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DISTRIBUTION OF MICROORGANISMS IN TYPICAL GRAY SOILS

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Abstract
This article analyzes the microbiological properties of typical gray soils widespread in Uzbekistan, the distribution of microorganisms along the soil profile, and their role in the formation of soil fertility. Typical gray soils are formed in arid and semi-arid conditions of Central Asia, and their biological activity changes significantly as a result of irrigation and agricultural use. Literature analysis shows that the amount and ratio of physiological groups such as bacteria, fungi, actinomycetes, ammonifiers, and oligonitrophils in the soil are closely related to soil moisture, organic carbon, humus, nitrogen, pH, mechanical composition, plant roots, irrigation, and agrotechnical measures. In typical gray soils, the main part of microorganisms is usually found in the upper layers, where organic matter and plant roots accumulate more. As a general rule, a decrease in microbial biomass and biological activity with increasing depth is observed. In the conditions of Uzbekistan, irrigation, erosion, and the use of mineral and organic fertilizers can change this vertical distribution. The article also discusses the prospects for using microbiological indicators to assess the biological productivity of typical gray soils.

Keywords: Typical gray soil, microorganisms, soil microflora, bacteria, fungi, actinomycetes, ammonifiers, oligonitrophils, microbiological activity, humus, irrigated soil, soil fertility.

Introduction

Soil is a complex natural-biological system, the fertility of which is determined not only by its physical and chemical properties, but also by the vital activity of microorganisms. The soil microbiome includes bacteria, fungi, archaea, protists and other microorganisms. They play an important role in the decomposition of organic matter, the carbon and nitrogen cycle, the conversion of phosphorus into forms available to plants, and the formation of soil structure.

Gray soils are of particular geo-geographical importance in Uzbekistan. According to FAO, typical gray soils constitute a significant part of the country's soil cover and are especially widespread in areas with developed irrigated agriculture. They are found in regions such as Tashkent, Samarkand, Jizzakh, Kashkadarya and Surkhandarya.

In the natural conditions of typical gray soils, the relatively limited moisture and low organic matter content create unique ecological conditions for microorganisms. However, irrigation, the introduction of plant residues into the soil, and the use of manure and mineral fertilizers change the moisture, nutrient, and oxidation-reduction regimes of the soil. Therefore, the number, composition, and distribution of microorganisms along the soil profile may be different from those in natural gray soils.

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Studying the vertical distribution of soil microorganisms is particularly important because the density of organic carbon, nitrogen, moisture, oxygen, and plant roots is not the same in different layers of the soil. International studies have often noted that microbial biomass decreases with increasing depth, especially below the top 10 cm layer.

Purpose of the study

The purpose of the study is to analyze the distribution patterns of the main groups of microorganisms in typical gray soils based on the literature, determine their relationship with the physicochemical properties of the soil, and highlight the importance of microbiological indicators in assessing soil fertility.

Research materials and methods

The article was prepared in the form of a literature review. Scientific articles on typical gray soils of Uzbekistan, soil science data, and international soil microbiology studies were analyzed.

The following indicators were taken as the main criteria when assessing the distribution of microorganisms along the soil profile:

- total number of microorganisms;
- the spread of bacteria and fungi;
- the amount of actinomycetes;
- ammonifiers and oligonitrophiles;
- soil humus and organic carbon content;
- soil moisture;
- pH;
- mechanical composition;
- plant roots and the impact of agrotechnical measures.

Discussion of results

Microbiological properties of typical gray soils. The biological activity of typical gray soils is directly related to their moisture and organic matter supply. In irrigated typical gray soils, the increase in plant biomass and root residues increases the carbon and energy sources for microorganisms.

One study in Uzbekistan investigated ammonifiers, oligonitrophiles, actinomycetes, and fungi in typical irrigated gray soils in the Middle Chirchik region of Tashkent region. The study noted that the number of microorganisms varied depending on soil depth, erosion rate, and growing season.

The data from this study indicate that microbiological activity in the upper 0–30 cm layer may be higher than in the 30–50 cm layer. For example, in some variants of the experiment, the amount of ammonifiers was recorded as high as 210,000 units in the 0–30 cm layer, and around 130,500 units in the 30–50 cm layer. These indicators decreased even further in eroded soils.

These results are consistent with a general ecological law indicating that microorganisms accumulate more in the biologically active layer of the soil.

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Distribution of microorganisms by vertical zonation. Due to the high content of plant residues, root exudates and organic matter in the upper part of the soil profile, the nutrient environment for microorganisms is more favorable. Therefore, the biomass of bacteria and fungi is observed to be higher in the upper layers.

An international meta-analysis covering soil profiles found that microbial biomass decreases with depth, with fungal biomass being distributed closer to the surface than bacteria. The study showed that the majority of microbial biomass is located in the top 10 cm of soil.

However, depth alone is not enough to explain this process. Soil organic carbon, total nitrogen, pH, clay fraction, moisture, and plant root distribution have a significant impact on the vertical structure of the microbial community, as can be seen in this table.

Soil layer	Microbiological properties
0-10 cm	High biological activity due to the abundance of organic matter and roots
10-30 cm	Active zone of roots; bacteria, actinomycetes, and some fungi are active
30-50 cm	Microbial biomass usually decreases due to depletion of organic substrates
Deeper than 50 cm	Microbial numbers and metabolic activity are generally lower, but adapted groups are maintained

Estimated vertical distribution of microorganisms in typical gray soils

This table represents a generalized ecological pattern and should not be interpreted as a direct experimental result for a typical gray soil in a specific area.

Bacterial distribution. Bacteria are one of the most active microbiological components of typical gray soils. They are involved in the decomposition of organic residues, mineralization of nitrogen compounds, conversion of some phosphorus compounds into soluble forms, and various interactions with plants.

The vertical distribution of soil bacteria can be strongly correlated with the amount of organic carbon and total nitrogen. Experiments show that the total carbon of the soil has a significant impact on the structure of the bacterial community.

In typical gray soils, the higher number of bacteria in the upper layers is primarily due to the presence of plant roots and organic residues. Irrigation, however, can provide the moisture necessary for the activity of microorganisms and, at certain times, can enhance their reproduction.

Fungal distribution. Fungi are important in the decomposition of soil organic matter, especially complex polymers. They are involved in the decomposition of cellulose, hemicellulose, and other organic components.

The species composition of fungi in typical gray soils of Uzbekistan has also been studied. In studies in the southwestern Hissar region, fungi belonging to the genera Aspergillus, Penicillium, Fusarium, Alternaria, Cladosporium, Trichoderma and others were recorded in typical gray soils. This study showed that the amount of fungi in typical gray soils is lower than in some other mountain soils.

This situation may be due to the formation of gray soils in relatively dry conditions, low organic matter content, and specific moisture regimes.

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The importance of actinomycetes and ammonifiers. Actinomycetes play an important role in the decomposition of soil organic matter, the mineralization of complex organic compounds, and the maintenance of the microbiological balance in the soil. They can adapt to relatively dry environments better than some bacteria.

Ammonifiers, on the other hand, participate in the decomposition of organic nitrogen compounds and the formation of nitrogen in the ammonium form. Therefore, their activity is an important biological indicator of the nitrogen cycle in the soil.

In a study conducted on typical irrigated gray soils of the Tashkent region, the amount of ammonifiers and oligonitrophiles varied depending on soil depth and erosion status.

The effect of erosion on the distribution of microorganisms. Soil erosion causes the top layer, rich in organic matter, to be washed away or carried away by the wind. As a result, food sources for microorganisms are reduced.

Studies conducted in Uzbekistan have noted a decrease in the abundance of ammonifiers, oligonitrophiles, actinomycetes, and fungi in typical gray soils that have been eroded.

This situation shows that microbiological mechanisms are also important in the decline of soil fertility. Therefore, combating erosion is important not only from the point of view of reducing physical soil loss, but also from the point of view of maintaining soil microbiological activity.

The impact of irrigation and agrotechnical measures. In the arid climate of Uzbekistan, irrigation significantly changes the biological regime of typical gray soils. Irrigation can increase soil moisture, increase plant biomass, and increase the amount of substrate for microorganisms.

However, excessive irrigation can worsen soil aeration, increase the risk of salinization or secondary degradation. Therefore, optimal conditions for microorganisms depend on the amount and frequency of irrigation.

The activity of microorganisms and enzymes in irrigated Uzbek soils is of great importance in the mineralization of organic matter. Studies conducted on typical gray soils have shown that mineral, organic, and bacterial fertilizers can affect the activity of carbohydrate-degrading enzymes.

Also, in modern research, enzymes such as dehydrogenase, urease, catalase, and phosphatase are being used as bioindicators to assess the biological activity of soil.

The above results indicate that the distribution of microorganisms in typical gray soils cannot be explained by a single factor. The formation of a microbial community is the result of the interaction of several environmental factors at the same time.

Conditionally, this relationship can be expressed through the following conceptual model:

Organic matter + moisture + temperature + plant roots + aeration + pH → microbial biomass and activity → mineralization of organic matter → nutrient cycling → soil fertility.

In this case, microorganisms are not a simple "result" of soil fertility, but a biological factor actively participating in its formation. Therefore, the use of microbiological indicators in combination with agrochemical and physical indicators in assessing the ecological state of typical gray soils is a scientifically sound approach.

Microorganisms and soil fertility. It is not enough to assess soil fertility only by the amount of humus, nitrogen, phosphorus and potassium. Microorganisms play a major role in the transformation of these elements in the soil into a form that can be used by plants.

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Microorganisms:

1. decomposes organic residues;
2. converts organic nitrogen into mineral forms;
3. mobilizes some insoluble forms of phosphorus;
4. helps in the formation of soil aggregates;
5. forms symbiotic and associative relationships with plant roots;
6. participates in the suppression of certain plant diseases;
7. controls the storage and cycling of carbon in the soil.

Therefore, it is appropriate to use microbiological biomass, enzymatic activity, and microbial community structural indicators in addition to the number of microorganisms when monitoring the biological productivity of typical gray soils.

In conclusion, the literature review shows that the distribution of microorganisms in typical gray soils is closely related to the vertical structure of the soil, organic matter content, moisture, pH, plant roots, erosion, and agrotechnical measures.

The most biologically active part of typical gray soils is usually the topsoil. As depth increases, microbial biomass and microbial activity tend to decrease as organic substrates decrease. However, different groups of microorganisms do not respond to this change in the same way.

In Uzbekistan, irrigation can improve moisture and nutrient conditions for microbial activity, but improper irrigation can exacerbate soil degradation processes. Erosion, in turn, leads to a decrease in microbiological activity through the loss of topsoil rich in organic matter.

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