where it began.

For development of community required a long period of time. So, for overgrowing of sand dunes - about 1000 years, for the resumption of timber - from 100 to 200 years, to restore the disturbed steppe vegetation cover - more than 50 years. As you can see, the secondary succession grows faster than the primary.

Populations

Decisive biotic components of natural ecosystems are not individual organisms but populations. Each species is a complex ecological system - a system of populations.

Different parts of the distribution range differ from each other not only geographically, but also by the composition of groups within a species. Each group has its own genetic, morphological and physiological characteristics. Such groups are called populations. Population - group of individuals of one species with a common gene pool, similar morphology and common united lifecycle.

One of the main characteristics of population - the free crossing of its individuals that determines evolutionary unity of population. Each population is characterized by:

1. Population density - numbers of population divided by total land area or water volume.

2. The genetic structure of population - determined by variability and diversity of genotypes frequencies of individual variations in gene - alleles, as well as the division of the population into groups of genetically similar individuals, among which there is a constant exchange of alleles.

3. Population Distribution. This aspect deals with how the individuals in a population are located relative to one another across the environment.

- Some populations have clumped distributions, with multiple, similarly sized groupings of individuals spread fairly evenly across the landscape.
- Other populations have a random distribution, with some clumping and some more even spreading of individuals.
- Still other populations have an even distribution

4. Sexual structure of populations - Genetic mechanism for sex determination of offspring provides splitting by sex in a ratio of 1: 1, so-called sex ratio. But it does not follow that the same ratio is typical of the general population. Sex-linked attributes often determine significant differences in physiology, ecology and behavior of males and females. Due to different vitality of male and female organisms this primary ratio is often different from secondary and especially tertiary - typical for adults.

5. Age structure of population - it's a summary of the number of individuals of each age in the population. Age structure is useful in understanding and predicting population growth.

Fertility and mortality, population dynamics are directly related to the age structure of population. Population consists of individuals different by age and sex. Each species, and sometimes each population has their own relation ages.

Usually there are three ecological age: pre-reproductive, reproductive and postreproductive.

Ecologists use graphs called age pyramids to depict the age structure of populations.

Fertility - the number of new individuals appearing in the population in per unit time based on a certain number of its members.

There are absolute and specific fertility. The first is characterized by the total number of individuals who were born. Specific calculated as the average change in the number per individual over a specified time interval

Different organisms have different strategies for reproduction. Some organisms produce a huge number of offspring once in their lifetime and then die or never reproduce again. This type of reproductive strategy is called "big bang reproduction," or, semelparous reproduction.

Many fish and insects experience this type of reproduction, including salmon and some species of spiders and butterflies.

Some organisms have only a few, or even a single, offspring at a time, but will reproduce multiple times throughout their lives. Most large mammals, including humans, and many insects utilize this reproductive strategy, called iteroparous reproduction. some organisms have mixed strategy between semelparity and iteroparity reproduction.

In addition to various reproductive strategies, organisms differ in their survivorship strategies. Some organisms are at high risk of dying early in life, but danger lowers as they become older. Some have same risk of death through al life, and some species have low risk to die because of environmental factors and their main cause of death is old age.

High reproductive capacity plays an important role in survival of species. Populations that have reduced their number can recover quickly under favorable conditions. Some species only by mass reproduction can withstand predation of different enemies. The high rate of reproduction contributes to the rapid development of new spaces.

However, the unlimited reproduction dangerous for any population, because it can lead to a rapid erosion of resources, lack of food, shelter, space and so on. and will lead to a weakening of the population. Overcrowding is so dangerous for any species that most of them have evolved a variety of mechanisms that prevent excess individuals and maintaining a certain level of population density.

The mortality rate in the population also depends on many factors: genetically programmed lifespan of individuals, their genetic and physiological usefulness, influence of unfavorable natural conditions of the environment, the impact of predators, parasites and diseases and so on.

In practice, when it is necessary to analyze the mortality progress in populations, researchers make the survival table, where for each age group are specified empirically obtained data describing the death of individuals of a given age. On the basis of these tables comprise **curves of survival** (figure 5), to predict the state of the next generation in similar conditions.

The most common variant in nature **-** high death of young animals. Adult forms are more protected and strong. Mortality curve of such populations drops sharply to the horizontal axis at the beginning.

Example – biggest part of fish species, rodents, plants and other. Humans also had high infant mortality rate trough all history, which has fallen sharply since the successful development of medicine.

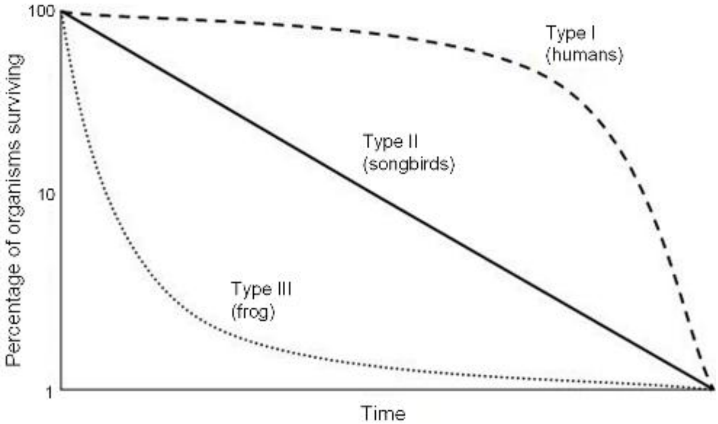


Fig. 5 - Three idealized types of survival curve

Now we have other type of survival curve, but in our genetic memory, we have previous one. This is the cause of overpopulation of the Earth.

If a species is suffers under indiscriminate mass elimination, or death from many enemies, which he is powerless to avoid or if it suppressed other extreme circumstances, the only direction of selection becomes high fertility. In a case of indiscriminate elimination differences between individuals don't play any role for their survival.

When there is selective elimination, and survival of animals depends on their individual features, there starts natural selection and evolution of organisms.

At the end of the 60s there was a theory of **r-strategy and k-strategy**, this terminology of r/K-selection was coined by the ecologists Robert MacArthur and E. O. Wilson.

r/K selection theory describes to the selection of combinations of traits in an organism that trade off between quantity and quality of offspring. Of course, in nature there are many transitional forms of survival strategies.

Limiting factors of the environment

Habitat of an organism - a combination of abiotic and biotic conditions of his life.

Organisms on Earth have mastered the following habitats: aquatic, air-terrestrial, soil and bodies of other organisms

Features or elements of the environment, which affects on individual are called environmental factors.

There are:

Abiotic factors - wind, currents, the terrain - all the properties of inanimate nature, which directly or indirectly affect the living organisms

Biotic factors - impact of living beings to each other.

Anthropogenic factors - the forms of human society activity, which lead to a change in a habitat of other species, or have a direct impact on their lives.

A **limiting factor** is that substance of quality in the environment, the supply of which is least abundant or over abundant in relation to the need of the living organism concerned.

Limiting factors are of two types on the basis of their correlation with population density: the density dependent limiting factor; the density independent limiting factor.

The Density Dependent Limiting Factor:

The effect of such type of limiting factor has direct correlation with population density. The influence of limiting factor increases with the increase in population density. For example, food supply is density dependent. Higher the population density lower food will be available to eat and higher will be food scarcity.

The Density Independent Limiting Factor:

The effect of such type of limiting factor is limited to many or few individuals without reference to the population level. For example, flood is density independent. It may wipe out entire population of a species whether these are few or many.

Besides, the other limiting factors which influence living organisms are the various environmental factors. The environmental factors may be abiotic or biotic. The abiotic factors are either physical factors (light, temperature, water, soil, wind, etc.) and chemical factors (nutrients).

Laws of Limiting Factors

To explain the effect of different limiting factors on living organisms, a number of laws and principles are proposed by different scientists which may be described as follows:

1. Liebig's Law of Minimum:

The law was suggested by Jestusvon Liebig in 1840. After doing a series of experiments on the effect of inorganic nutrients on growth of crop plants, he suggested that the growth of a plant is limited whenever the essential nutrients were in short supply, in comparison to the minimum need of the plants. This observation was proposed in the form of the law of minimum.

This law states that an organism requires minimum quantity of a particular nutrient for its proper growth. For example, plants will either not grow at all or exhibit poor growth if any nutritive component of the soil or air is deficient.

The nutrient deficiency makes the other nutrients metabolically inactive. Subsequently, the law has been used in a broader sense to include limitations imposed by other factors of environment and it was modified as follows:

"If the factor is depleted below the critical minimum level the organism will fail to grow or will grow abnormally".

2. Blackman's Law of Limiting Factor:

The law was proposed by F.F Blackman in 1905. Blackman extrapolated the law of minimum including both deficient and controlling factors. He studied the process of photo-synthesis in detail and suggested that the process is controlled by five important factors.

These are—the availability of the quantity of water, the quantity of carbon-dioxide, the intensity of solar radiation, the quantity of chlorophyll and the temperature of chloroplast. A deficiency of any of these factors will affect the rate of photo-synthesis.

From the above experimental observations, he suggested the law of limiting factors which states that a biological process is controlled by a number of factors and deficiency of any of these factors, will affect the process.

3. Shelford's Law of Tolerance:

It Shelford in 1913 extended the concept of limiting factor so as to include the limiting effects of maximum as well as minimum quantity of a factor on organisms. This concept of Shelford is known as Shelford's Law of Tolerance (figure 6).

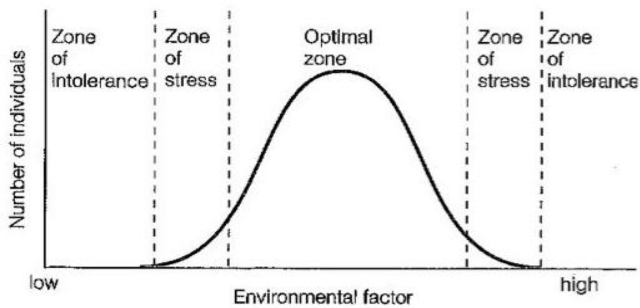


Fig.6 - Shelford's Law of Tolerance

According to him, not only less amount of a factor can be limiting but also the excess amount of the same factor can be limiting to the growth and development of an organism. For example, carbon dioxide is necessary for photo-synthesis, but if concentration of the gas becomes considerably higher it would be toxic for the plant.

Thus, every organism has an ecological minimum and maximum for every factor and the range between these two limits is known as limits of tolerance or zone of tolerance. In other words, any factor which is below or above the zone of tolerance, for an organism or community may be taken as the limiting factor for the same. The zone beyond or prior to the range of tolerance is known as zone of intolerance.

According to this law, every environmental factor has several zones:

Zone of Tolerance:

This zone is favorable for the growth and development of the organism which may be further subdivided into three sub-zones:

Optimum Zone:

It is the most favorable zone for the growth and development of organism. The temperature of this zone is called optimum temperature of organism.

Critical Minimum Zone :

It is the lowest minimum limit of temperature below which the growth and development of the organism ceases and organism becomes non-functional.

Critical Maximum Zone:

It is the highest maximum limit of temperature above which the growth and development of the organism ceases.

Zone of Intolerance:

It is the zone below the critical minimum and above critical maximum. This zone is unfavorable for the survival of the organism for a longer period of time.

There is a variation of tolerance from species to species with respect to a particular factor. An organism may have narrow range of tolerance for one factor but wide range of tolerance for other factor.

Organisms having wide range of tolerance for all factors have better chances for survival and are widely distributed. By combining the idea of the minimum and the concept of limits of tolerance, a more general and useful concept of limiting factors can be obtained.

Thus, in the environment, the organisms are controlled by:

-The quantity variability of materials for which there is a minimum requirement.

- The physical factors which are critical.

- The limits of tolerance of the organisms themselves to these and other components of environment.

Questions:

1.What is a Biome? Which kinds of biomes you do know?

2. What is the ecological succession? What is the primary succession? Give an example.

3. Give the definition of a population. Name the main characteristics of a population.

4. What is the secondary succession? Give an example.

5. What is the age structure of a population? Name 3 ecological age for age structure.

6. What is the fertility? Which types it can be?

7. What are the curves of survival? Draw a picture.

8. What are the r-strategy and k-strategy?

9. Which kinds of environmental factors you do know?

10. What is the Liebig's Law of Minimum?

11. What is the Blackman's Law of Limiting Factor?

12. Make a picture of the « Law of Tolerance »

Theme 5. Environmental pollution

At the end of the second millennium because of population growth, science and technology development there is a big anthropogenic impact on the biosphere. Its level can be compared with natural disaster.

landscape transformations in cities and other human settlements, agricultural land and industrial complexes have covered more than 20% of the land area.

The volume of material transported in production processes currently much higher than matter, involved in the natural relief-forming processes.

Nowadays the anthropogenic interference is becoming a guiding force for further evolution of ecosystems.

Anthropogenic impacts can be divided into:

- Pollution – emission of uncharacteristic physical, chemical or biological agents into the environment or exceeding of its natural levels

- Technical conversion and destruction of natural systems and landscapes - in the process of natural resources extraction in agricultural work, construction, etc .;

- Depletion of natural resources (minerals, water, air, biological components of ecosystems);

- Global climate impacts (the climate change due to human activities);

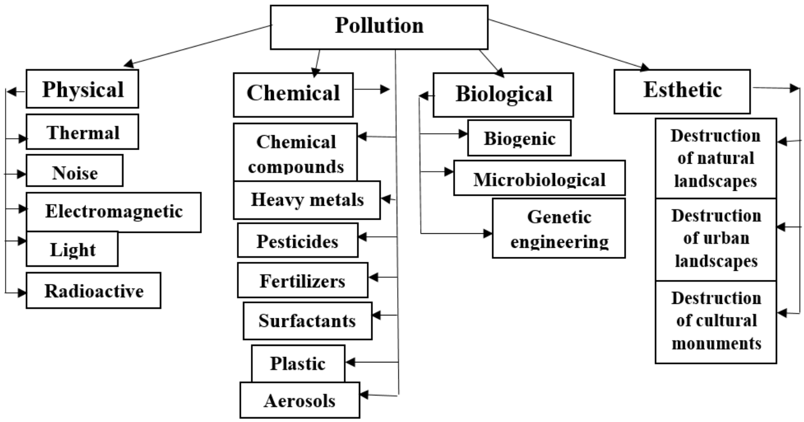
- esthetic destruction (changing of natural forms, unfavorable for visual and other perceptions, the destruction of historical and cultural values, etc.).

It should be noted that pollution can be natural, resulting from natural processes, powerful volcanoes emissions with huge mass of dust, ash, gas, steam and so on.; forest and steppe fires; floods; dust and sandstorms, etc.

Pollutant - any physical agent, chemical or biological species entering the environment or arising in it in amount out of the ordinary, and causing pollution.

Environmental pollution - adding of new, not typical for it physical, chemical and biological agents or excess of their natural level (picture 7).

If the up to 40-ies of XX century natural products has dominated (cotton, silk, wool, soap, rubber, food free of additives and etc), now in the industrialized countries they are replaced by synthetic compounds, which are difficult to break down and it is the cause of environmental pollution.



Pic. 7 -The main types of anthropogenic pollution

A particularly large amount of pollutants formed by receiving energy from the burning of fossil fuels.

Approximately the same number of environmental pollutants is produced in agriculture. For example, there are more than 1500 pesticides products in the world.

All pollution is divided into four main groups: physical, chemical, biological and esthetic.

Physical pollution is associated with changes in physical, temperature-energetical, wave and radiation parameters of the environment. Thus, the thermal effect is shown, for example, in degradation of permafrost, a change in the structural characteristics of certain soils at high temperatures (under metallurgical furnaces, brick factories, and so on.)

Changing thermal regime of rivers due to the discharge of heated wastewater. There are ice-free areas, leading to a change of life cycles of fish and river birds

The sources of thermal pollution in the city are: underground gas pipeline, heating mains, sewers and communications, and so on.

Pollution includes the impact of noise and electromagnetic radiation, and sources of the latest are high-voltage power lines, electrical substations, radio antennas and television broadcasting stations, and more recently microwave ovens, computers, cordless phones.

It was found that long-term impact of the electromagnetic fields, even in healthy people causes fatigue, headaches, feeling of apathy.

Chemical pollution is an increasing number of chemical components in a particular environment, as well as spread of non-characteristic chemical substances, in concentrations, which exceed the normal rate.

This kind of pollution is the most dangerous for natural ecosystems and quality of human life.

Biological pollution is a random or related to human activities penetration of alien plants, animals and micro-organisms (bacteriological) in to exploited ecosystems and devices, as well as in natural ecosystems. Biological contamination includes deliberate or accidental colonization, or excessive multiplication of organisms. For example it is the well-known relocation of rabbits and sheep in Australia.

In addition, presence of dumps and untimely cleaning of solid domestic wastes in cities has brought to numerical growth of scavengers animals, such as rats, pigeons, crows, insects and others.

Esthetic pollution - it is usually associated with human activities deliberate or accidental visual changes in natural or man-made landscapes. Esthetic pollution of anthropogenic origin is almost always associated with the construction (urban planning and hydraulic engineering) activities, mining, agriculture, and so on. This pollution has negative effect on parameters that define the quality of human life, sometimes even causing psychophysical disorders, and other changes in people's health.

Of all the human impacts pollution factor has the most significant destructive nature, which leads to a permanent change in certain ecosystems and the biosphere as a whole, and to the loss of material assets (agricultural products, etc.), energy, human labor.

However, a great harm is caused by technical transformation and destruction of natural systems through urban planning process, road, hydraulic, energy and other types of construction and so on.

For example, construction and paving of large areas in the cities, not only remove some earth's surface from natural circulation, but also significantly change hydrogeological characteristics of the area, changing the direction and volume of surface flow.

Air pollution

The natural sources of pollution include volcanic eruptions, dust storms, forest fires, dust particles of the space origin, sea salt, vegetable, animal and microbial products. Level of air pollution, which creates impurities from natural sources, called the background, it usually has a small deviation from the medium-long-term value.

The main natural process of the atmosphere pollution - the Earth's volcanic activity. Large volcanic eruptions lead to global and long-term air pollution. This is due to the fact that in the upper layers of the atmosphere there are instantly ejected huge amounts of gas, which are picked up at high altitude by high speed air flow and quickly spread across the globe. Duration of contaminated atmosphere state after major volcanic eruptions is up to several years.

Anthropogenic contamination has different kinds of diversity and multiplicity of their emission sources.

Anthropogenic sources of pollution are caused by human activities. These include:

1. Combustion of fossil fuels
2. The work of thermal power plants
3. Emissions of modern turbojet aircraft
4. Emissions from cars.
5. Production activity.
6. Pollution of suspended solids (by grinding, packing and loading, from boilers, power plants, mine shafts, quarries waste incineration).
7. Industrial emissions of various gases.
8. Fuel combustion in boilers
9. Air emissions with excessive ozone concentration from high-energy devices (accelerators, ultraviolet sources and nuclear reactors).

The atmosphere impurities come as solid and liquid particles, gases and vapors.

Gases and vapors are form with air mixtures, solid and liquid particles - aerosols (dispersed systems) which are subdivided into dust (particle sizes greater than 1 micron)smoke (particle sizes less than 1 micron) and fog (the size of liquid particles less than 10 microns). Dust, in its turn, can be coarse (particle size more than 50 microns), medium size (50-10 microns) and fine (less than 10 microns).

The main chemical impurities, polluting the atmosphere, are the following|:

Carbon dioxide (CO_2) - the most large-tonnage anthropogenic pollutant. It is a colorless gas with sour smell and taste, the result of carbon product full oxidation (burning of coal, oil, gas, and so on.). Part of the CO_2 released into the atmosphere is involved in photosynthesis, and the excess part of it is involved in creation of the greenhouse effect.

Carbon monoxide (CO) is a gas with no smell, color and taste. It is formed due to incomplete combustion of the carbonaceous fuel (because of the lack of oxygen) and at low temperature.

65% of all carbon monoxide emissions come from transport, 14% - from industry, and 21% - from domestic sector and small consumers. Proceeding in to the lungs, the CO forms stable compounds with hemoglobin, thereby blocking the flow of oxygen into the blood.

Sulfur dioxide (SO_2) is formed during the combustion of fuels containing sulfur, as well as in processing of sulfurous ores (involving oxygen) at high temperature. The global emission of SO_2 is estimated at almost 200 million tonnes a year. Its concentration is particularly high in the areas of thermal power plants, metallurgical and ore-dressing plants. Sulphur dioxide is an active participant in acid rain formation. Prolonged or massive impact SO_2 on a human body can lead to inflammation and pulmonary edema, disruptions in cardiac, circulatory problems and even cessation of breathing.

Nitrogen oxides (NO and NO_2) are typically combined by general formula NOx. In all combustion processes where involved air at first level formed monoxide that sufficiently rapidly oxidized to nitrogen dioxide. It is a red-and-white gas with an unpleasant odor, and has a strong impact on human mucous membranes. It is estimated that the amount of nitrogen oxides entering the atmosphere is 65-70 million tons per year. Of all carbon monoxide emissions come from transport 55% , energy - 28%, industry - 14%, domestic sector and small consumers - 3%. In the atmosphere nitrogen dioxide rather quickly turns into nitric acid - a component of acid rain. In addition, in bright sunlight nitrogen oxides react actively with petrol vapor and other hydrocarbons to form low-atmospheric ozone. The consequence of these processes is the formation of smog. At concentrations above 0.15 mg / m3 occur acute respiratory diseases. In acute poisoning with nitrogen dioxide may develop pulmonary edema.

Ozone (O_3) - a gas with a characteristic odor, more energetic oxidizer than oxygen. Being the most toxic of all common air pollutants (hazard class 1), ozone is formed in the lower atmospheric layer (troposphere) by photochemical processes involving NO2 and volatile organic compounds (VOCs). As to the latter include over 200 chemical compounds, in the formation of ozone a photochemical smog occurs, consisting of hundreds of chemicals.

Among the air pollutants big share belongs to hydrocarbons -chemical compound of carbon and hydrogen. This are many thousands of substances that contained in unburned gasoline, fluids used in industrial and household solvents, and so on. The vast majority of hydrocarbons is harmful to humans. For example, hexane can cause severe damage to the nervous system, benzene can cause leukemia, butadiene exhibits a property of strong carcinogen. Often combined presence of some hydrocarbons dramatically increases the negative effects on a body.

Freons are fluorinated and chlorinated carbohydrates (CFCs) synthesized by man. They are relatively inexpensive, non-combustible and neutral, so earlier they were widely used as coolants in refrigerators and air conditioners, fire-fighting devices, in aerosol sprays, and so on. Going up into the stratosphere they actively destroy ozone.

Lead (Pb) - metal toxic in any known form. Lead and its compounds reduce the activity of the enzymes in human organism, disrupt the metabolism, and it has the ability to accumulate in tissues.

Dangerous anthropogenic factor which leads to deterioration of the atmosphere is radioactive dust contamination. So, in case of accidents at nuclear power plants (or nuclear explosions), most of the radionuclides are formed by the fission of uranium-235, uranium-238 and plutonium-239. Particular potential danger to humans and animals represents strontium-90 (half-life 29 years), not only as an long-lived isotope, but also as a calcium analogue, which is able to replace it in the bones.

During nuclear explosions radionuclides are in a gaseous state and with temperature decreasing are condensed into an aerosol cloud. The largest particles (diameter larger than 40 microns) are fall from the atmosphere and deposited on the surface. The fine particles (diameter from 1 to 20 microns) are goes not only in to upper troposphere but also in to the stratosphere, causing so-called global pollution accompanied by fallout of radionuclide within both hemispheres.

Aerosol pollution of the atmosphere

From natural and anthropogenic sources to the atmosphere come hundreds of millions tons of aerosols every year. Aerosols - a solid or liquid particles that are suspended in the air. Aerosols are divided into primary (emitted from contamination sources), secondary (formed in the atmosphere), volatile (carried over long distances) and nonvolatile (deposited on surfaces near the dust-gas-emission zones). The main sources of man-made aerosol pollution of the atmosphere are thermal power plants, which consume coal of high ash content, steel, cement, magnesia and soot plants, burning of residual oil products during pyrolysis process in refineries, petrochemical plants and other similar facilities. A constant source of aerosol pollution are industrial dumps which are artificial mounds of redeposited material, mostly overburden rock. The source of dust and poisonous gases are massive blasting works. Thus, as a result of one average weight explosion (250 - 300 tonnes of explosives) emits about two thousand cubic meters of carbon monoxide and more than 150 cubic meters of dust. Production of cement and other building materials is also a source of dust pollution of the atmosphere.

Acid rain

The term "acid rain" refers to all kinds of meteorological precipitation - rain, snow, hail, fog, rain and snow, the pH of which is less than the average pH of rainwater (average pH of rainwater is equal to 5.6). Produced during human activity a sulfur dioxide (SO_2) and nitrogen oxides (NOx) are transformed into acid-particles in the atmosphere. These particles react with atmospheric water, transforming it into acid solutions - sulfuric, sulfurous, nitrous and nitric. Then, together with snow or rain, they fall to Earth.

$$SO_x + H_2O \rightarrow H_2SO_3, H_2SO_4$$
$$NO_x + H_2O \rightarrow HNO_3, HNO_2$$

Global anthropogenic emissions of sulfur dioxide are more than 150 million tons in year. Acid rains are mostly observed in areas with developed industry. Although the water droplets are rapidly removed from the atmosphere, they still moved for hundreds of kilometers from the thermal plants producing emissions, industries, etc.

Acid rain has a negative impact on water bodies - lakes, rivers, creeks, ponds - by increasing their acidity to the point that flora and fauna in them die. Aquatic plants are grow best at pH values between 7 and 9.2.

With an increase of the acidity water plants begin to die, depriving local animals of food. At pH 6 pH die freshwater prawns. When the acidity increased to pH 5.5, die the bottom bacteria that decompose organic substances and leaves, and the organic debris begins to accumulate at the bottom. Then dies plankton -a tiny animal, which is the basis of the pond food chain and feeds on substances formed during the decomposition of organic matter by bacteria. When the acidity reaches a pH of 4.5, die all the fish, most frogs and insects.

The increased water acidity leads to the higher solubility of such hazardous metals as aluminum, cadmium, mercury and lead from sediments and soils. These toxic metals are dangerous to human health.

$$Pb(OH)_2 + 2\ HNO_3 \rightarrow Pb(NO_3)_2 + 2H_2O$$

A huge harm is caused by acid rain to forests. The forests wither and get dryness of the tree tops over large areas. Acid increases the mobility of aluminum in soil, which is toxic for the roots, and this leads to inhibition of leafs and needles and fragility of branches. Conifers are particularly affected because the needles are replaced less often than the leaves, and therefore accumulates more harmful substances for the same period.

Acid rains not only kill living nature, but also destroy monuments. Solid marble is a mixture of calcium oxides (CaO and CO_2) and it reacts with a solution of sulfuric acid and converts into gypsum ($SaSO_4$). Changes of temperature, rain and wind flows destroy the soft material.

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$$

Smog

In the air, primarily of industrial centers and cities, as a result of complex chemical reactions in a mixture of gases (primarily nitrogen oxides and hydrocarbons in automobile exhaust gases) flowing in the lower atmospheric layers under the action of sunlight, forms toxic fog, or it other name – smog. For its emergence promote certain weather conditions: absence of wind and rain, temperature inversion. Smog is extremely harmful to living organisms. During smog there is worsening of people health, dramatically increasing number of pulmonary and cardiovascular diseases, arising of flu epidemics.

Smog **-** Excessive air pollution by harmful substances emitted as a result of industrial production, transport and heat producing devices, under certain weather conditions (temperature inversion, UV radiation).

Temperature inversion in the atmosphere **-** the air temperature increase with height instead of the usual for the troposphere decrease.

To smog formation leads the high concentrations of nitrogen oxides, hydrocarbons, ozone, and other compounds.

For example, nitrogen oxide NO_2, generated in internal combustion engines.

Part is dissolved in the water vapor to form nitric acid.

caused by ultraviolet radiation reaction occurs:

$$NO_2 + h\nu \rightarrow NO + O^*$$

The resulting atomic oxygen may enter into a variety of reactions, including the reaction of ozone formation.

Photochemical smog is extremely dangerous for the respiratory and circulatory systems, violates the blood's ability to assimilate and transport oxygen.

Greenhouse effect

The greenhouse effect is one of the manifestations of the global environmental crisis. This tendency has emerged due to the increase in atmospheric concentrations of carbon dioxide, methane and other greenhouse gases.

In recent decades, and especially in recent years the greenhouse effect has become a major scientific problem, from solution of which depends the possibility of moving civilization on the path of sustainable development. The most important reason for the climate change is an accumulation in the atmosphere of anthropogenic greenhouse gases and caused by them a violation of the rational balance of the atmosphere. Under greenhouse gases are understood the gases in the atmosphere which create a intercepting of infrared rays screen. This results in heating of the lower layer of the atmosphere. The atmosphere acts as a kind of "blanket", keeping heat. The most important natural greenhouse gases are water vapor contained in the atmosphere in large quantities, as well as carbon dioxide that enters the atmosphere both natural and artificial way and it is the main component that causes the greenhouse effect. It is known that in the absence of carbon dioxide in the atmosphere a surface temperature would be approximately 7^o lower than at present, which would create an extremely unfavorable conditions for animals and plants life. An increase in carbon dioxide in the atmosphere increases the greenhouse effect because CO_2 successfully passes the long-wavelength rays of sunlight to the earth's surface and keeps a shortwave radiation. Therefore, the higher a CO2 concentration in the atmosphere, than the less heat dissipates the Earth, and higher the average temperature at the earth's surface.

To warming of the Earth's climate also helps heat which comes into the atmosphere due to the burning of oil, coal, peat, various engines work.

Increasing of average temperatures on the planet could significantly change the course of natural processes of the biosphere.

The main greenhouse gases are: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), tropospheric ozone (O_3) and water vapor (H_2O).

It is predicted that with increase in sea level by 1.5 - 2 m about 5 million km^2 of land will be flooded.

Ozone "hole"

Ozone "hole" - a significant space in the ozone layer at an altitude of 20-25 km, with markedly reduced ozone content.

In the upper atmosphere under the influence of hard ultraviolet radiation occurs reaction:

$$O_2 + h\nu \rightarrow O^* + O^*$$

$$\underline{O_2 + O^*} \leftrightarrow O_3$$

The most part of O_3 molecules decompose into O_2 and O *, and balance of the process of is shifted to the left.

The process of ozone formation is exothermic. Ultraviolet radiation is absorbed by oxygen, and converted into heat energy, which leads to an increase of temperature in the stratosphere. The resulting ozone molecules are short-lived, and by absorbing the UV energy in the range of 200 to 320 nm, disintegrate quickly. It is the presence of ozone, which is able to absorb the waves of this range, protects the biosphere from hard ultraviolet radiation.

The cause of the ozone holes is that the ozone depletion process is much more intensive than the process of its generation. It is caused by the anthropogenic emissions in to the atmosphere of different ozone-depleting compounds. These include chlorine, fluorine, bromine and carbon and hydrogen in various combinations. It is often speaks of chlorine fluorine carbon compounds as the key threat to the ozone layer. When chlorine or some other element reaches the ozone layer, it reacts with the ozone molecules. The resulting reaction produces chlorine oxide (ClO) and oxygen molecules (O_2). When chlorine meets oxide free oxygen atom, then there is another reaction which resulted in the released chlorine and formed oxygen molecule (O_2). Further, the chain is repeated, since chlorine can not go beyond the atmosphere, or go down to the Earth's surface. Thus, the emergence in the ozone layer of foreign elements leads to an accelerated ozone splitting, which reduces its concentration and, consequently, leads to the formation ozone holes.

$$Cl_2 + O_3 \rightarrow ClO + O_2$$
$$ClO + O^* \rightarrow Cl_2 + O_2$$

According to the World Health Organization, the ozone decrease by 1% leads to an increase in skin cancers by 6%, there is also suppression of the human immune system. In addition, ultraviolet radiation growth leads to lower crop yields.

Hydrosphere pollution

The intensive use of water resources leads to a sharp change in their quality parameters because of discharge in water a variety of anthropogenic pollutants. Because of it water loses its ability to cleanse itself. Self-cleaning in the hydrosphere is connected with circulation of substances. In water bodies it is provided by the total activity of organisms inhabiting them. Therefore, one of the most important water management tasks is to maintain this ability.

Water quality - characteristics of composition and properties of water, determining its suitability for specific uses.

According to sanitary rules and norms (in Russian federation)

- The first category of water includes the use of water objects or their parts as a source of drinking and household water use, as well as for water supply of the food industry.

- The second category of water includes the use of water objects or their parts for recreational water use. Water quality requirements established for the second category of water use, are to apply in all areas of water bodies located within the boundaries of populated areas.

The content of chemical substances should not exceed the maximum permissible concentration of hygiene and approximate permissible levels of substances in water bodies, approved in the established order.

As a rule, the main indicators, on which make water analysis, as follows:

- Chemical oxygen demand, biological oxygen demand, suspended solids, pH, organoleptic characteristics - taste, color, smell, contents of sulfates, phosphates, nitrogen compounds, petroleum products, and some others that may be characteristic for some kinds of production

as well as indicators of biological contaminants such as pathogens of intestinal infections, helminth eggs and others.

Oil pollution

The most common and dangerous type of pollution - oil pollution.

The source of the spill are many. Crude oil can be released by tankers on land. In water bodies, the spill occurs due to drilling rigs, offshore oil platforms and well. An oil spills and their effects can also be experienced with refined petroleum or even waste oil from large scale industries. What is common in all of them is that the damage caused by them is permanent and takes a long time to clean up.

Oil is a liquid from yellow or light-brown to black. This is a mixture of hydrocarbons and their derivatives, each of which may be regarded as an independent toxicant.

This crude oil consists of around 10,000 individual substances, with hydrocarbons being the main component (more than 95 per cent). However, the precise composition can vary considerably according to the place of origin. Crude oil also contains heavy metals and nitrogen compounds.

With oil and gas extraction in addition to the oil into the environment comes drilling muds and chemicals.

As oil spill, it floats on water and prevents sunlight to pass through it. Oil spill can prove fatal for plant, animal and human life. The substance is so toxic that it can cause massive loss of species that live in the sea. Oil spill penetrates into the plumage and fur of birds, breaks down the insulating capabilities of feather which makes them heavier, disallow them to fly and kill them via poisoning or hypothermia. In most cases, the oil simply chokes the animals to death. Many baby animals and birds starve to death, since their parents cannot detect their natural body scent. Birds that preen themselves to get rid of the oil accidentally swallow the oil and die due to the toxic effects. In many cases, the animals become blind due to repeated exposure to the oil. Dolphins, sea otters, fish, countless species of birds and many oceanic mammals face these consequences. Countering these effects and cleaning the oil can take anywhere between a few weeks to many years, depending on the damage caused.

Nitrates and phosphates

Nitrates and phosphates, are an important cause of a process called eutrophication. Nitrates normally occur in drainage waters and are derived from soil nitrogen, from nitrogen-rich glacial deposits, and from atmospheric deposition. Anthropogenic sources include synthetic fertilizers, sewage, and animal wastes from feedlots. Land-use changes (e.g., logging) can also increase nitrate inputs to streams. Phosphate levels are also rising in some parts of the world. Major sources include detergents, fertilizers and human wastes.

Metals

Metals, such as nitrates and phosphates, occur naturally in soil and water. However, as the human use of metals has burgeoned, so has the amount of water pollution they cause. In addition, some metal ions reach river waters because they become more quickly mobilized as a result of acid rain. Aluminum is a notable example of this. From a human point of view, the metals of greatest concern are probably lead, mercury, arsenic, and cadmium, all of which have adverse health effects. Other metals can be toxic to aquatic life, and these include copper, silver, selenium, zinc, and chromium. The anthropogenic sources of metal pollution include the industrial processing of ores and minerals, the use of metals, the leaching of metals from garbage and solid waste dumps, and animal and human excretions.

Chemical pollution by agriculture and other activities

Agriculture may be one, if not the most, important cause of pollution, either by the production of sediments or by the generation of chemical wastes. With regard to the latter, it has been suggested that denitrification processes in the environment are incapable of keeping pace with the rate at which atmospheric nitrogen is being mobilized through industrial fixation processes and being introduced into the biosphere in the form of commercial fertilizers. Nitrogen, with phosphorus, tends to regulate the growth of aquatic plants and therefore the eutrophication of inland waters. Excess nitrates can also cause health hazards to humans and animals.

As agriculture has, in the developed world, become of an increasingly specialized and intensive nature, so the pollution impact has increased. The traditional mixed farm tended to be a more or less closed system that generated relatively few external impacts. This was because crop residues were fed to livestock or incorporated in the soil; and manure was returned to the land in amounts that could be absorbed and utilized. Many farms have become more specialized, with the separation of crop and livestock activities; large numbers of stock may be kept on feedlots, silage may be produced in large silos, and synthetic fertilizers may be applied to fields in large quantities.

Pesticides are another source of chemical pollution brought about by agriculture. There is now a tremendous range of pesticides and they differ greatly in their mode of action, in the length of time they remain in the biosphere, and in their toxicity. Much of the most adverse criticism of pesticides has been directed against the chlorinated hydrocarbon group of insecticides, which includes DDT and Dieldrin. These insecticides are toxic not only to the target organism but to other insects too (that is, they are nonspecific). They are also highly persistent. Appreciable quantities of the original application may survive in the environment in unaltered form for years. This can have two rather severe effects: global dispersal and the ‘biological magnification’ of these substances in food chains.

Thermal pollution

The pollution of water by increasing its temperature is called thermal pollution. Many fauna are affected by temperature, so this environmental impact has some significance. In industrial countries probably the main source of thermal pollution is from condenser cooling water released from electricity generating stations.

Thermal pollution of streams may also follow from urbanization. This results from various sources: changes in the temperature regime of streams brought about by reservoirs according to their size, their depth, and the season; changes produced by the urban heat island effect; changes in the configuration of urban channels (e.g., their width/depth ratio); changes in the degree of shading of the channel, either by covering it over or by removing natural vegetation cover; changes in the volume of storm runoff; and changes in the groundwater contribution.

Such temperature increases were detrimental to temperature-sensitive fish such as trout. On the other hand, the temporary shutdown of power plants may create severe coldshock kills of fish in discharge-receiving waters in winter. Moreover, an increase in water temperature causes a decrease in the solubility of oxygen that is needed for the oxidation of biodegradable wastes. At the same time, the rate of oxidation is accelerated, imposing a faster oxygen demand on the smaller supply and thereby depleting the oxygen content of the water still further. Temperature also affects the lower organisms, such as plankton and crustaceans. In general, the more elevated the temperature is, the less desirable the types of algae in water.

One further ecological consequence of thermal pollution is that the spawning and migration of many fish are triggered by temperature and this behavior can be disrupted by thermal change.

Plastic Debris

The debris consists of many different materials, which tend to be nondegradable and endure in the marine environment for many years. The most notorious are the plastics {e.g. bottles, sheets, fishing gear, packaging materials, and small pellets), along with glass bottles, tin cans, and lumber. This litter constitutes an aesthetic eyesore on beaches, but more importantly can be potentially lethal to marine organisms. Deleterious impacts on marine birds and mammals result from entanglement and ingestion. Lost or discarded plastic fishing nets remain functional and can continue 'ghost fishing' for several years. This is similarly true for traps and pots that go astray. Plastic debris settling on soft and hard bottoms can smother benthos and limit gas exchange with pore waters.

Pollution of The World Ocean

The World Ocean occupies more than 70% of the Earth's surface and plays an important role in the development and functioning of geographic shell, it regulates climate processes on Earth. The World Ocean pollution occurs in three ways:

- first - rivers flow, with which millions tons of pollutants fall into the ocean;
- second way of pollution associated atmospheric precipitation, with them to the oceans comes large part lead, half of mercury and pesticides;
- third way is connected with human activities in the World Ocean.

Sources of Water Pollution

Sources of water pollution, particularly ground water pollution are group under two categories based on the origin of the pollutant.

Point Source Pollution

Water pollution caused by point sources refers to the contaminants that enter the water body from a single, identifiable source like pipe or ditch. Point source pollutants can be discharges from sewage treatment plant, factories or a city storm drain.

Nonpoint Source Pollution

Pollution caused by nonpoint sources refers to the contamination that does not originate from a single source. Nonpoint source pollution is the cumulative effect of small contaminants gathered in large area. Leaching of nitrogen compounds from agricultural land, storm water runoff over an agricultural land or a forest are examples of nonpoint source pollution.

Lithosphere pollution. Waste disposal

Humans produce vast quantities of waste—in factories and offices, in our homes and schools, and in such unlikely places as hospitals. Even the most sophisticated waste processing plants, which use plasma torches (electrically controlled "flames" at temperatures of thousands of degrees) to turn waste into gas, produce solid waste products that have to be disposed of somehow.

Waste disposal didn't always mean land pollution. Before the 20th century, most of the materials people used were completely natural (produced from either plants, animals, or minerals found in the Earth) so, when they were disposed of, the waste products they generated were natural and harmless too: mostly organic (carbon-based) materials that would simply biodegrade (break down eventually into soil-like compost). There was really nothing we could put into the Earth that was more harmful than anything we'd taken from it in the first place. But during the 20th century, the development of plastics (polymers generally made in chemical plants from petroleum and other chemicals), composites (made by combining two or more other materials), and other synthetic (human-created) materials has produced a new generation of unnatural materials that the natural environment has no idea how to break down. It can take 500 years for a plastic bottle to biodegrade, for example. And while it's easy enough to recycle simple things such as cardboard boxes or steel cans, it's much harder to do the same thing with computer circuit boards made from dozens of different electronic components, themselves made from countless metals and other chemicals, all tightly bonded together and almost impossible to dismantle.

Mining

Although there are many responsible mining companies, and environmental laws now tightly restrict mining in some countries, mines remain among the most obvious scars on (and under) the landscape. Surface mining (sometimes called quarrying or opencast mining) requires the removal of topsoil (the fertile layer of soil and organic matter that is particularly valuable for agriculture) to get at the valuable rocks below. Even if the destruction of topsoil is the worst that happens, it can turn a productive landscape into a barren one, which is a kind of pollution.

That leaves behind waste products and the chemicals used to process them, which historically were simply dumped back on the land. Since all the waste was left in one place, the concentration of pollution often became dangerously high. When mines were completely worked out, all that was left behind was contaminated land that couldn't be used for any other purpose.

Dumps which are formed by the unused rocks are not only unsuitable for the growth of plants, but cause significant air dusting.

Urbanization

Humans have been making permanent settlements for at least 10,000 years and, short of some major accident or natural disaster, most of the cities and towns we've created, and the infrastructure that keeps them running, will remain with us for thousands more years into the future. Not many of us would automatically classify cities and other human settlements as "land pollution"; people obviously need to live and work somewhere. Even so, urbanization marks a hugely important change to the landscape that can cause land pollution in a variety of subtle and not-so-subtle ways.

One of the problems of urbanization is that, by concentrating people, it concentrates their waste products at the same time. So, for example, crudely disposing of sewage from a big city automatically creates water or land pollution, where the same number of people and the same volume of sewage might not create a problem if it were created in 10 smaller cities or 100 small towns. Concentration is always a key factor when we talk about pollution.

Soil erosion: general considerations

Loss of soil humus, whether as a result of fire, drainage, deforestation or plowing, is an especially serious manifestation of human alteration of soil. Humus has many beneficial effects on both the chemical and the physical properties of soil. Its removal by human activity can be a potent contributory cause of soil erosion.

Soil erosion - the destruction of water currents and wind soil (water and wind erosion).

Water erosion is divided into rainfall erosion, snow-melting and irrigational erosion.

Since the development of agriculture some 12,000 years ago, soil erosion is said by some to have ruined 4.3 million km2 of agricultural lands, or an area equivalent to rather more than one-third of today’s crop-lands . . . the amount of agricultural land now being lost through soil erosion, in conjunction with other forms of degradation, can already be put at a minimum of 200,000 km2 per year.

Although nearly $15 billion has been spent on soil conservation since the mid-1930s, the erosion of croplands by wind and water remains one of the biggest, most pervasive environmental problems the nation faces. The problem’s surprising persistence apparently can be attributed at least in part to the fact that, in the calculation of many farmers, the hope of maximizing short-term crop yields and profits has taken precedence over the longer term advantages of conserving the soil. For even where the loss of topsoil has begun to reduce the land’s natural fertility and productivity, the effect is often masked by the positive response to heavy application of fertilizer and pesticides, which keep crop yields relatively high.

Although construction, urbanization, war, mining, and other such activities are often significant in accelerating the problem, the prime causes of soil erosion are deforestation and agriculture

One serious consequence of accelerated erosion is the sedimentation that takes place in reservoirs, shortening their lives and reducing their capacity. Many small reservoirs, especially in semi-arid areas and in areas with erodible sediments in their catchments such as the loess lands of China, appear to have an expected life of only 30 years or even less. Soil erosion also has serious implications for soil productivity. A reduction in soil thickness reduces available water capacity and the depth through which root development can occur. The water-holding properties of the soil may be lessened as a result of the preferential removal of organic material and fine sediment. Hardpans and duricrusts may become exposed at the surface, and provide a barrier to root penetration. Furthermore, splash erosion may cause soil compaction and crusting, both of which may be unfavorable to germination and seedling establishment. Erosion also removes nutrients preferentially from the soil. Some damage may be caused by associated excessive sedimentation, while wind erosion may lead to the direct sandblasting of crops. Finally, extreme erosion may lead to wholesale removal of both seeds and fertilizer.

Pesticides in soil

Pesticides are toxic substances which people use for kill living things. The term "-cide" comes from the Latin word "to kill."

Pesticides are used almost everywhere -- not only in agricultural fields, but also in homes, parks, schools, buildings, forests, and roads. It is difficult to find somewhere where pesticides aren't used -- from the can of bug spray under the kitchen sink to the airplane crop dusting acres of farmland, our world is filled with pesticides.

There are several most known types of pesticides:

- Insecticides (against insects)
- Herbicides (against plants)
- Rodenticide (against rodents)
- Fungicides (against fungi)
- Bactericides (against bacteria)
- Acaricides (against ticks)

And others

Only a small dose of pesticide reaches the organisms actually planned be destroyed. A significant part of the negative effect goes to beneficial organisms, including living in the soil.

Since any pesticide, in fact, is a pure poison, you clearly can predict its effect on environment. It is killing of live organisms in any possible form – microorganisms, birds, animals, insects, humans.

It is decreasing of the general biodiversity. It has mutagenic and carcinogenic effects and so on.

Big part of pecticides are hard for degradation and accumulates in food networks.

Pesticides have been linked to a wide range of human health hazards, ranging from short-term impacts such as headaches and nausea to chronic impacts like cancer, reproductive harm, and endocrine disruption.

Questions:

1. Give definitions of a pollutant and environmental pollution.
2. What are natural and anthropogenic pollution?
3. What are primary and secondary pollution?
4. What kinds of pollution can be classified as physical, chemical?
5. What kinds of pollution can be classified as biological, esthetic?
6. Name the main pollutants of the air.
7. What is “acid rain”? Write examples of chemical reactions, which results in acid rain.What harm causes acid rain?
8. What is a smog? What conditions it needs for formation?
9. What is a greenhouse effect? Which gases you do know as greenhouse ones?
10. What is a ozone hole? Write chemical reactions of ozone formation in the atmosphere.
11. Which harm makes oil pollution to hydrosphere?
12. Which harm make pesticides, nitrates to environment?
13. Which harm make thermal pollution to environment?
14. Which ways occurs the Word Ocean pollution?
15. What are point and non-point source pollution?
16. Which harm make mining to environment?
17. What is a soil erosion? Which types it can be?

Theme 6. Air purification

Environmental regulation - is the establishment of environmental quality and the maximum permissible impact on it, as well as scientific, legal, administrative activities aimed at establishing the maximum allowable impact on the environment, under which there is no degradation of ecosystems, and conservation of biological diversity and ecological safety of the population are guaranteed.

The system of environmental standards in Russian Federation are:

• Environmental Quality Standards;

• standards of maximum permissible harmful effects on the environment;

• standards of natural resources use;

• environmental standards;

• standards of sanitary and protection zones.

There are two different types of environmental standards:

• environmental quality standards - give an estimate of the environment; environmental quality standards are established to assess the condition of air, water, soil on chemical, physical and biological parameters.

• standards of impact on the environment – give limits for the sources of harmful impact on the environment.

Norms of permissible impact establish requirements to source of harmful influence limiting its activities by defined concentration.

In practice, this is reflected in the development of environmental projects in a company. This document indicates how much of matter and in what amounts and speed can be released into the environment, that environmental indicators were within the norms of MPC.

For example, waste water may contain substances in concentrations exceeding the MPC, but when it mixed with water of a natural object concentration of this substances should be below the MPC.

The Russian Federation establishes the following standards of permissible impact on the environment:

• standards of permissible emissions and discharges of substances and microorganisms;

• standards waste production and limits for their disposal;

• permissible physical influences (heat, noise, vibration, ionizing radiation, electromagnetic fields, and others.);

• standards of permissible withdrawal of environmental components;

• norms of permissible anthropogenic load on the environment.

Harmful substance - a substance that is in contact with the human body can cause occupational injuries, occupational diseases or deviations in health status both in the course of work, and in the following periods of life of present and future generations.

The standards of maximum permissible concentration (MPC) of chemicals - standards, established in accordance with the indicators of the maximum permissible content of chemical substances, including radioactive waste and microorganisms in the environment; the failure of MPC could lead to environmental pollution, degradation of natural ecological systems.

For each substance at least two legal values are established: the maximum permissible concentration in a working area (MPCwa) and maximum permissible concentration in air of a settlement area (MPCair).

MPCwa– with this concentration in air workers who work less than 41 hours per week can not have disease themselves as well as their children.

MPCair – This limiting concentration of chemicals, which should not have a harmful influence on person throughout his life as well as on the environment as a whole.

For air of settlements are established two types of MPC: one-time MPC - It is such a concentration of harmful substances in the air that should not cause by inhalation for 30 minutes reflex reactions in a human body (sense of smell, change the light sensitivity of the eye, etc..).

The average daily maximum permissible concentration. - It is such a concentration of harmful substances in the air that should not have direct or indirect harmful effect on a person with an indefinitely long (years) exposure.

Contaminants in the atmosphere can come from sources continuously or periodically, in volleys or immediately. In the case of volley emissions in a short period of time a large amount of harmful substances is released into the air. Volley emissions are possible in case of emergencies, when burning fast-flaming industrial waste at special sites of destruction.

With exhaust gases into the atmosphere are emitted solid, liquid, vaporous or gaseous inorganic and organic substances.

Exhaust gases, containing suspended solid or liquid particles are two-phase systems. Containing phase in the system are gases, and disperse - solid particles or liquid droplets.

Such aerodisperse systems are called aerosols, which are divided into dust, smoke and fog.

Gas emissions are classified also

- by the organization of drainage and control - to organized and not-organized;
- by temperature - heated (temperature above the gas-dust mixture air temperature) and cold;
- on the basis of cleaning - emitted without treatment (organized and unorganized) and after cleaning (organized).

Gas cleaning systems and devices

Gas cleaning systems from contaminants are represented in figure 8.

There are some parameters, which play an important role in choosing a method of treatment.

The particle size is its main parameter. Industrial dust particles have various shapes (spheres, rods, platelets, needles, flakes, fibers, etc). Dust particles can coagulate together and to join in agglomerates. The dust removal is usually characterize a particle size by a value, determining its rate of sedimentation.

To characterize the particulate composition of a dust the entire dust mass breaks up at some fraction restricted by certain size, indicating what percentage by weight they comprise.

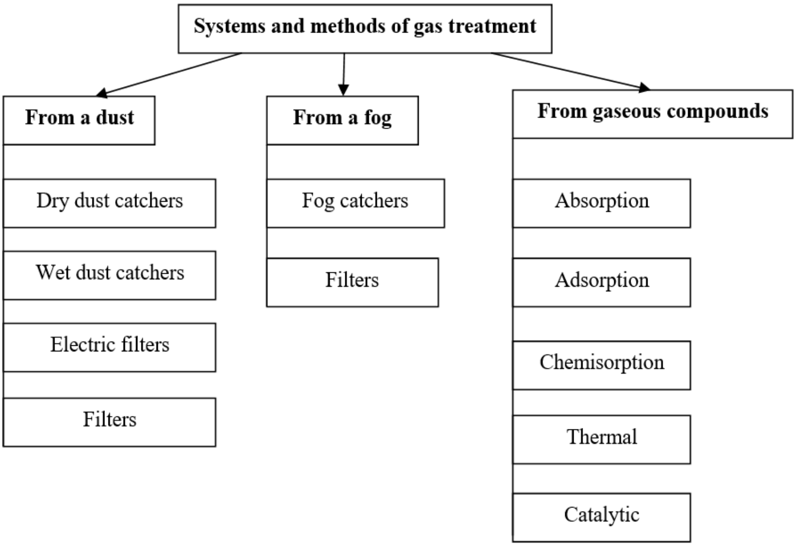


Fig.8 – Systems and methods of gas treatment

Adhesive properties of the particles - determine their tendency to gluing. Increased adhesiveness of particles can lead to partial or complete clogging of devices. The smaller dust particles, the easier they stick to surface of the device. Dust in which 60-70% of the particles have a diameter less than 10 microns, behave as adhesive, although the same dusts having a particle size greater than 10 microns have good flowability. Dust stickability are divided into 4 groups (table 3).

Table 3

Types of materials according to dust stickability

Dust characteristic	**Dust type**
Not-adhesive	Dry slag, quartz; dry clay
Low-adhesive	Coke oven; magnesite dry; apatite dry; domain; fly ash containing much unburned products; shale ash
Medium-adhesive	Peat, wet magnesite; metal containing pyrite, lead oxides, tin and zinc oxides, dry cement; fly ash without incompletely burned; peat ash; soot, powdered milk; flour, sawdust
High-adhesive	Cement; isolated from humid air; plaster and alabaster; containing nitro phosphate, triple superphosphate, clinker, sodium salt; fibrous (asbestos, cotton, wool)

Abrasiveness of a dust. dust abrasiveness describes the intensity of metal wear at the same rate of gas and dust concentrations. It depends on the hardness, shape, size and particle density. Abrasiveness takes into account when calculating equipment (gas rate selection, wall thickness of equipment and facing materials).

Wettability of a dust. Wettability of the particles affects the efficiency of wet dust extractor, especially when its working with recirculation.

Based on how the water drop interacts with a solid surface, the surface can be categorized as hydrophilic, hydrophobic or superhydrophobic. Water contact angle measurements are often used to characterize the wettability of the solid surface. A hydrophilic surface shows strong affinity towards water, whereas a hydrophobic surface strongly repels water.

By the nature of wetting all solids are divided into three main groups:

1) hydrophilic materials - well wetted: calcium, silica, silicates and most oxidized minerals, alkali metal halides;

2) hydrophobic materials - poorly wetted: graphite, charcoal, sulfur;

3) completely hydrophobic - paraffin, teflon, bitumen.

Electrical conductivity of dust layer. This index is measured in specific electrical resistance of dust layer, which depends on properties of individual particles (inner and surface electrical conductivity, shape and particle size) and the structure of a layer, and gas flow parameters. It has a significant impact on the work of electric filters

Ability of dust particles to self-ignition and formation of explosive mixtures with air. Combustible dust due to the strongly developed contact surface of the particles with oxygen in the air is capable of spontaneous combustion and formation of explosive mixtures.

Dust of some organic substances - formed during the processing of dyes, plastics, fibers and dust metals: magnesium, aluminum and zinc - has the ability to ignite.

The higher the oxygen content in a gas mixture, the more likely an explosion and greater its power. When oxygen content is less than 16% a dust cloud is not explosive.

Methods of dry gas treatment

Dry mechanical dust catchers include devices, which use various mechanisms of sedimentation: gravity (dust-settling chambers), inertial (dust sedimentation occurs because of changing direction of gas flow), and centrifugal (solitary, group and cyclones, vortex and dynamic dust-catchers).

These devices are easy to manufacture and operate, they are widely used in industry. However, the collection efficiency of dust is not always sufficient, and therefore they often play the role of the preliminary gas treatment devices. Types of dust-catching cameras are shown in Figure.

Inertial dust catchers. With a sharp change in direction of gas flow dust particles under the influence of inertial forces will move in the same direction and after turning of gas flow fall into the hopper.

On this principle operates a number of devices. The efficiency of these devices is small. For particles of 25-30 micron dust collection efficiency is about 65-80%. Such cameras are used at factories of ferrous and non-ferrous metallurgy.

Purification of gases in filters

The basis of all porous filters work is process of gas filtering through a porous wall which catch solid particles, but allow to pass a gas through it.

Filter walls are very diverse in structure, but they are mainly composed of fibrous or granular elements and conditionally divided into the following types:

- flexible porous walls - textile materials of natural, synthetic and mineral fibers;
- non-woven fibrous materials, honeycomb sheet;
- semirigid porous walls - the layers of fibers, flakes, woven mesh, placed on a support device or clamped in between;
- rigid porous walls - granular materials (porous ceramic or plastic, sintered or compacted metal powders, porous glass, carbon-graphite and other materials.); metal mesh and perforated sheets.

As dust accumulates it is necessary to remove it and regenerate filter.

Fabric filters. These filters are the most widely used. Opportunities of their use are expanding in connection with creation of new heat-resistant and resistant to corrosive gases fabrics.

The most common are bag filters. The filter housing is a metal cabinet, divided by vertical partitions into sections in each of which is located a group of filter bags. The upper ends of the sleeves are closed and fixed to a frame, connected with shaking mechanism. At the bottom there is a dust bin with a screw for its unloading. Shaking of bags in each of the sections is performed alternately.

Bulk filters. In such filters catching elements (pellets, chunks, etc.) are not associated with each other. In bulk filter are used next materials: sand, gravel, slag, crushed rocks, sawdust, chips of rubber, plastics, graphite and others. Choice of material depends on the desired thermal and chemical stability, mechanical strength and availability. From time to time loosening of layer occurs. After several cycles of loosening the layer is washed or replaced.

Purification of gases in wet scrubbers

Wet scrubbers have a number of advantages and disadvantages in comparison with other types of devices.

Advantages: 1) low cost and higher efficiency of suspended particles capturing; 2) possibility to use for cleaning gases from 0.1 micron particles; 3) possibility of cleaning gas at high temperature and humidity, as well as in danger of fire and explosion of purified gas and collected dust; 4)possibility of catching along with dusts both vaporous and gaseous components.

Disadvantages: 1) location of collected dust in as a sludge which has to be treated or utilized, and it will increase costs of production; 2) possibility of liquid droplets carryover, and deposition of them with dust in flues and smoke exhausts; 3) in case of aggressive gas treatment it need to protect equipment and communication with anti-corrosion materials.

In wet scrubbers as scrubbing most commonly used liquid is water.

Wet scrubbers, used for removal of gases and other chemicals as well as particulates, are the most common type of air pollution control in use by industries. They are also the most extensive, in terms of complexity of equipment, moving parts, requirement for controls, and operation and maintenance requirements. Wet scrubbers can be designed for a single target pollutant—for instance, particulates—but while in operation they will remove, to some degree, any other pollutant that will react with, or dissolve in, the scrubber fluid. Wet scrubbers can also be designed for multipurpose removal. For instance, a scrubber can be designed to remove both particulate matter and sulfuric acid fumes by using a caustic solution as the scrubbing fluid in a system also configured to remove particulates. Wet scrubbers that are intended for different target pollutants have several design and construction features in common.

The components of a basic scrubber include a vessel, some type of packing (of which there are many different types), a fan, or blower, a reservoir for the scrubber fluid, and a pump for the fluid. There are many options for additional features and many optional configurations for the system as a whole.

Electric treatment

In electric filters gas treatment occurs because of electricity powers. There are negatively (corona-forming) and positively (settling) charged electrodes, to which is applied a high voltage direct current.

Dusty gas flows in space between the electrodes. Here occurs ionization of the gas molecules on negatively and positively charged ions. Negatively charged ions moving in a dusty gas, give to the dust particles their charge and carry them to the collecting electrodes where particles are lose their charge and deposit.

Usage of a caught dust

Ways of possible usage of industrial dust:

1) Usage as finished product
2) returning it back in to production
3) processing it in other production
4) utilizing in building materials
5) extracting of useful components
6) usage in agriculture (in some cases as fertilizers);
7) Usage of dust's some physico-chemical properties

Classic example of usage as finished product is a soot industry. Soot is need in many kinds of industry: in rubber industry, car tire industry, paints and varnishes industry and other.

Returning dust back in to production - is one of the most common and rational methods of non-waste production with increasing of effectiveness and environmental protection.

Processing it in other production - for example, burnt pyrites dust trapped in cyclone and electric filters through cleaning of sulfur dioxide-containing gas in production of sulfuric acid and containing iron, sulfur, copper, zinc, lead, and other compounds, can be used in production of cast iron.

Absorption

Absorption, as a process, is concentration of one substance in a volume of another substance. It is a selective capturing of one or more components from a gas mixture by liquid. The reverse process, i.e., removal of condensed gas molecules from liquid volume, called degassing or de (ab) sorption.

The liquid us called a solvent, or absorbent.

Absorption can be two types: physical absorption and chemical.

When it is physical absorption, physical dissolution of absorbable component in a solvent occurs, and the absorbent molecules and molecules of a gas not enter into a chemical reaction.

When it is chemical adsorption, occurs chemical reaction of liquid and gas molecules with formation of new chemical compounds.

Devices, which used for absorption, called absorber.

Absorption is one of the most common methods of gas treatment. It is widely used for purification of a gas from hydrogen sulfide and other sulfur compounds, vapor of hydrochloric acid, sulfuric acid, cyanide compounds, organic compounds (phenol, formaldehyde, and others.).

With combining of absorption and desorption it can be made closed cycle process without wastes of a solvent.

Absorption occurs on a border between liquid and gaseous phase. For its intensification needed a device with advanced contact surface. By method of its formation devices can be classified:

1) film devices; 2) Nozzle devices; 3) bubble devices; 4) spray devices.

The primary purpose of absorption equipment is to first, contain the pollutants, and then to maximize the opportunity for pollutants to move from the gas phase to the liquid phase. This is accomplished by maximizing the surface area of the liquid absorbent and causing the gas stream to move past as much of the liquid surface as possible. Time of contact, of course, is a major parameter. Where the target pollutants are highly soluble in water, the liquid absorbent can be water. However, a chemical substance is usually present in the liquid absorbent that readily reacts with the target pollutant to form a product that is either highly soluble in the liquid absorbent or that forms a precipitate. For instance, sulfur dioxide, a gas at ambient temperatures, can be removed from a stream of air by contacting it with a solution of sodium hydroxide. Soluble sodium sulfate will quickly form and remain in the liquid. As another example, a stream of air containing silver sulfate in aerosol form can be contacted with an aqueous solution of sodium chloride. Insoluble silver chloride will form and remain suspended in the liquid until it is removed by an additional treatment step.

The basic components of absorber, also called a “packed tower,” consists of the following elements: • A vessel (tower), usually cylindrical, usually constructed of steel and coated as needed to prevent corrosion or other forms of destruction. • Packing to promote intimate contact between molecules of target pollutants and the liquid absorbent. • A spray distribution system to apply the liquid absorbent evenly over the entire top surface of the packing. • A reservoir, usually at the bottom of the tower, to serve as a wet well for the pump. • A pump to transfer liquid absorbent from the reservoir to the spray system. • A blower to force the gas stream from its source to the packed tower and up through the packing. • A support floor, highly perforated, to hold the packing above the reservoir to providea space for incoming gas (influent) to distribute itself evenly across the cross-section of the tower. It also serves as an inlet device to promote even application of the influent gas to the bottom of the column of packing. It must also allow the liquid absorbent to readily drain away from the packing.

A description of the operation of the packed tower is as follows: The liquid absorbent is pumped continuously from the reservoir to the spray distribution system. After being applied evenly over the top surface of the packing material, the liquid absorbent flows slowly down over the surfaces of the packing. As the gas stream, which has entered the tower in the space between the reservoir and the bottom of the packing, flows up through the packing, substances that can dissolve in the liquid do so. These substances have thus been removed from the gas stream, which continues its upward flow and exits the tower at the top. Excess moisture in the form of aerosol-size droplets or larger are trapped by the demister as the gas stream passes through.

Adsorption

Adsorption is the adhesion of one chemical substance to a surface of another chemical substance. So, adsorption is a surface-based process while absorption involves the whole volume of the material.

Chemical component, on which surface adhesion occurs, is called adsorbent.

In the most cases adsorbent is a solid matter.

The same as in absorption, it can be physical and chemical adsorption.

Physical adsorption, and absorption are processes which can be reversed. When it is chemical interaction, desorption is almost impossible.

Adsorption may take place in a fixed bed, a moving bed, a fluidized bed of adsorbent.

By way of adsorption process organizing devices can be divided into two groups: adsorbers with periodic and continuous action.

As adsorbent are usually used materials with high specific surface area. Inner structure of adsorbents is characterized by sizes and forms of cavities and pores. Pores are divided in macropores, mesopores and micropores. The main industrial sorbents are: activated carbon, silica gel, aluminogel (activated alumina), zeolites.

This materials differ from each other in nature of material and, consequently, its adsorption properties, granules size, density and others. Activated carbon is the most universal adsorbent, and because of it widely used.

Such adsorbent materials as activated carbon, are expensive, so usually they need to be regenerated for multiply usage. As methods of regeneration of a sorbent are usually used hot water or vapor, vacuum, chemical extraction and others.

Removal of air pollutants by adsorption onto granules of activated carbon is an extremely effective technology for volatile organic compounds and other organic pollutants. It is not effective for removing most inorganic substances, however. Activated carbon is a nonreactive material with an extremely high surface-to-volume ratio. Activated carbon is normally manufactured in a two-step process: The first is to char the raw material (bituminous coal and coconut shells are examples) to eliminate hydrocarbons; the second is to heat the charred material to 750º to 950ºC in the presence of steam and the absence of oxygen. The result is a very highly porous residual. Many activated carbon products have surface areas of 1,000 to 1,500 m^2/gram. The highly developed system of pores accounts for the extremely large surface area, and the large surface area accounts for the highly effective adsorptive characteristic of activated carbon.

In being removed from a gas stream by adsorption, the pollutant moves from a gas phase to a solid phase, and must now be managed as a solid waste. An advantage of activated carbon is that the spent carbon can be reheated so that the adsorbed pollutants are incinerated (converted to carbon dioxide, water [vapor], and ash), and the activated carbon regenerated for reuse. With each regeneration cycle, however, a certain amount of adsorptive capacity is lost. There is always the requirement for makeup with some portion of new activated carbon. Activated carbon treatment systems for treating gas streams are usually configured next way.

Cylindrical containers referred to as “carbon columns” are filled (“packed”) with beds of activated carbon granules through which the gas stream to be treated is forced to flow by use of a blower. Very often, several containers are connected in series. The multiple container arrangement allows for a factor of safety, as well as provides a means to remove one or more columns for maintenance or bed replacement without stopping the flow of gas for longer than the time required to shunt out the column to be removed. As the contaminated gas stream travels through the bed, adsorption of the pollutants takes place. The purified effluent gas exits the last column in the series. The portion of the bed that is closest to the inlet receives a continuous dose of concentrated pollutants and is thus driven to the point of saturation by the highest possible driving force. Portions of the bed that are downstream of the inlet receive progressively less concentrated amounts of the pollutants. As the portions of the bed closest to the inlet become progressively saturated, a “front of saturation” moves steadily toward the outlet end.

Eventually, dilute concentrations of pollutants appear in the effluent. When these concentrations increase to the point of unacceptability, “break-through” is said to have occurred, and it is necessary to remove the columns from service.

Certainly, activated carbon is the most commonly used adsorbent for treatment of gas streams for removal of gaseous pollutants. Other adsorbents that have been successfully used include a variety of resins, activated alumina, silica gel, and so-called molecular sieves. One of the primary characteristics of a good adsorbent is a high surface area per unit weight. Although no commercially available products compare to activated carbon in this respect, other characteristics in combination with reasonably high surface area per unit weight make some adsorbents useful for certain applications.

Resins are produced by inducing controlled cross-linking between certain organic substances. Resins with a surface area of 100 to about 700 m^2 per gram can be produced to exhibit a high selectivity for certain substances. For instance, phenolic resins have been successfully used to remove odorous substances from air streams. Resins can be produced in granular form such that they resemble activated carbon in physical size and shape. Resins can, therefore, be used in a packed bed configuration, using the same vessels and equipment as are used for activated carbon.

Activated alumina is produced by a specialized heat treatment of aluminum trihydrate, a primary ingredient of bauxite as it is mined. It can be obtained in granular form similar in size and shape to activated carbon granules. Therefore, it can be directly substituted for activated carbon to use the same physical set-up and equipment. Although activated alumina is most often used to remove moisture from air, it has been used, and has potential use, for removal of certain air pollutants from gas streams that are either being discharged to the air or are being recycled. A potential use is in series with another adsorbent. Surface areas of activated alumina products are in the range of 300 m^2 per gram.

Silica gel has been used to remove sulfur compounds from a gas stream, and to remove water from gas. It is produced by neutralizing, washing, drying, and roasting sodium silicate. It can be obtained in granular form, and as is the case with resins and activated alumina, it can be used in the same physical set-up as activated carbon. Silica gel products have surface areas of about 700 to 800 m^2 per gram.

Condensation

Gases can be changed to liquids by decreasing temperature, increasing pressure, or both.

The most commonly used equipment that employs condensation technology uses temperature decrease as the mechanism. Often, watercooled condensers are used as pretreatment devices to remove easily condensed substances (such as vapors of sulfuric acid) to protect or prolong the operating cycle times of downstream equipment.

Incineration

The fundamental mechanism on which incineration technology for air pollution control is based is combustion. Combustion of organic pollutants entails conversion to carbon dioxide, water, and ash. Some inorganic materials, such as sulfur and nitrogen, are often oxidized to problematic substances during the combustion process. Other inorganic materials—for instance, heavy metals—become incorporated in the ash and can add to ultimate disposal problems. As an air pollution abatement technology, incineration is used for many purposes, including odor control, reduction of releases of hydrocarbons to the air (flares at petroleum refineries, for example), and destruction of volatile organic compounds (VOCs). In the context of air pollution control, incinerators are of two types: thermal oxidizers and catalytic oxidizers. The difference between the two is that thermal oxidizers accomplish combustion by use of heat alone. Catalytic oxidizers, on the other hand, use a catalyst to decrease the activation energy of the combustion process, or to otherwise effect acceleration of the combustion process, and are thus able to accomplish reasonably complete combustion at significantly lower temperatures.

Questions:

1. Give a definition of harmful substance.

2. How can be classifies aerosols?

3.Which types of systems and methods use for a gas treatment from a dust? From gaseous compounds?

4. Give examples of a) not-adhesive and low-adhesive dust, b) high-adhesive dust

5. Give examples of hydrophilic, hydrophobic and completely hydrophobic materials.

6. What are the fabric filters, bag filters, bulk filters?

7. What are the wet scrubbers, which components of a basic scrubber you do know?

8. Describe the electric gas treatment method.

9. How a caught dust can be used?

10. What are adsorption and absorption, what is the difference between them?

11. Describe the incineration gas treatment method.

Theme 7. Water treatment

Before we will talk about water treatment, we need to talk about water standards, because the main goal of water purification – is to reach some level of pollutants' concentration which is allowed for the water object.

The quality standards of natural waters are oriented mainly on the protection of human health and fishing industry and virtually don't take into account the water ecosystems' environmental safety.

The quality of water means the characteristics of its composition and properties, which determine its suitability for specific kinds of water use (GOST 17.1.1.01-77). Requirements to the natural waters quality are regulated with Rules of Surface Waters Protection against Pollution (SanPiN 2.1.5.980-00). The sea water quality is regulated with Sanitary Rules and Norms of coast waters protection in water use areas (SanPiN № 44631-88).

The consumers' requirements to the water quality depend on its purpose of use. There are three types of water use:

1) drinking and household – using water bodies or their parts as the source of utility and drinking water supply, and for the water supply of food industry enterprises;

2) cultural and general – using water bodies for swimming, sports and recreation. These include parts of water bodies, located within the populated areas, independently of their usage;

3) fishery water bodies, which, in their turn, are divided into three classes;

• top class – areas of spawning grounds, ongrowing areas and wintering holes of valuable and especially valuable fish species and other commercial aquatic organisms, as well as protective zones of fish and aquaculture farms;

- first class – water bodies, used for preservation and reproduction of valuable fish species, sensitive to oxygen content;
- second class – water bodies, used for other fishery purposes.

Natural water is the water which is qualitatively and quantitatively formed under the influence of natural processes in the absence of human impact. Its qualitative characteristics are on the long-time average annual level.

Water, which is used in industry, is divided into the cooling water, process water and power water.

Cooling water: water is often used for cooling liquid and gaseous products in heat exchangers. In this case it doesn't contact material seepages and doesn't get contaminated, only heated. About 65-80% of consumed water in industry is used for cooling. At large chemical factories the consumption of cooling water amounts to 440 mln. m3/year. The aggregate amount of water in cooling systems of chemical industry enterprises makes up 20 bln. m3/year.

Process water is divided into environmental-forming, flushing and reaction water. The environmental-forming water is used for dissolving and pulping, at the ores beneficiation and processing, hydrotransport of products and production wastes; the flushing water — for flushing gaseous, liquid and solid products; the reaction water is used as reagents' component, as well as in many other processes. The process water contacts the products directly.

The **power water** is used for steam generation and heating equipment, premises and products.

The most promising way of reducing the fresh water consumption is creating recycling water supply systems.

At the recycling water supply the necessary wastewater purification, the cooling of recycling water, the treatment and reusing of wastewater must be provided. In the plan a water is heat carrier and in the process of usage it gets not polluted but heated; it is cooled before re-usage. In the plan b the water is purified before re-usage. In the plan c the water is both cooled and purified.

In all cases only the make-up water is added when necessary. The application of recycling water supply allows reducing the natural water consumption by 10-50 times.

For example, the production of 1 t of raw rubber requires 2100 m^3 of natural water at direct-flow water supply system in old enterprises, and at the recycling water supply it requires only 165 m3.

Waste waters

Various types of wastewaters are formed in the process of production. Waste water is the water which has been used in household, industry or agriculture, or having passed through some contaminated and polluted land. Depending on the formation conditions wastewaters are divided to domestic sewage, meteorological and industrial wastewaters.

Domestic waters are the sewage waters of shower rooms, baths, laundries, kitchens, lavatories, water from floor mopping etc. They contain matters, which include about 58% of organic substances and 42% of mineral substances.

Meteorological waters are formed as a result of atmospheric precipitation or drain from the territories of industrial enterprises. They are contaminated with organic and mineral substances.

Industrial wastewaters are liquid effluents, which are formed at the production and processing of organic and non-organic raw stuff.

Many industries' wastewaters, apart from the soluble organic and non-organic matters, contain colloid impurities and the suspended coarsely dispersed and finely dispersed impurities, the density of which can be higher or lower than the water density.

There are two ways of wastewater treatment: dilution and decontamination. Dilution doesn't eliminate the action of wastewaters, but only weakens it at the certain local area of water body. The main way is purification of wastewaters from the impurities (figure 9).

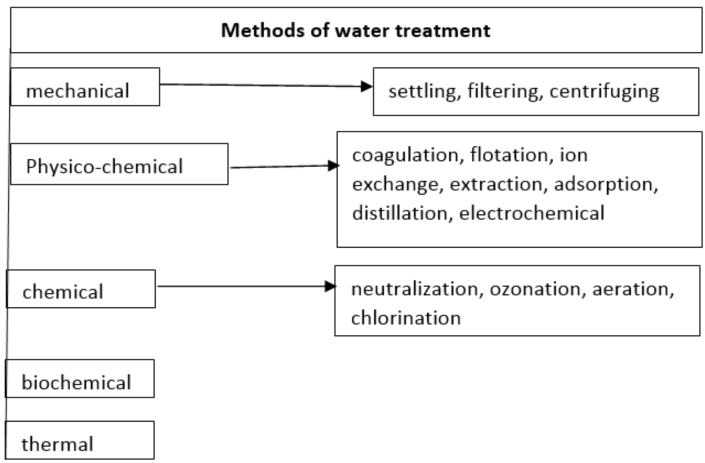


Fig. 9 – Methods of water treatment

The above-mentioned purification methods are divided to: recuperating and destructive. Recuperating methods imply extraction all the valuable substances from wastewater and their further processing. In the destructive methods the contaminated substances are destroyed by means of oxidation or reduction. The disintegration products are removed from water in the form of gases or sediment.

In case of discharging the treated wastewater to the water body the purification method is considered efficient, if it provides the maximum permissible discharge.

The maximum permissible discharge is the amount of substance in the waste water, which is maximum allowable according to the specifications in the given area of the water body in a unit of time, meeting the requirements to water quality in a control point.

It means that at discharging such waste waters the concentrations of substances in the water bodies mustn’t exceed the maximum permissible concentration limits. So, wastewaters may contain impurities in concentrations, exceeding MPC, but at diluting them with water of the natural water body their concentrations should be lower than MPC. For this purpose the special calculations are done, which take into account concentrations and sewage flow rate, background concentrations of substances in the water body, water consumption from the water body and some other parameters. According to the Russian legislation, such ecological account or the «maximum permissible discharge project» should be done at every industrial enterprise, which discharges any types of wastewaters to the environment.

Industrial and household wastewaters contain suspended particles of low-soluble and insoluble substances. Suspended impurities are divided into solid and liquid ones; they form a disperse system with water. According to the particle size, disperse systems are divided into three groups:

1) coarsely dispersed systems with particles over 0,1 μm (suspensions and emulsions);

2) colloid systems with particles 0,1 μm — 1 nm;

3) real solutions, the particle size of which is comparable with individual molecules or ions size.

Sometimes wastewaters at the industrial enterprises are formed in an uneven manner: their amount and composition may vary significantly depending on production cycles, seasons of the year and other factors. The wastewater treatment facilities can’t be rearranged quickly according to the alterations of waste waters, so the waste waters are usually equalized. For this purpose the large equalization tanks are built, in which a certain amount of water is accumulated. If necessary, they can be diluted before conveying them to treatment facilities.

So, often before reaching wastewater treatment facilities, wastewaters are collected in equalization tanks.

Mechanical wastewater treatment

The first stage of wastewater treatment is in most cases mechanical treatment, as almost all types of waste waters contain mechanical impurities.

Before the finer purification waste waters are strained through lattices and sieves, which are made before the sedimentation tanks in order to catch coarse impurities, which can stuff pipes and canals.

Sedimentation is used for the precipitation of coarsely dispersed impurities from wastewater. For this purpose sand traps, sedimentation tanks and clarifying tanks are used. In all these facilities the particles settle due to force of gravity.

Sand traps are used for the preparatory separation of coarse mineral and organic impurities (0,2-0,25 mm) from wastewaters. Horizontal sand traps are basins with triangular or trapeziform cross-section. Their depth is 0,25-1 m. The water velocity in them doesn’t exceed 0,3 m/s. They can also be radial (with circular water flow), vertical and with corkscrew water flos.

Radial sedimentation tanks

The water is conveyed to the central part of the radial sedimentation tank, and the treated water is discharged through a round opening at the top of the tank. The sediment, settled on the bottom, is collected with rotational scrapers. Sedimentation tanks of this type are used at the sewage flow rate over 20 000 m^3/day. The depth of the flow rate of the tank is 1,5-5 m, the width may amount to 100 m. The sedimentation efficiency is 60%.

Settling ponds

Creating sedimentation basins in the form of ponds is the simplest way of sewage treatment. The heavy fractions of waste settle on the bottom, and the light ones float on the surface.

The settling ponds are open pits, consisting of one or two sections. To protect soil or ground water from contamination or soil from water encroachment the bottom and slopes of pond are covered with clay, polyethylene film, asphalt concrete or concrete slabs.

This method, though, has a number of drawbacks: too large area; soil and air pollution; costly disposal; the influence of weather and atmospheric conditions on the degree of purification.

Sedimentation process is also used for purifying industrial wastewater from petroleum, oils, resins, fats etc. Purification from floating impurities is similar to precipitation of solid substances. The difference is that the density of the floating particles is lesser than the water density. To catch oil and fat particles the **oil separators** and save-alls are used. The efficiency of these facilities is 96-98%. They can be of various shapes: horizontal, vertical, shelf and radial. To improve the purification efficiency, water may be also aerated.

In all **filtration** processes two main groups of facilities are used:

- with stationary filtering plate;
- with granular, i.e. noncohesive filtering layer.

The filters of the first group are some trap devices for any useful elements, contained in an enterprise's wastewater. They can also be used for obtaining low-humidity sediment.

The filters of the second group are filters with granular, i.e. noncohesive filtering layer, which are used at industrial enterprises for purification of large amounts of wastewater. Besides, they are often used in the water supply systems of industrial enterprises.

Filtration is used for the separation of solid or liquid substances from waste waters, if they are not easily removed by sedimentation. The separation is done with porous liquid- permeable membranes, trapping the solid phase.

Filters are classified according to various characteristics:

process character — periodical and continuous,

type of process — for separation, concentration or clarification;

filtration pressure — under vacuum, under pressure or at the liquid column hydrostatic pressure;

filtering direction — up, down or sidewise;

and others.

Centrifugal force usage

Sedimentation of suspended particles with the use of centrifugal forces is done in hydrocyclones and centrifuges.

In a centrifuge the centrifugal force is generated as a result of its bulk rotation. In a hydrocyclone its contents are rotated in the stationary bulk. In terms of structure hydrocyclone is simpler than centrifuge, as it has no moving elements, but in the qualitative characteristics of dividing suspension to the light (centrate) and heavy (sediment) phases it is inferior to centrifuges.

The operating principle of a hydrocyclone is based on a high velocity of suspension, tangentially conveyed to it. As a result of the spiral rotational motion inside the bulk due to the flow swirl, a centrifugal force field appears, and the suspension is divided to light and heavy components, discharged from the hydrocyclone through different outlets.

For wastewater purification the pressure and open (low-pressure) hydrocyclones are used. Hydrocyclones are simple in their structure, compact and easy to maintain. They are highly-efficient and low-priced. At the rotation of liquid in a hydrocyclone the particles are influenced by centrifugal forces, which throw the heavy particles to the flow periphery, by the flow resistance force, by gravity forces and inertial forces. At the high rotation speed the centrifugal forces are considerably higher than gravity forces.The hydrocyclones efficiency is about 70%.

To remove sediments from wastewater the filtering and sedimentation centrifuges are used. The centrifugal filtration is achieved by the rotation of suspension in a perforated cylinder, stretched over with net or filtration fabric. The sediment is formed on the cylinder walls. It is removed by hand or by knife discharge. Such filtering is the most efficient, when the product with the lowest moisture level or the sedimentation washing is required.

Physical-and-chemical treatment

The physical-and-chemical methods of wastewater purification include coagulation, flotation, adsorption, ion exchange, extraction, rectification, evaporation, distillation, reverse osmosis and ultrafiltration, crystallization, desorption etc. These methods are used to remove the finely-dispersed suspended particles (solid and liquid), dissolved gases, mineral and organic substances from the waste water.

Application of physical-and-chemical methods for wastewater purification has a number of advantage in comparison with biochemical ones: 1) possibility of removing the toxic biochemically-inoxidizable organic pollutants from wastewater: 2) achievement of finer and more stable level of purification; 3) smaller size of structures, 4) smaller sensitivity to the loads alteration; 5) the possibility of complete automation: 6) the more profound knowledge about the kinetics of some processes, as well as about modeling mathematical description and optimization issues, which is important for the correct choosing and calculation of equipment; 7) methods don’t require control over living organisms’ activity; 8) possibility of recuperating various substances.

The mechanical treatment purifies wastewater from particles of 10 μm and larger easily enough. The finer particles are able to form in water, and especially in wastewater, which contains a lot of various components, very stable systems, which don’t settle under the influence of gravity force and are resistant to filtering.

For their treatment the coagulation methods are used; as a result, the systems' stability is disturbed, the larger aggregates of particles are formed, which can be removed from wastewater with mechanical methods.

Coagulation is the process of dispersed particles consolidation as a result of their interaction and assembling into aggregates. Coagulation is especially effective for the removal of colloid-dispersed particles from water, i. e. particles 3—100 μm large.

Coagulation can take place spontaneously or under the influence of chemical and physical processes. In the process of wastewater treatment it is caused by special additives — coagulants. Coagulants form the flakes of metal hydroxides in water, which settle rapidly under the influence of gravity force. The flakes carry the suspended particles of pollutants to the bottom of sedimentation tank.

The coagulating effect of salts is the result of hydrolysis, which takes place after the solution. A metal ion forms a number of intermediate compounds as a result of reacting with hydroxide ions and polymerization. The formed compounds have positive charge and are easily absorbed by the negatively charged particles of pollutants. As coagulants the aluminum or iron salts, or their mixes are normally used. The selection of a coagulant depends on its composition, physical and chemical properties, cost, and concentration of impurities in water, on its pH and the salt composition of water.

Flocculation is the process of suspended particles agglutination as a result of adding high-molecular compounds, which are called flocculants, to waste water. Flocculation is carried out to intensify the process of aluminum and iron hydroxides' flakes formation in order to increase their precipitation rate. The application of flocculants allows reducing the amount of coagulants and the time of coagulation process and increase the precipitation rate of the formed flakes. For wastewater purification both natural and synthetic flocculants can be used. The natural flocculants are starch, dextrine, cellulose esters etc. Among the synthetic organic flocculants polyacrylamide has gained the most widespread usage in our country $(C_3H_5NO)_n$.

Flotation is used for removing the insoluble dispersed impurities from water, which are not prone to sedimentation. Sometimes flotation is also used for removing the dissolved matters, for example the surface-active substances. This process is called foam separation or foam concentration. Flotation is used for purification of wastewaters of many industries: oil-processing, artificial fiber production, cellulose and paper production, leather industry, machine building, foodstuff industry, chemical industry.

Flotation consists in treating wastewaters with gas or air bubbles, which carry over the particles and molecules of pollutants.

The elementary act of flotation consists in the following: at the closing in of a raising air bubble with a solid hydrophobic particle they stick together. Then the aggregate “particle — bubble” raises to the water surface, where bubbles are accumulated, and the foam layer is formed with the higher concentration of particles, than in the initial wastewater. The possibility of the “particle — bubble” flotation aggregate formation, the rate of the process and the strength of adhesion, the longevity of this aggregate depend on the character of particles, as well as on the character of reagents’ interaction with the particles’ surface and the particles’ wetting ability.

The probability of agglutination depends on the wetting ability of the particle, which is characterized with the contact angle of wetting value q. The higher is the contact angle of wetting value, the higher is the probability of agglutination and the strength of the bubble’s adhesion to the surface of the particle.

Adsorption methods are widely used for the fine purification of waste waters from the dissolved organic matters after the biochemical treatment, or in local facilities, if the concentration of these matters is low, and they don’t degrade biologically or are high-toxic.

Adsorption is used for purification wastewater from phenols, herbicides, pesticides, aromatic nitro compounds, surface-active coloring agents etc. The advantage of this method is the high efficiency, the possibility of purifying wastewaters, containing several substances, and recuperation of these substances. The adsorption purification can be regenerative, i. e. with the extraction of the substance from adsorbent and its utilization, and destructive, at which the substances, removed from wastewater, are eliminated together with the adsorbent. The efficiency of adsorption purification amounts to 80-95% and depends on the chemical nature of adsorbent, the size of the adsorption surface and its availability, on the chemical composition of the substance and its state in the solution.

As sorbing agents, one can use activated carbon, synthetic adsorbents and some kinds of industrial waste (ashes, slags, sawdust etc.). The mineral adsorbents — clays, silicagels, alumogels and metal hydroxides are rarely used for adsorbing various substances from wastewaters, as their interaction energy with water molecules is high — sometimes exceeds the adsorption energy, i.e. they interact with water molecules more intensively, than with the pollutant which they should extract.

The most universal of adsorbents is activated carbon.

But the activated carbon has certain drawbacks, too – it is rather expensive and requires regeneration for its re-utilization.

The adsorption purification process of wastewater is carried out at the intensive stirring of adsorbent with water (static purification), at filtering water through the static or moving adsorbent layer or in the fluidized layer in batch-operation and continuous-operation facilities (dynamic purification).

The most important stage of adsorption purification process is the **regeneration of activated carbon**. The adsorbed substances are extracted from carbon by means of desorption with the saturated or superheated steam, or with heated inert gas. After desorption the steam is condensed, and the substance is extracted from the condensation. Carbon can be also regenerated by means of extraction with low-boiling organic solvents, easily distilled with water steam.

If the adsorbed substances hold no value, then the destructive regeneration is carried out with the use of chemical reagents (with chlorine or ozone oxidation, or thermally). The thermal regeneration is carried out in furnaces of various designs at temperature 700-800°C in the anoxic environment.

Electrochemical methods

In order to purify wastewater from various soluble and dispersed impurities the processes of anodic oxidation and cathodic reduction, electrocoagulation, electroflotation and electrodialysis are used. All these processes take place on electrodes at the direct electric current flow through the water. Electrochemical methods allow extracting valuable products from the wastewater at the relatively simple automatized process scheme without using chemical reagents. The main drawback of these methods is the high energy consumption.

Ozonation

Ozone has high oxidation power and at the normal temperature it degrades many organic substances in the water. During this process the simultaneous oxidation of impurities, decolouring, deodorizing, desinfection and oxygenation of wastewater takes place. The advantage of this method is the absence of chemical reagents at wastewater treatment.

The solubility of ozone in the water depends on pH and the amount of impurities in the water. At the presence of acids and salts in the water the solubility of ozone increases, and at the presence of alkali it reduces.

Ozone dissociates spontaneously in the air and in water solutions, transforming into oxygen. In water solutions it dissociates faster. With the increase of temperature and pH the rate of ozone dissociation increases rapidly.

The treated water can be mixed with ozonized air by various methods: water barbotage through filters, perforated (porous) pipes, blending with ejectors, mixers etc.

Chemical purification

The chemical methods of wastewater purification include neutralization, oxidation and reduction. All these methods imply the consumption of various reagents, that's why they are expensive.

The waste waters, which contain mineral acids or alkali, are neutralized before discharging them to water bodies or using them in technological processes. The water is considered neutral if it has pH = 6,5-8,5. Neutralization can be achieved in various ways: by blending acidic and alkaline wastewaters, adding reagents, filtering acidic wastewaters through neutralizing materials, adsorption of acid gases with alkaline waters or adsorption of alkaline gases with acidic waters. The selection of neutralization method depends on the amount and concentration of wastewaters, their flow mode, availability and cost of reagents.

One of the drawbacks of this method, apart from reagents consumption, is the formation of residue, which needs disposal.

For neutralizing acidic wastewaters the following reagents can be used: NaOH, KOH, NH_4OH (ammonia aqua), $CaCO_3$, $MgCO_3$, dolomite, cement. Though the most low-priced reagent is calcium hydroxide (lime milk) containing active lime Ca(OH), 5-10%.

Sometimes various industrial wastes are used for neutralization. For example, the slags of steelmaking, ferro-chromium and blast-furnace industries are used for neutralizing wastewaters, containing sulphuric acid. Reagents are selected depending on the composition and concentration of the acidic wastewater.

Biological wastewater treatment

Biological purification methods are used in the first place for treating wastewater, containing organic pollutants. The essence of this method is mineralizing organic pollutants with active sludge. The active sludge is the clump of bacteria, protozoa, algae, which use organic compounds of wastewater as the source of carbon for their nutritive processes.

All these living organisms rapidly grow, which is conditioned by the organic matters of the wastewater and the excess of oxygen, which is conveyed to the facility with the supplied airflow. Bacteria agglutinate, forming floccules, and evolve the ferments, mineralizing organic pollutants. The sludge with floccules settles rapidly, separating from the treated water.

The natural biological treatment is carried out at the sewage fields, filtration fields, biological ponds, and the artificial biological treatment – in aerotanks and biological filters.

Aerotank is an artificial structure in the form of flow-through basin for biological wastewater treatment.

Before the biological purification wastewaters undergo mechanical treatment, and after the biological purification they are chemically treated and chlorinated with liquid chlorine or chlorinated lime to eliminate pathogenic bacteria. Other physical and chemical methods are also used for water disinfection.

Questions:

1. Which types of water use you do know?
2. What are the cooling water, process water and power water?
3. How can be classified wastewaters depending on the formation conditions?
4. Which main categories of water treatment methods you do know?
5. What is the mechanical wastewater treatment? Which devices are used for it?
6. Which devices use the centrifugal force for water treatment?
7. What is a coagulation?
8. What is a flotation
9. How can be regenerated used activated carbon?
10. What is the ozonation method?
11. What is the chemical purification of wastewaters?
12. What is the biological wastewater treatment?

Theme 8. Methods of dealing with lithosphere pollution

Many kinds of wastes represent an increased danger to the environment, urban and rural population due to the high toxicity. Even their storage or burial without observance of proper security measures could lead to serious consequences for nature and people & environmental damage. At the same time some of the wastes according to their chemical composition and physical state are harmless, they can be dug also can they be drowned in the seas and oceans. Production and consumption of wastes can be valuable forms of secondary material and energy resources. For their “extraction” there is no necessity to produce special geological surveys, to build mining enterprises, to transport technological energy raw materials over long distances. Secondary materials and energy resources to the greatest extent are formed precisely in large industrial centers where there are basic possibilities for their re-use.

A radical solution of the environmental problems from negative effects of industrial objects is possible with extensive use of non-waste and low-waste technologies. The usage of cleaning devices and structures cannot localize completely toxic emissions, and the usage of more advanced treatment systems are always accompanied by an exponential increase of expenses cleaning process costs expenses even in cases where it is technically possible. For example, sewage treatment of a major engineering plant with efficiency up to 90% is provided relatively easy, but each subsequent percent gives rise to costs, soaring up on the exponential curve. Hundred - percent purification is theoretically possible, but practically not reacheable because of the treatment devices cumbersome and their enormous cost. Therefore, you need to look for an alternative solution, namely - to introduce low-waste and resource-saving technologies.

Currently, in accordance with the decision of the United Nations and Research and Economic Commission declaration of low-waste and non-waste technology and the use of waste the following formulation of non-waste technology was accepted : " non-waste technology is a practical application of knowledge, methods and means, so that within the human needs to ensure the most rational use of natural resources and energy and protect the environment ". Non-waste technology, non-waste production, non-waste system are understood as not just technology or production of a product (or products), but the principle of organization and function of enterprises, regional industrial production associations & the regional & national economy as a whole.

Low-waste technology is an intermediate step in creating non- waste production. The basis of non-waste and low-waste productions is the complex processing of raw materials, using all of its components, because the production wastes are unused part of the raw material for one reason or another.

To meet the needs of the economy annually per capita in economic circulation up to 20 tons of natural raw materials is involved. The industry accounts for 70% of the costs for raw materials, fuel and energy. In this regard, in the cases of constantly increasing shortage of natural resources metal and energy consumption play the important role.

Wastes classification is based on the systematization of their industries, refining capacities, state of aggregation, toxicity, etc. In each case, the nature of the classification used corresponds to aspects considered: storage, purification, recycling, wastes disposal, the prevention of their toxic exposure and etc. Every industry has its own waste classification.

Classification of wastes is possible on a variety of indicators, but the most important of them is the degree of danger to human health.

For example, the class of danger of certain chemicals is determined by calculation:

- the presence of mercury in the waste, mercuric chloride, potassium chromate, benzo (a) pyrene, arsenic oxide and other higher toxic substances. It allows you to concern them to the first class of danger;
- presence copper chloride in the wastes, nickel chloride, lead nitrate and other less toxic substances gives reason to revise the wastes as the second class of danger;
- the presence of sulfuric acid copper, copper oxalate, nickel chloride, lead oxide, carbon tetrachloride and other substances in the wastes allows to consider them a third class of danger;
- the presence of manganese sulfate, phosphate, zinc sulfate, zinc chloride in the waste gives reasons to refer them to the fourth class of danger.

All kinds of industrial and household wastes are divided into solid and liquid. Solid ones are waste metals, wood, plastics and other materials, dust of mineral and organic origin from the waste water treatment systems in installations of gas emissions of the industrial enterprises purification, as well as industrial waste, consisting of various organic and minerals substances (rubber, paper, fabric, sand, slag etc.). Liquid wastes include sewage sludge after their treatment, as well as mineral dusts and sludge of organic origin in the wet scrubbing systems.

All kinds of production and consumption wastes can be divided, on the one hand, on the secondary material resources, which are already processed or processing of which is scheduled, and on the other hand on the wastes, which at this stage of economic development process is inappropriate and that will form irrecoverable losses.

Formally, all types of wastes are a combination of those or other chemical compounds which are by different technological ways, in particular by chemical conversion can be converted into the expected products.

Solid domestic wastes (SDW) are formed as a result of everyday activities of people and consist of food waste, used containers and packaging, clothes worn and other obsolete textiles, overage household appliances, furniture, electrical and electronic devices.

The extent of the formation of solid wastes in the Russian cities is characterized by the size of about 200 ... 500 kg per person annually.

Disposal of solid wastes in the most cases leads either to the necessity of a division into the components in the (processes of purification, enrichment, recovery of valuable components) with the following processing of the separated materials by different methods, or giving them a certain type, providing the possibility of recycling the wastes . Several methods are used for treatment and disposal:

- Composting;
- Incineration;
- Landfilling;
- Pyrolysis;
- Recycling.

The collection of the most widespread solid waste treatment and processing methods is shown in figure 10.

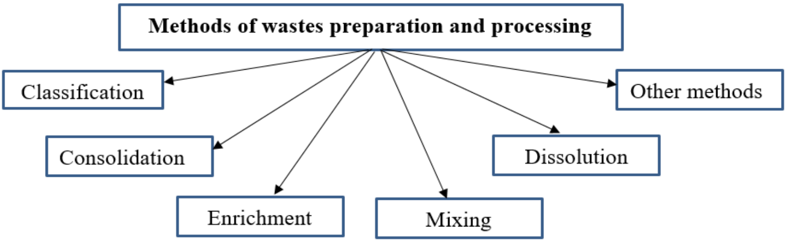


Fig. 10- Methods of wastes preparation and processing

Recycling of wastes is a technological operation or set of process steps, resulting in one or more kinds of commodity products from the waste.

Wastes disposal is much broader concept than recycling, because it includes all the types of their use, including as a fuel for heat and power, as well as for irrigation lands in agriculture, fillings of worked out mountain area, etc.

Wastes treatment is the technological operation or some operations as a result of which the primary toxic substance or group of substances are transformed into neutral, non-toxic and non-degradable compounds.

Centralized processing of wastes is some operations for the collection, transportation and recycling at a specialized production site.

Local wastes processing is a set of operations according to wastes processing, carried out in the zone of production plants, where wastes are formed.

Wastewater sediment (sludge)

At present, the problem of wastewater sediment arises mostly, the volume of which is about 1% of the volume of wastewater.

Sealing of wastewater sediment is the primary stage of their processing. Gravity and flotation methods of sealing are widespread which are in landfill-seals in installations of pressure flotation. A centrifugal sealing in cyclones and centrifuges are also used.

Promising vibratory sealing is done by filtering set-down water sediment through the filter septum or using vibrators embedded in sediment.

Sediment stabilization is used to destroy part of the biodegradable organic material that prevents the rotting of sediment during prolonged storage in the open air (drying on sludge beds, use as an agricultural fertilizer etc.). To stabilize the sediment of industrial waste water mainly aerobic stabilization is mainly used

Aerobic stabilization is long aeration sediment of such type as aeration facilities, resulting in a collapse of main part of biodegradable substances subjected to rotting. Aerobic stabilization period at 20 ° C is 8 ... 11 days.

Air sediment conditioning is carried out for the destruction of the colloidal structure of organic sludge and increase of their water yield during dehydration. In industry the reagent conditioning method with a use of ferric chloride and lime is primarily used. Such processing fee costs to 40% of all for sludge treatment, so development and implement of economic conditioning methods such as heat treatment, freezing and electric coagulation is carried out.

Dewatering of wastewater sediment is intended to obtain sludge with the volume concentration of polydisperse solids to 80%. Until recently, the dehydration was carried out mainly by drying of sediment on sludge beds. However, the low efficiency of such process, shortage of land in industrial areas and air pollution led to the development and application of more effective dehydration methods. Thus, sediment of industrial wastewater is dewatered by vacuum-filtration on filter presses, centrifugation and vibration filtration.

The elimination of sludge is used in those cases where the disposal is impossible or economically unprofitable. The choice of elimination sediment method of is determined according to their composition and also industrial plant layout. Burning is one of the most common methods for the elimination of sludge.

Industrial wastes

The most rational way to protect the lithosphere against wastes production and life is the development of special technologies on the collection and recycling wastes. For the processing of solid wastes such ways as crushing and grinding, classification and sorting, enrichment, magnetic and electric separation, drying and granulation, thermochemical roasting, extraction and others are used.

When the solid wastes are crushed the degree of grinding is different. It depends on the hardness, brittleness and original shape piece. After each stage of the crushing the part of the material can be smaller than the original size and it will be an extra load for the next crushing machine. Therefore, before crushing, and between the rests of its stages the material is sorted according to size into classes by applying for this screening machines. For the separation of lump and bulk materials into fractions the different ways are used e.g. screening or screen sizing; division under the influence of gravitational forces of inertia; division under the action of gravity centrifugal forces.

Enrichment is typically a preparatory stage, which is used to improve the quality of solid waste as a raw material. It allows you to define a significant part of the waste rock and impurities having increased concentration of the valuable components in raw materials and wastes. The chemical composition of the mineral part thus typically does not change, unlike subsequent refining processes in which waste mineral components undergo chemical and physical transformations.

The main directions of the elimination of solid industrial wastes (excluding metal wastes) are export and burial of wastes in landfills, incineration, storage and keeping on the territory of the industrial enterprise to the appearance of a new processing technology of them into useful products (raw materials).

Combustion of solid and pasty wastes can be carried out in virtually all types of furnaces.

SDW (solid domestic wastes)

The problem with the industrial processing of solid wastes consists primarily in the fact that this type of wastes has a complex morphological composition. There is no rational technology of processing such different in its composition of the materials which are contained in the domestic wastes in one technological process but the separation of a mixture into various components on composites on landfills and dumps is almost impossible. The most rational solution of the problem of solid domestic wastes could be the organization of selective collection, or at least a rough pre-sorting prior to incineration or composting. The technology of complex processing of solid domestic waste would be even better, supposing pre-sorting of waste with the following burning of combustible fraction and recycling the released heat, composting, when it is possible & organic fraction and processing of remaining wastes including waste incineration. It should be noted that the scale of the use of complex processing technology SDW in the world is insignificant yet.

In the most European countries preliminary sorting of solid domestic wastes (SDW) is led by population. For the separate collection of waste plastics, glass containers, food waste etc. containers are set; the people are given the special bags & boxes. Waste disposal is carried out by enterprises of public utility or the processing enterprises.

One of the methods of neutralizing household waste is biological processing with the production the compost and biofuels.

In our country and abroad composts from waste are used in agriculture, landscaping with cities, etc. Composting is also contributes to the organization of the natural cycle of matter in nature.

Incineration is widespread abroad. There are many reasons for it the main of them is perfectibility for hygiene requirements, so incinerating plants abroad are set near the residential buildings, what significantly decrease costs for waste collection from households. Under incinerating wastes it is possible to obtain heat, electricity or a combination of both, as well as the metal for second recycling. Under incinerating wastes in the incinerators there is a danger of atmospheric pollution. The combustion process is accompanied by the formation of flue gases containing a large number of suspended particles such as ash and unburned carbon. In some cases when the combustion of solid domestic wastes is done completely in the furnace besides carbon dioxide and water vapor generated sulfur oxides and hydrogen chloride are generated.

SDW incineration requires a high degree of purification of exhaust gases, since dangerous decomposition products such as chlorine and fluorine-containing polymer and other materials, products of oxidation nonferrous metals, dioxins, etc. may be present.

Storage of waste in landfills

Storage of waste in landfills is the simplest, cheapest and often used method of their neutralizing.

On the landfills are not accepted the follows: radioactive wastes, for which the effective methods of extracting metals and other substances are developed; wood waste (sawdust, container, etc.); industrial and construction waste; oil.

Large territories of land, total area of which in Russia is about 10 thousand hectares is given for solid domestic waste storage. Many dumps are already filled or nearly filled, and the construction of new landfills and dumps is connected with certain difficulties in large cities, as a rule, especially when there are large water bodies.

Unorganized wastes dumps, which were used earlier, resulted in the formation of dust, odors, causing a fire & contamination of ground and surface water. Therefore, in recent decades a technology of higher loaded of solid domestic wastes landfills was developed, with a drainless system, which allows to reduce these negative effects to a minimum.

In our time, the garbage is dumped on specially equipped landfills (figure 11).

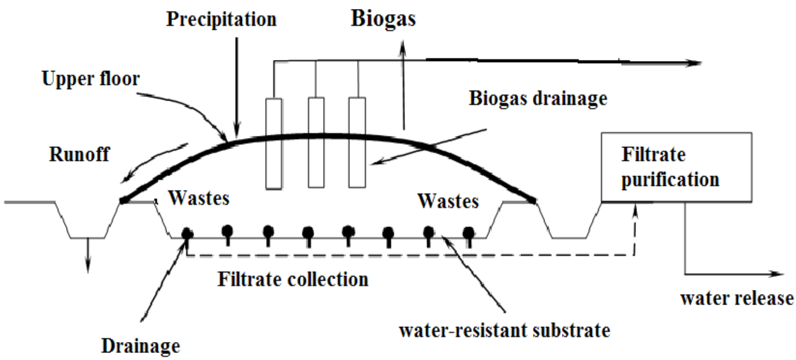


Fig. 11 - Specially equipped landfill

Wastes are stored on a ground under the conditions of protection observation against atmospheric pollution, soil, surface and ground water preventing the spread of disease microorganisms. On landfills solid domestic wastes sealing is made which allows increasing waste load per unit area, thereby giving the economic use of land. After the closure of landfills the surface of ground is re-cultivated for future use of land site.

Land re-cultivation

Besides recycling of various wastes, fertile soil should be recovered or created it on places where it has been spoiled as a result of mining operations & creating landfills, etc. In such cases a set of measures known as land re-cultivation are used.

Land re-cultivation is a set of measures aimed at restoring the productivity of disturbed lands in the process of environmental management, as well as to improve environmental conditions.

The objects of re-cultivations are disturbed lands such areas on which components of nature spoiled, destroyed or completely destroyed e.g. plant and soil cover, soil, groundwater, local hydrographic network (streams, springs, small rivers, lakes, etc.), & topography areas are altered.

The contaminated lands can be also referred to the spoiled grounds, i.e., the lands on which an increase in the content of substances causing adverse toxic and environmental consequences for biota in the components of the nature.

According to the State report "On the state of the natural environment of the Russian Federation in 1996" the total area of land disturbed during mining and exploration work amounted to 697.6 thousand hectares but under disturbing lands during peateries is 300.5 thousand hectares.. By 1 January 1998 an area of disturbed lands belonging to industrial, transport and other non-agricultural use has exceeded 1.2 million. Hectares .

Re-cultivated land is a disturbed land on which productivity, national economic values are restored and environmental conditions are improved.

Re-cultivated land has 3 stages:

1. Preparatory

First re-cultivation project is being developed, which takes into account the location, purpose of re-cultivation, the optimal balance of economic work. When the original data are not enough exploratory work are held.

If necessary, the disturbed land can be preserved, but with the advent of new technologies for their recovery to regulatory requirements they can be used for commercial purposes.

2. Technical is a preparation of land for future intended use.

Technical measures for re-cultivated of disturbed lands are subdivided into the following types:

- Structural and projective: the creation of new design surfaces and landforms, Land reclamation (putting soil layer), peateries, creating screens, removing unnecessary trees and shrubs, stumps, stones, cutting of tussocks;
- Chemical: liming, gypsuming, acidification, introduction of sorbents, organic and mineral fertilizers;
- Water (hydro technical): drainage, irrigation, regulation of the timing with surface water flooding.

3. Biological is fertility restoration, carried out after the technical stage and includes a complex of agro-technical and phyto re-cultivation activities aimed at the resumption of the historical set of flora, fauna and microorganisms.

The works on this stage are carried out by forestry or agricultural enterprise profile, for permanent use of which after technical re-cultivation the land is introduced.

There are areas or types of re-cultivation, which are characterized by specific techniques and methods, depending on the targeted use of re-cultivated areas. The most widely used directions of re-cultivation are agricultural, forestry, fisheries, water management, recreation, sanitation and construction.

The most effective method of biological re-cultivation of disturbed areas is the creation of multi-species vegetation with perennial grasses and resistant species of shrubs and trees. With such a multi-tiered structure the disturbed land is well protected from erosion and deflation but thanks to leaf litter and root systems they get big boost organic substances.

On the lands contaminated by man-made products, the main task the biological re-cultivation is to increase self-purification capacity of the soil. The solution to this problem is possible by co-operation of technical and biological systems that operate on a wide range of activities, including using specially grown microorganisms.

Re-cultivation (cleaning) of soil from the man-made products with the help of microorganisms is based on the destruction (decomposition) of these products within the regulated time. In practice, this method is used for cleaning soils contaminated with oil, petroleum products and pesticides. Biodegradation technology includes the creation of favorable water and air, heat and nutrient conditions for microbes and regular monitoring of the number of employed population.

Organizational biological re-cultivation is carried out in two stages. At the first stage pioneer (preliminary, avant-garde) cultures are cultivated, able to adapt to the existing conditions and with high resilience. At the second stage it is necessary to pass to the intended use. Lands contaminated by heavy metals, organic materials or products of industrial processing are purified at the first step using sorbents, plants or microorganisms (bio destructor), and then they are included into the economic use under strict supervision of the sanitary - epidemiological services.

In order to develop effective methods of biological re-cultivation is very important to study the processes of vegetation evolution in the various natural areas and technological conditions.

Formation of vegetation on dumps of overburden rocks is very slow because of the complex varying time dump topography, poverty of rocks in nutrients, water and heat instability modes.

On the sand pits in the steppe zone vegetation appears in 5 ... 7 years, up to 10 ... 12 years it can amount 5 ... 10 kinds of the most resistant plants.

On gravel pits individual plants can be seen in 3 ... 4 years. By the age of 5 ... 6 there are 8 -10 kinds of herbs. By age of 15, there are about 30 species.

On the exhausted peat quarries with enough moisture and nutrients vegetation appears at the first year. First, there are rare plants, in 2 ... 3

years a continuous ground cover is formed, after 5 ... 6 years shrubland plants appear.

Overgrowth of disturbed lands creates the stock of organic matter in the young soils, which is a result of biochemical processes, improves the nutrient status of the soil and promotes the formation of stable vegetation.

The rate of soil formation and the formation of soil horizons depend on the properties of parent rocks, their water and heat conditions, topography, climatic conditions of the area, the species composition of the vegetation and the duration of the restoration of natural land.

For the success of the re-cultivation it is necessary to have special knowledge and information about the kinds of plants that grow in the area, especially their growth, requirements soils, relationships in ecosystems. The specialists who carry out the work to restore the soil should decide which species will be most effective to grow in the given conditions, which ones will accumulate a pollution, which species will have high or low sensitivity for them, which plants are better to plant at the second and the third stage to provide the most rapid and efficient recovery of land.

Questions:

1. Give a definition of a non-waste technology.
2. Which methods are used for waste treatment and disposal?
3. Name the main methods of wastes preparation and processing.
4. Describe the main methods of dealing with wastewater sediment (sludge).
5. How can be treated industrial wastes?
6. What are solid domestic wastes and how they can be treated?
7. How wastes can be stored in landfills? Draw a scheme of a specially equipped landfill.
8. Describe the 3 stages of land re-cultivation.

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