THE ROLE OF SOIL MICROORGANISMS IN ECOLOGICAL BALANCE

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Abstract

This article highlights the role of soil microorganisms in maintaining ecological balance, as well as their importance in soil fertility and biogeochemical processes. In addition, the decline of microbiological activity under the influence of anthropogenic factors and the ways of its restoration are analyzed based on scientific data. The research results demonstrate that the protection of soil microorganisms is essential for ecological sustainability and food security.

Keywords: soil microorganisms, soil microbiota, ecological balance, soil fertility, humus, biogeochemical cycling, rhizosphere, agroecosystem, soil degradation, desertification, pesticides, heavy metals, bioremediation, ecological sustainability, food security

Introduction

In recent years, improper use of land resources, climate change, and increasing anthropogenic pressure have disrupted the stability of soil ecosystems. Soil degradation, the depletion of humus reserves, and the decline in biological activity have had serious negative impacts on agricultural productivity and natural ecosystems, leading to desertification and the disruption of ecological balance.

At the center of these processes are soil microorganisms, which play a leading role in the decomposition of organic residues, humus formation, nutrient cycling, and the formation of soil structure. A decrease in microbial activity sharply reduces soil fertility and weakens ecosystem stability.

Particularly in arid regions, the biochemical processes carried out by microorganisms serve as a key factor determining ecosystem viability. Therefore, their in-depth study is of great importance for the development of sustainable agriculture and the provision of environmental security.

Literature Review

Soil microorganisms — including bacteria, fungi, archaea, and other microbial groups — are fundamental components of ecosystem stability and soil functional integrity. Recent studies, including Yuxing An et al. (2024), confirm that microorganisms directly affect soil quality and fertility through organic matter decomposition, nutrient transformation, and plant growth stimulation.

Microorganisms regulate biogeochemical cycles by converting carbon and essential nutrients such as nitrogen, phosphorus, and potassium into plant-available forms. Their interaction within the rhizosphere enhances nutrient uptake efficiency and increases plant tolerance to environmental stress [1]. Over the past three decades, research has demonstrated that the soil microbiome plays key roles in detoxification, pathogen suppression, enzymatic regulation, and stress mitigation [2].

Arbuscular mycorrhizal fungi improve soil aggregation and water infiltration, while nitrogen-fixing bacteria such as *Rhizobium* increase nitrogen availability and reduce dependence on synthetic fertilizers [3].

However, excessive mineral fertilizer use, particularly nitrogen-based fertilizers, decreases microbial biomass and functional activity. Pesticides suppress soil enzyme systems and may reduce microbial activity by 25–60%. Heavy metal contamination (Pb, Cd, Zn, Hg) lowers microbial diversity and weakens soil resilience. Intensive mechanical tillage disrupts microbial habitats, whereas reduced or conservation tillage maintains higher biological activity.

Table 1. Influence of Soil Microorganisms on Soil Quality

Microorganism Group	**Improvement of Soil Quality (%)**	**Research Analysis**
Bacteria (general)	~30–50%	Soil bacteria decompose organic matter, fix nitrogen, and enhance plant nutrition. They play a key role in increasing soil fertility (ouci.dntb.gov.ua).
Nitrogen-fixing bacteria	~40–60%	Convert atmospheric nitrogen into plant-available forms, significantly enhancing plant growth (link.springer.com).
Actinomycetes	~20–35%	Decompose complex organic compounds such as lignin, improving soil structure and quality (orientjchem.org).
Microalgae (*Chlorella*, *Scenedesmus*)	~15–30%	Enzymatic activity contributes bioactive compounds and improves soil fertility (openscience.uz).
Arbuscular mycorrhizal fungi (AMF)	~35–55%	Form symbiotic associations with plant roots, improving water and nutrient uptake (publishing.emanresearch.org).

Overall microbial community	~50–95%	The soil microbial community has a strong positive impact on soil health and plant growth (ouci.dntb.gov.ua).

Methodology

This study is based on a qualitative analytical approach. Relevant peer-reviewed scientific articles, international research reports, and academic publications on soil microbiology, soil degradation, and agroecological management were systematically reviewed.

The selected sources were analyzed to determine the role of soil microorganisms in maintaining ecological balance and soil fertility. Particular attention was given to research examining the impact of chemical and anthropogenic factors on soil microbial communities.

A comparative and synthesis method was applied to summarize documented evidence regarding soil quality decline and microbial activity disturbances. In addition, scientifically grounded agroecological strategies for preventing soil degradation and restoring microbial activity were systematized.

Table 2. Chemical Factors Contributing to Soil Quality Decline

Chemical Factor Group	Impact on Soil Quality	Main Negative Effect
Excessive mineral fertilizers	Soil degradation	Soil acidification and reduced microbial activity
Excess nitrogen fertilizers	Nutrient imbalance	Nitrate accumulation and microbial disruption
Excess phosphorus fertilizers	Altered nutrient dynamics	Suppression of microbiological activity

Pesticides (insecticides, fungicides, herbicides)	Microbial suppression	Reduction of beneficial microorganisms
Heavy metal salts (Pb, Cd, Hg)	Soil toxicity	Loss of microbial diversity and biological dysfunction
Petroleum products and industrial waste	Structural degradation	Severe disturbance of soil structure and microbial life

Conclusion

Today, the decline of soil microorganisms is not merely a scientific concern but a serious threat to global food security and environmental sustainability. Scientific observations indicate that in some agricultural regions, soil microbiological activity has decreased by 40–60% over the past three to four decades. This trend suggests the gradual loss of soil vitality as a living system.

If soil microbial activity is disrupted, humus formation declines, nutrient cycling is interrupted, and soil fertility decreases sharply. As a consequence, crop yields are reduced, desertification intensifies, and biodiversity is lost. Although this process is not immediately visible, it progressively and irreversibly undermines the food resources of society.

The extensive use of pesticides, mineral fertilizers, heavy metals, and industrial pollutants creates toxic conditions for millions of soil microorganisms. The loss of billions of microorganisms living in a single gram of fertile soil represents a silent degradation of entire ecosystems. The deterioration of soil health may not be immediately apparent, but its long-term consequences will affect human well-being.

Therefore, protecting soil microorganisms is not only an environmental issue but also a matter of safeguarding humanity's future. Without restoring the living foundation of soil today, sustainable agriculture, environmental health, and food security may become increasingly difficult to achieve in the future.

References

1. Jurys A., Feizienė D. *The Effect of Specific Soil Microorganisms on Soil Quality Parameters…*, *Plants*, 2021. MDPI

2. Wang, X., Chi, Y., & Song, S. (2024). *Important soil microbiota's effects on plants and soils: a comprehensive 30-year systematic literature review*. *Frontiers in Microbiology*, 15, 1347745. https://doi.org/10.3389/fmicb.2024.1347745

3. Raja Noor Zaliha Raja Abd. Rahman et al. *Impacts of Pesticides on Soil Microbial Communities: Balancing Agricultural Productivity and Environmental Health*, *Microbial Bioactives*, 2025. publishing.emanresearch.org

4. Zambrano-Gary C.C., Kirichuk A.A. *Bioremediation of polluted soils with pesticides using microorganisms*, *RUDN Journal of Ecology and Life Safety*, 2023. journals.rudn.ru

5. *Controllability of soil loss and runoff using soil microorganisms: A review*, *Ecohydrology & Hydrobiology*, 2025. ScienceDirect

6. *Tuproq degradatsiyasi*, FermerMaktab.uz, 2025. fermermaktab.uz

7. Usmonova G., Amonova S. *Tuproq mikroflorasi va uni aniqlash usullari*. Worldly Journals

8. *Tuproq unumdorligini saqlashda yangi biotexnologik yondashuvlar*, Int. Journal of Science and Technology, 2025. science-technol

9. Kamalova Y. B., Istamboyeva M. Strategies For Conservation Of Rare And Endangered Plant Species In The Flora Of Uzbekistan //International Conference on Global Trends and Innovations in Multidisciplinary Research. – 2025. – T. 1. – №. 6. – C. 62-64.

10. Kamalova YB Virtual laboratoriya orqali talabalarga oqsil denaturatsiyasini tushuntirishning afzalliklari // Ko'p tarmoqli tadqiqotlarda global tendentsiyalar va innovatsiyalar bo'yicha xalqaro konferensiya. – 2025. – T. 1. – №. 4. – S. 118-120.