Unit 1. The Biosphere*

The biosphere, also called the ecosphere, is the natural environment of living organisms and is the complex biological epidermis of the Earth whose dimensions are not precisely defined. It consists of the surficial part of the lithosphere, a lower part of the atmosphere, and the hydrosphere. Several ecosystems have been developed within the biosphere. Each ecosystem is a fundamental division of the total environment consisting of living organisms in a given area and having a *balanced* cycling of chemical elements and energy flow.

Among the principal resources of which man disposes, are terrestrial ecosystems consisting of soil and water, and associated animal and plant life. Ecosystems are functional environmental units, having *balanced* cycles of chemical elements, organic materials and energy flow. There is a homeostatic interrelationship between the nonliving media (abiotic compartments) and the living organisms (biotic compartments). However, a significant part of the ecosystems has already been considerably modified by humans, and these processes will continue.

The energy for life is derived from the radiant energy of the sun, which drives the chemical reaction of photosynthesis. The other sources of energy, e.g., geothermal, gravitation, and electrical, are of negligible importance in the total energy flow, but may determine specific conditions of some ecosystems.

Organisms have adjusted during the course of evolution and life to the chemistry of their environment and have developed their biochemistry in close connection to the composition of the natural environment. These phenomena have been easily observed, mainly in microorganisms and plant populations that have evolved tolerance to high concentrations of trace elements either in natural geochemical provinces, or under man-induced conditions.

Most of the chemical elements for life on the land are supplied mainly from the soil overlying the surficial lithosphere (Fig. 1). Although mechanisms of biological selection of chemical elements allow plants to control, to a certain extent, their chemical composition, this barrier is somewhat limited in respect to trace elements. Therefore concentrations of trace elements in plants are often positively correlated with the abundance of these elements in growth media. This creates several problems for plants, animals and humans associated either with deficiency or with excess. Thus, questions of how and how much of an element is taken up by organisms have been hot topics of research in recent decades. Usually the quantitative differences between essential amounts and biological excesses of trace elements are very small. A proper balance between trace and major elements plays a significant role in biochemical processes. The bioavailability of these elements is variable and is controlled by specific properties of abiotic and biotic media as well as by physical and chemical properties of a given element.

The biochemical functions of essential trace elements are already known. A great number of trace elements are known to have a biological role, often as cofactors or part of cofactor in enzymes and as structural elements in proteins. Some of them also are used in several processes of electron transfer. Non-essential

elements seem to be involved in vital processes but their biochemical functions are not yet understood. The essentiality of other trace elements, possible at very minor concentrations, may be discovered in the future. Most of trace elements that are essential to humans are also essential to plants. Unfortunately, contents of most elements that may be harmful to humans and animals are not toxic to plants. This has created an increased transfer of some elements in the food chain.

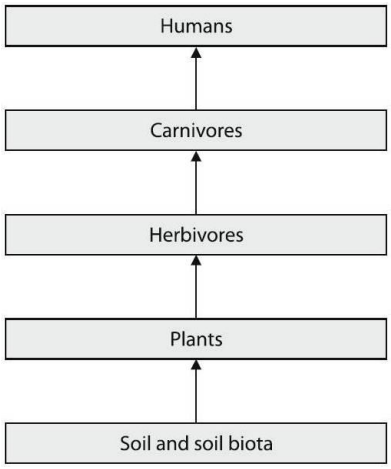

Fig 1. The transfer of chemical elements in schematic terrestrial trophic chain

The survival of mankind is a story of food. Both, lack of food and bad quality of food have created throughout the centuries serious problems for people. Nowadays it is calculated that over 3 billion people worldwide suffer from either deficiency or toxicity of some trace elements.

Here is a place to remind Paracelsus'[1] (1538) statement:

All substances are poisonous, there are none which is not a poison; the right dose is what differentiates a poison from a remedy.

The anthroposphere. Many ecosystems have been considerably modified by humans and therefore it has become necessary to distinguish the anthroposphere – the sphere of man's settlement and activity. The anthroposphere does not represent a separate sphere, but may be applied to any part of the biosphere that has been changed under an influence of technical civilization.

While geological, geochemical and biological alterations of the lithosphere have been very slow, changes introduced or stimulated by humans have been accumulated extremely quickly in recent decades of the past century. Anthropogenic changes, associated mainly with chemical pollution, lead most often to a degradation of the natural human environment. Among all chemical pollutants, trace elements are of a special ecological, biological and health significance.

The production of energy and the consumption of natural resources are the main source of trace elements as contaminants. However, agricultural activities

[1] Парацельс (лат. *Paracelsus*) (настоящее имя Филипп Ауреол Теофраст Бомбаст фон Гогенхайм (Гогенгейм), так же Хоэнхайм, лат. *Philippus Aureolus Theophrastus Bombast von Hohenheim*) (родился в конце 1493 г. в г. Эйнзидельн, кантон Швиц, умер 24 сентября 1541 г. в Зальцбурге) – знаменитый алхимик, врач и оккультист. Ему также приписывается именование цинка.

and especially application of sewage sludge, manure, mineral fertilizers (NPK), and pesticides also contribute significantly to the trace metal status of agroecosystems.

Bowen (1979) [2] has suggested that when the rate of mining of a given element exceeds the natural rate of its cycling by a factor of ten or more, the element should be considered a potential pollutant. Thus, the potentially most hazardous trace metals to the biosphere may be: Ag, Au, Cd, Hg, Pb, Sb, Sn, Te, W. Also those elements that are essential to plants and humans, such as: Cr, Cu, Mn, and Zn, may be released, in some regions, in excessive amounts.

*Original text from the book «Trace elements from soil to human», 2007.

Task

Put in the words missed.

1) A significant part of the ecosystems _____ already _____ considerably modified by humans.

2) The other sources of energy, e.g., geothermal, gravitation, and electrical, are of _____ importance in the total energy flow.

3) Although mechanisms of biological _____ of chemical elements allow plants to control, to a certain extent, their chemical composition, this barrier is somewhat limited in _____ trace elements.

4) A _____ balance between trace and major elements _____a significant role in biochemical processes.

5) The biochemical functions of _____ trace elements are already known.

6) Contents of most elements that may be _____ to humans and animals are not toxic to plants.

7) The _____ of mankind is a story of food.

8) Many ecosystems have been considerably modified by _____ and therefore it has become necessary to distinguish the anthroposphere – the sphere of man's settlement and _____.

9) Anthropogenic changes, associated mainly with chemical _____, lead most often to a degradation of the _____ human environment.

10) The production of energy and the _____of natural resources are the main source of trace elements as contaminants.

11) The potentially most _____ trace metals to the biosphere may be: Ag, Au, Cd, Hg, Pb, Sb, Sn, Te, W.

Read the following text and answer the questions after the text.

[2] Bowen H.T.M. Environmental chemistry of the elements. London: Acad. Press, 1979

Ecosystem*

An ecosystem is a natural ecological niche with unique physical and chemical characteristics. It supports a complex community of dynamically interacting populations of organisms called a biome. The interactions involve the search and competition for food, the use of space and natural resources, and nutrient recycling through a food web. There is a natural mutual regulation of population size in the community that maintains an ecological balance and benefits all organisms. This natural ecological entity is wee or grand in size. Its biome or community of organisms is distinguished by vegetation. The ecosystem is defined by the adaptation of living populations to unique environmental attributes.

Ecosystems vary greatly in natural physical conditions (e.g., climate [temperature, precipitation]). They may be bathed in full sunlight, shielded from the sun, in shaded to dim light, or they may exist in dark conditions. Ecosystems in caves or in the deep oceans contain life that survives in total darkness. Chemical characteristics of ecosystem waters and soils vary markedly. Atmospheric chemistry varies less.

Together, temperature, rainfall, and soil composition largely determine the vegetation assemblage in an environment. This creates ecological regimes in geographically distinct regions that sustain flourishing biomes or biomes in a constant struggle for survival.

Terrestrial ecosystems with clean air to breathe, safe water for drinking and hygiene, and uncontaminated fertile soils sustain and nurture all living creatures. Vegetation that roots and grows with vigor, watered by rainfall or by irrigation, feeds humans and other life forms with its vegetables, grains, fruits, nuts, berries and leaves. It is a nutrient source for food animals (e.g., cattle, sheep, goats, fish, foul). Similarly, clean fluvial, lacustrine, estuarine and ocean ecosystems provide nutrition to sustain their communities of organisms.

Although air and water can be considered abiotic in a strict sense, the atmosphere contains airborne organisms such as Roseobacteria which aid in the formation of clouds by producing gases that nucleate water droplets. The hydrosphere contains minute to large algae/vegetation species and a grand diversity of aqueous life. Soils sustain productivity with their nutrients (from rock/mineral decomposition) and the activity of bacteria and other organisms in soils. The so-called abiotic matter nourishes biotic forms from the lowest to the highest trophic levels. A continuum of this relationship preserves equilibrium in food chains and food webs, and in ecosystem vitality.

In order to attain and maintain a good standard of living and improve it, human populations have needs in addition to clean air, safe water, and untainted, fertile soils. Some of these are fibers, wood, metal ores, industrial rocks and minerals, and energy sources. Access to these and consumption of commodities and products crafted from them varies among global populations. Two principal factors that influence the variations are geographic location and economic status. Mineral deposits are an example of the former. They are small and irregularly and widely dispersed. An example of the latter is that economically advantaged groups

have access to clean water from collection, treatment, and distribution networks at reasonable prices. This contrasts with poor groups who may have to use tainted water or elect to buy clean water at highly inflated prices from unscrupulous water vendors.

Environments with biomes in ecological balance can be stable throughout the year or vary seasonally. Life forms adjust to changing natural or anthropogenic induced physical and/or chemical properties in ecosystems in different ways to reproduce and survive. Organisms may adapt to changes and stay as inhospitable conditions evolve, perhaps with a slowdown of activity. Some mobile species move away to find favorable ecological conditions. Others do not readily adapt to a deteriorating ecosystem and try to survive environmental intrusions despite high death tolls in their populations. When ecosystem conditions return to "livable", organisms revive from their survival modes to reestablish their biorhythms and natural activities.

Ecosystem degradation can cause a rupture in the interrelationships between populations dependent on each other symbiotically or as a source of nutrition along a food chain or within a food web. Sometimes this can be overcome. When there is a great diversity of organisms, predators that lose their prey may switch to other prey.

In ecosystems with limited diversity, a rupture between dependent populations can endanger biome niches or threaten organism survival within the ecological system.

Ultimately, if a cascading effect of changing conditions (e.g., salinity, drought, wildfires) or missing biological links in the food chain/food web continues, more organism populations can decline and an ecosystem can crash. Even with a crash, there will be survivors that adapt to the new conditions and live on. Others do not adapt and will either move to habitable ecosystems or die.

* By Siegel F.R. Demands of expanding populations and development Planning. Berlin-Heidelberg: Springer-Verlag, 2008.

Task

Answer the questions:

1. What are the main components of an ecosystem?
2. Which external factors do influence the living organisms?
3. How these factors are called?
4. What can you say about the changes in ecosystems and adaptation of organisms in these changes?