LECTURE

THE ROLE OF LIVING ORGANISMS IN SOIL FORMATION

Plan of the lecture

1. The role of microorganisms in soil formation
2. The role of higher plants in soil formation
3. Plant formations in nature
4. Participation of animals in soil formation

1. The role of microorganisms in soil formation

The main function of microorganisms in soil formation is the decomposition of organic residues of plant and animal origin to humus formation and complete mineralization.

Bacteria, algae, lichens and fungi take part in the process of soil formation.

Bacteria are the most numerous and diverse group of microorganisms that inhabit the soil. About 50 genera and 250 species of soil bacteria are known.

Autotrophic bacteria - the source of nutrition of which is the inorganic environment. They absorb carbon from carbon dioxide and are able to synthesize organic matter themselves, for which they need external energy. This group of bacteria can exist in the environment where there is no form of organic matter. These bacteria use the energy released during the oxidation of mineral compounds to ensure the processes of life.

Heterotrophic bacteria require finished organic matter for their life. They absorb carbon from finished organic compounds. It is this group of microorganisms that decomposes a huge mass of dead organic residues that get into the soil and its surface.

Fungi – lower organisms that make up a special kingdom of wildlife. In nature, they are spread everywhere. The main function in soil formation is the

decomposition of organic residues. Representatives of all classes take part in this process. Molds are the most common in soils.

Soil algae – these plant organisms have the ability to use solar energy to form organic matter and accumulate it in the soil. Species of individual algae, such as green, blue-green and diatoms, grow well on solid media (rocks). Blue-green algae can often be observed on the surface of various rocks, and especially in the cracks of porous limestones, in which water is retained; they form dark or even black spots on them.

Lichens are a special group of living organisms whose body consists of two components: a fungus and an alga. They do not belong to soil microorganisms, but they participate in soil formation.

Lichens settle on stationary substrates (rocks, stones, trees) or grow on the soil surface. They emit complex organic acids, which are called lichen. These acids destroy minerals and thus create favourable conditions for soil formation.

2. The role of higher plants in soil formation

Familiarity with the role of microorganisms in soil formation indicates that they themselves do not yet create soil. Soil formation is possible only when the producers of organic matter settle on the parent rock. Higher plants are such producers on the Earth. It is these organisms that play a leading role in the processes of soil formation. Dead remains of higher plants, changed by microorganisms and animals, make up the main mass of the organic part of the soil. Thus, **green plants are the main source of organic matter for soil formation.**

Green land plants annually produce about $5.3 \cdot 10^{11}$ tons of biomass. Part of this biomass in the form of dead remains of roots and aboveground organs gets into the soil annually. The amount of biological mass getting into the soil depends on the type of vegetation and climatic conditions (Table 1). Part of the leaf and branch shedding is decomposed by microorganisms, and the second part accumulates in the form of forest litter and steppe mat.

The following indicators were introduced: total biomass, mass of dead organic

residues, annual growth and mass of annual shedding to estimate the dynamics of organic matter in the plants – soil system. These indicators are usually expressed in c/ha.

Analyzing the data given in table 1, it is possible to establish at what rate the decomposition of biomass of the leaf and branch shedding by microorganisms occurs. Microorganisms do not have time to decompose the entire mass of annual shedding in the taiga-forest zone, where the summer is relatively shorter and cooler. Therefore, a strong forest litter is formed here. The annual shedding of the humid tropical forest (250 c/ha) is almost completely mineralized during the year. Therefore, there is practically no forest litter on the surface of red-yellow tropical soils.

Assimilation of chemical elements of the soil by the roots of higher plants, synthesis of organic substances, their return to the soil and their decomposition by microorganisms are the main elements in the biological cycle of substances. From the above it is clear that **green plants are the main agent of the biological cycle**, and the soil is its arena. **This is the second function of plants as soil formers.**

Table 1. Indicators of the biological productivity of the main types of vegetation (L. S. Rudin and N. I. Bazylevych, 1965)

Types of vegetation	Biomass			Growth, %	Shedding, c/ha	Forest litter (steppe mat), c/ha
	c/ha	Aboveground part, %	Roots, %			
Arctic tundras	50	30	70	10	10	35
Shrub tundras	280	17	83	25	24	835
Spruce forests of the northern taiga	1000	78	22	45	35	300
Spruce forests of the southern taiga	3300	78	22	85	55	350
Oak woods	4000	76	24	90	65	150
Meadow steppes	250	32	68	137	13	120
Dry steppes	100	15	85	42	42	15
Deserts of temperate zone	43	13	87	12	12	-
Savannah (Ghana)	666	94	6	120	115	13
Humid tropical forest	5000	82	18	325	250	20

Plants in the process of life carry out biogenic migration of chemical elements in the system soil - plant - soil. In this case, a significant part of the ash elements, as well as nitrogen accumulates in the upper soil horizon. In this case, plants act as **concentrators of chemical elements**. **This is the third function of plants in soil formation.**

3. Plant formations in nature

There is a close connection between higher plants and microorganisms. Coexistence of higher green plants with lower chlorophyll-free ones is the main factor of soil formation. Academician V. R. Williams called such natural combinations as plant formations, there are four of them:

1. Tree plant formation is the coexistence of woody plants and fungi, actinomycetes and anaerobic bacteria. In this formation, podzolic soils are formed.

2. Meadow-herbaceous plant formation is characterized by the coexistence of meadow herbaceous green plants with aerobic bacteria, but with a sharp advantage of anaerobic bacteria.

Chernozems and meadow soil are the main soils that predominate in this formation.

3. Steppe plant formation consists mainly of herbaceous green plants, common in the steppes, where aerobic bacteria predominate. Southern chernozems and chestnut soils are formed in this formation.

4. Desert plant formation differs from steppe in that mainly chymotrophic bacteria and algae play the role in creating organic matter, except some plants, and aerobic and anaerobic bacteria and fungi destroy the remnants in these soils.

The speed of accumulation of organic matter and its destruction depends on which plant formation is involved in soil formation processes. For example, the destruction of plant residues will be slower under the predominant action of anaerobic bacteria, resulting in more favourable conditions for the formation of humus, while “ammonia, mineralization will be more actively under aerobic conditions; this will accumulate nutrients for the plant, but the content of humus in the soil will be less.

Plant formations in nature replace each other, their replacement causes changing in the soil formation process, and hence the type of soil and its fertility.

4. Participation of animals in soil formation

The soil fauna is extremely numerous and diverse. Representatives of the following types of animals take part in the processes of soil formation: protozoa, worms, mollusks, arthropods and mammals. The soil fauna is divided into four groups according to the size: nano-, micro-, meso- and macrofauna. Each group of animals is adapted to certain living conditions, to a certain interaction with the environment. The total stocks of zoomass in soils relative to phytomass are insignificant - on average 1–2 %.

The main function of animals in the biosphere and soil formation is consumption, primary and secondary destruction of organic residues, redistribution of energy reserves and its conversion into thermal, mechanical and chemical. Herbivores play an important role in this process. They synthesize animal organic matter - zoomass. Herbivores open the "food chain" of organisms.

Invertebrates predominate among the animals inhabiting the soil. Their total biomass is 1000 times higher than the total biomass of vertebrates. Earthworms, enchitreids, mites, springtails, etc. live in the soil. They significantly accelerate the biological cycle of substances by eating plant residues.

Earthworms among invertebrates play a particularly important role in soil formation. They are common in soils of different soil-and-climatic zones. Their number can reach several million individuals per 1 hectare of soil.

The activity of earthworms in soil formation is diverse, they form a dense system of passages in the soil, which improves its physical properties: porosity, aeration, moisture content. Products of life of earthworms - caprolite improve the structure of the soil and increase the water resistance of structural units. Soil rich in earthworms has low acidity, high humus content and other positive properties. It is estimated that earthworms mix the entire surface horizon of the soil for 50 years.

A significant number of larvae of different insects, termites, ants, etc. live in

the soil. They also intensively mix the soil mass, form a large number of passages in it and thus improve the water and air properties of the soil.

Among vertebrates, steppe rodents (voles, marmots, moles, gophers, etc.) take an active part in soil formation processes. They build deep holes and long passages in the soil. The volume of soil they mix reaches several hundred cubic meters per 1 hectare. Intensive mixing of soil mass by earthmoving animals causes not only physical but also profound chemical changes. Soil mass removed from the depths to the surface changes the chemical composition of the upper soil horizons.