CONTENTS

Chapter 1
SOME ISSUES OF GENERAL ECOLOGY

1.1. ECOLOGY AS A SCIENCE. AGGRAVATION OF ENVIRONMENTAL PROBLEMS AS A RESULT OF SOCIAL DEVELOPMENT

Advent of humans on Earth has predetermined development of the environment. For a long time, the man-made environmental impact was minor, as long as people were just a biologic species living on Earth and were subject to the same laws as other organisms.

With scientific and technical progress, the environmental impact from work activities of individuals became extremely notable.

Nowadays, work activities of individuals affect the environment to a greater extent and can cause unpredictable disastrous effects as large as complete destruction of life; and the entire world is focused on solution for ecological issues. We encounter them constantly, day by day; they are widely discussed by mass media and on TV: purity of air, purity of potable water, green products, changes in radiation background, etc.

Every professional pharmacist will have to deal with environmental problems one way or another. The objective of this course is to acquire theoretical and practical knowledge that is essential for successful solution of such tasks.

A number of terms used in daily life are more applicable when used scientifically. The term **«ecology»** was proposed in **1866** by German biologist **Ernst Haeckel**. Literally, ecology is **the science of organisms in their natural habitat** (from Greek «oikos» — household, fatherland, and «logos» — study of). According to Haeckel, ecology is the science of the relations between organisms and the environment (V.F. Protasov, 1995).

Nowadays, «ecology» is **the science studying the laws of existence, formation and functioning of biological systems of any level — from organisms to the biosphere, and their relations with external environment** (V.F. Protasov, 1995).

As such, ecology is **a theoretical foundation of the sustainable use by individuals of natural resources, a scientific foundation for development of a strategy and tactics of relations between the human society and nature.**

The current state of ecology. Significance of ecological education and training

In the process of its development, ecology split into several scientific branches and disciplines depending on the object of study. The branches of ecology are presented in fig. 1.1.

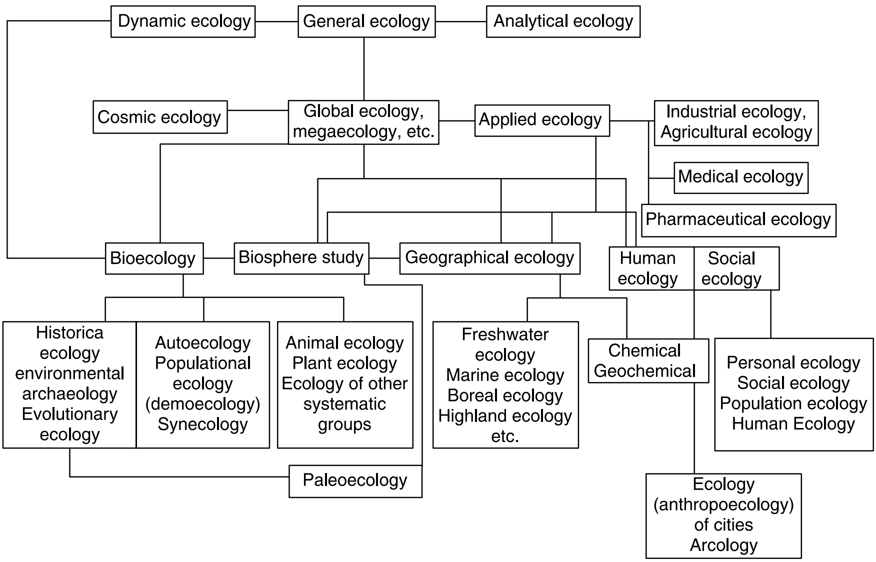

Fig. 1.1. Branches of ecology

Pharmaceutical ecology is a part of applied ecology; its objective is to solve the problems arising in the process of pharmaceutical activities.

Currently, there are novel conditions in use and application of medicines, which allow considerably widening the scope of pharmaceutical ecology and including problems caused by **active distribution and avail-**

ability of medicines for the population, as well as **by counterfeiting** and **production of low-quality medicines.**

Overdosage, unjustified self-prescription, drug addiction and abuse, use by patients of counterfeit and low-quality medicines cause harm to health, give rise to a number of diseases, e.g. **microelementosis, hypervitaminosis,** etc.

Of note, production, storage, destruction, and unauthorized disposal of counterfeit products, which can contain unknown or uncontrolled biologically active chemical compounds, can cause huge damage to the environment. For instance, increased or non-claimed metals in a medicine can cause harm to the environment, even if disposed of in an authorized way. Unauthorized disposal is very dangerous, since then the environmental pollution is not only chemical, but also biological and microbiological in nature. It is also worth mentioning that stricter measures to fight counterfeit medications can result in increase in unauthorized destruction of counterfeit products and, thus, harm to the environment. Accumulation of medicines at homes, which are flushed or end at dumps after shelf life expiration date is also a source of harm.

The field of study of the pharmaceutical ecology also includes study of the interaction specifics, thus, of the use of medicines containing compounds, any overdosage of which causes negative effects for the body. Fluoride compounds are a good example. Low fluoride content in potable water is known to affect dental enamel; the risk of caries decreases with increasing concentration of fluoride in potable water to approximately 1 mg/L. However, further increase in fluoride concentration causes increase in the rate of dental fluorosis, bone changes (osteoarthritis deformans), growth retardation, renal and thyroid damage. These factors should be taken into account when using medicines containing fluoride compounds in the regions, where groundwater passes through fluoride apatites or other fluoride-containing minerals and where water sources can contain discharges from aluminium, glass and phosphoric fertilizer production (V.F. Protasov, 1995).

In addition, in case of medicines containing selenium and some other compounds, water quality should be taken into account.

1.2. ENVIRONMENT. ECOLOGICAL FACTORS

All living and non-living objects around us are our **environment.** Elements of the environment impacting the organisms are **ecological factors**. They are conventionally divided into three major groups:

- **abiotic,** or physical and chemical factors: temperature, humidity, chemical composition, etc.;
- **biotic:** relations between living organisms;
- **anthropogenic:** caused by human activities (V.F. Protasov, 1995).

1.3. BIOSPHERE. BIOSPHERE COMPONENTS ACCORDING TO V.I. VERNADSKY

Evolution of life on Earth resulted in development of a biosphere. **Biosphere is an area where a living matter exists** (lower part of the atmosphere, the entire hydrosphere, and upper part of the lithosphere). In Russia, this notion was introduced by Vladimir Ivanovich Vernadsky. For an ecological philosophy in accordance with V.I. Vernadsky, biosphere should be considered as a whole, and it is essential to see the relations that shape its key features.

According to Vladimir Ivanovich Vernadsky, biosphere includes:

- **«a living matter»** — a totality of living organisms;
- **«a biogenic matter»** — organic-and-mineral and organic products created by a living matter (coal, peat, organic slime, humus);
- **«a bioinert matter»** — substances resulting from interaction between living organisms and inorganic nature (gases of the lower part of the atmosphere, sedimentary rocks, clay minerals, and water).

Over a number of geologic times, these three matters have been constantly interacting, with the living matter playing the leading role. The primary feature of the biosphere is **extremely diverse living organisms**, which appeared during the course of evolution.

The foundation of V.I. Vernadsky's theory is the notion of the biosphere as an integral shell of Earth, which is inhabited and transformed by the living matter of the planet. Continuous exchange of non-living, inert matter and living matter changes both organisms in biosphere and their environment, and new laws of natural interaction emerge.

1.4. BIOSPHERE BOUNDARIES

It is commonly believed that the boundaries of the biosphere pass 3 km below the land surface and 0.5 km below the ocean bed. The upper boundary covers the entire troposphere and the lower part of the stratosphere, extending 20 km above the Earth surface (see. fig. 1.2).

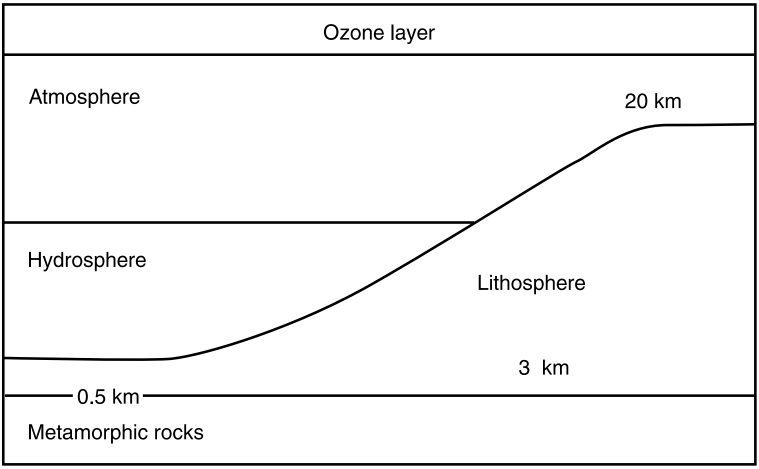

Fig. 1.2. Biosphere Boundaries

Therefore, the vertical section of the biosphere includes three layers: **lithosphere, hydrosphere, and atmosphere**. At the bottom, biosphere is surrounded by an area of «old biospheres» — «**metamorphic rocks**» and granite shell. At the top, biosphere borders on the **ozone layer** of the stratosphere. Ozonosphere (ozone layer), lying above biosphere and absorbing ultraviolet (UV) radiation which is harmful to living organisms of the biosphere, is formed by oxygen. Therefore, metamorphic rocks and ozonosphere are associated with biosphere in their origin (V.F. Protasov, 1995).

1.5. FUNDAMENTAL PRINCIPLES OF V.I. VERNADSKY'S THEORY

The biosphere integrity primarily depends on constant integration of its components. The three components of the biosphere — **hydrosphere, atmosphere and lithosphere** — are closely connected and form one functional system.

A part of the lithosphere, an integral component of the biosphere, called **«soil»**, has a lot in common with the hydrosphere and atmosphere. Connection with the hydrosphere is due to constant washout of groundwater s into various water bodies. This is the soil where surface water becomes groundwater participating in formation of the river discharges. Compounds in the soil carried with water take part in the bioproductivity development of water bodies. Sorption properties of the soil form a kind of barrier protecting water bodies against pollution.

Absorbing and reflecting solar radiation, soil acts as a powerful factor in the energy balance of the biosphere and is associated with atmospheric processes. Soil processes take part in regulation of the moisture circulation and gas conditions of the atmosphere. The connection between the lithosphere and soil is direct: soil originated from the upper layers of the lithosphere and facilitates geochemical transformation of these layers. At the same time, soil is a source of the matter to transform minerals, rocks, mineral products and promotes carry-over of accumulated solar energy into deep lithosphere.

All these processes are global functions of soil (**pedosphere**) that are of significance for the biosphere in general. More generally, if talking about these functions, the significance of the biosphere can be defined as a link between the **biological and geologic turnover** (V.F. Protasov, 1995).

The functional relations between the components of the biosphere also include interrelation between processes in the atmosphere and hydrosphere. First of all, this is **the water cycle**: replenishment of the hydrosphere due to precipitation and return of water to the atmosphere in the form of evaporation from the ocean and other water surfaces. Then, **energy bonds,** both direct (through **heat radiation)** and indirect (through **photosynthesis**). Finally, there are **chemical bonds**: dissolution of O_2 and CO_2 in water. The latter maintains dynamic balance in the aquatic environment. Altogether, the functional relationship between components of the biosphere makes it a self-balancing system, ensuring a stable **global cycle of matters**.

Numerous and diverse living organisms, the totality of which Academician V.I. Vernadsky called **«a living matter»,** have a **special role** to play in this system. This is due to the **high chemical activity of the living matter**. Chemical (biochemical) reactions in living organisms are facilitated by potent biological catalysers (enzymes) and are a thousand times faster that reactions in the inorganic world. Besides, enzymes shift temperature and other conditions of reactions. In addition, high reactivity of the living matter promotes continuous involvement of elements actively extracted from rocks. Biologically relevant chemical elements constantly take part in the global turnover with living organisms. It is estimated that, assuming that the biosphere appeared at least 3–4 billion years ago, the water of the global ocean passed the biological cycle no less than 300 times, and the free oxygen of the atmosphere — no less than 1 million times (V.F. Protasov, 1995).

High activity of the living matter is also impacted by **regulatory** processes in the biosphere. Oxygen maintains the ozone screen and, thus, a relatively **constant flow of radiative energy**, which reaches the surface of the planet. **Constant mineral composition of the ocean** water is a result of functioning of organisms that actively extract some elements, balancing their afflux with river discharge to the ocean. Such regulation can be seen in a number of other processes; it makes the biosphere an integral system capable of self-regulation (P. Revell, 1995).

It is beyond doubt that living organisms have potent back reaction over the biosphere, changing the composition and properties of the primary environments (I.A. Shilov, 1997). Results of the integrated activity of various living organisms are not only in the form of their adaptation to a certain environment, but also in the form of a back action over the environment, modifying its basic characteristics. It is based on the process of **exchange of matters** as a specific property of life.

Current properties of the biosphere components as environments are greatly dependent on the impact from the joint activities of living organisms in them. Accumulating over the geological history of our planet, this impact has drastically changed the initial chemical and physical properties of the environment to make it suitable for stable life.

As mentioned above, **soil origin and properties are** completely dependent on activities of living organisms. Only living organisms are capable of decomposing organic matter, without which any ground rock does not have the specific properties of soil, including fertility. Activities of microorganisms, plants and animals form the soil structure, its chemical properties and promote further soil formation.

As a result, if any active form of life penetrates the lithosphere not too deeply, then sedimentary rock layers generated are several kilometres thick. Some scientists call this part of the lithosphere «**metabiosphere**» (V.F. Protasov, 1995). It is a product of the biosphere and borders on it.

In the aquatic environment, the impact of living organisms over the **chemical composition of water** is strongly pronounced. Various groups of organisms constantly release metabolism products into the aquatic environment, including salt ions, organic acids, nitrogenous matters, hydrogen sulphide, etc. Plants release oxygen, which remains partially dissolved. Numerous filter feeders continuously allow passing large volume of water through their bodies, trapping suspended organic particles and dissolved salts. It has been calculated that during a 5-year period, the filter feeders in the Great Barrier Reef (Australia) filter all water in the Pacific Ocean (P. Revell, 1995).

Selective extraction of certain substances from the environment and their accumulation in the body, typical of many organisms, cause not only shifts in the chemical properties of the environment, but also **specific relief and properties of the seabed** (e.g., formation of reefs, atolls, organogenic silts, etc.). The bed relief is influenced by **large animals as well**: it is testified that, for instance in the north-eastern part of the Bering Sea, Pacific walruses and grey whales, who eat benthos, create pits and channels in the sea bed in the amount and of the size, impacting the relief in the same manner as geological processes. Many animals accumulate certain salts in their skeleton (Ca, Si, Mg, P, etc.). When dead, these organisms form thick deposits of limestone, dolomite, silicon, etc., making the geological stricture of the seabed (P. Revell, 1995).

Organic rock deposits formed not only the seabed relief and impacted chemical properties of water. Ending up on land as a result of geological processes, they made up the geological basis of a number of its areas, took part in formation of the continent relief and gave rise to various soil types. Moreover, secondary metamorphization of sedimentary rocks at high temperature and pressure can result in crystalline rocks, which usually are not called organogenic. Thus, the results of aquatic organism activities can be seen also in the current properties of the terrestrial environment.

The current gas composition of the atmosphere is mostly dependent on activities of living organisms, primarily through **photosynthesis and respiration**. The history of the atmosphere formation is quite complicated. Free molecular oxygen was emitted also during the prebiological period of the Earth development. It originated from photodecomposition of water vapour. However, no oxygen accumulated in the atmosphere at that time; it immediately reacted with carbon oxide in volcanic gases and with other substances and often gave rise to the ozone layer in the upper layers of the atmosphere, which prevented further steam photodissociation (P. Revell, 1995).

It might be that with the emergence of first photosynthetic organisms (probably similar to contemporary cyanobacteria) in Pre-Cambrian water bodies, oxygen content in the atmosphere was regulated by the same mechanism; and the oxygen resulting from photosynthesis dissolved in water completely. Anyway, during the pre-Palaeozoic period, oxygen accumulated slowly and was below 10% of the current level. The oxygen level in the atmosphere rose significantly only when ground vegetation appeared; the ozone layer and CO_2 and water vapour, which accumulated in the upper layers of the atmosphere, gradually screened off short-wave solar radiation and prevented further generation of oxygen as a result of water photodissociation (P. Revell, 1995).

During the early periods of the Earth development, carbon dioxide (CO_2) originated only from volcanoes, and CO_2 concentration in the atmosphere was higher than nowadays. Currently, a major part of CO_2 in the atmosphere has biological origin: it is emitted mostly with respiration in living organisms.

Overall, currently the ratio of oxygen and carbon dioxide in the atmosphere depends on the balanced functioning of the living organisms in the biosphere. V.I. Vernadsky (1967) was of the opinion that this is true for the free nitrogen in the atmosphere (V.F. Protasov, 1995).

Current properties of the gas envelope are very important for the thermal balance of the Earth. A major part of solar energy reaches the Earth surface in the visible spectrum. The Earth reflects energy, but (being a cold object) mostly in the infrared (IR) (long-wave) spectrum. The IR radiation of the Earth is shielded by water vapours, CO_2 and ozone. It prevents excessive heat loss by the Earth surface and facilitates increase in the planet surface temperature. It has been calculated that without this «greenhouse effect» the temperature in the near-Earth layer would be approximately 40 °C lower than the current value. Obviously, such temperature conditions would not be favourable for life development, at least in the forms encountered on the Earth.