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THE IMPORTANCE OF MICROORGANISMS IN THE ENVIRONMENT

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ABSTRACT

This article examines the importance of microorganisms in the environment, their role in ecological systems, and their key functions in the biosphere. Microorganisms actively participate in biogeochemical cycles, including carbon, nitrogen, and sulfur cycles, and play a crucial role in the decomposition of organic matter. They also contribute to soil fertility, natural water purification processes, and the maintenance of biogeochemical balance. The article discusses both beneficial and harmful effects of microorganisms, including pathogenic forms and their impact on environmental and human health. The findings highlight the indispensable role of microorganisms in maintaining ecosystem stability.

Keywords: Microorganisms, environment, biosphere, biogeochemical cycles, metabolism, soil fertility, water self-purification, ecological balance, pathogenic microorganisms, biodegradation.

INTRODUCTION

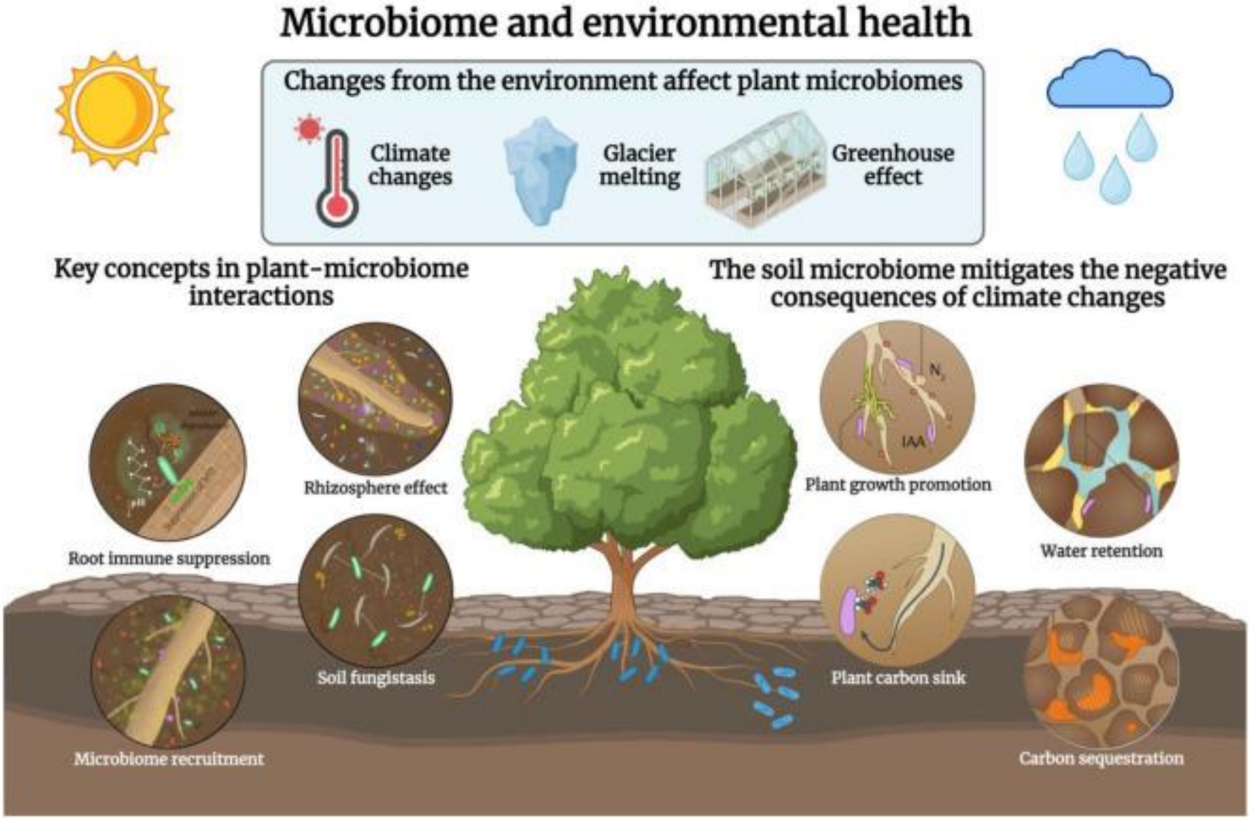
Microorganisms are microscopic living systems consisting of bacteria, viruses, fungi, and protozoa, and they are an integral part of the Earth's biosphere. They are widely distributed in all components of the environment, including soil, water, air, and within living organisms. The ecological significance of microorganisms is primarily determined by their active participation in matter and energy cycles. In particular, they play a key role in biogeochemical cycles, including the carbon, nitrogen, phosphorus, and sulfur cycles. Through these processes, organic substances are decomposed, converted into simpler compounds, and made available again for assimilation by living organisms. In the soil environment, microorganisms contribute to humus formation, nitrogen fixation, and nitrification processes, thereby ensuring soil fertility. In aquatic ecosystems, they decompose organic pollutants and carry out natural self-purification processes of water. At the same time, microorganisms play an important role in regulating the composition of atmospheric gases, including maintaining the balance of carbon dioxide and oxygen. Some microorganisms live in symbiotic relationships and have a positive impact on the жизнедеятельность of plants and animals. However, microorganisms have not only beneficial but also harmful effects. Pathogenic microorganisms cause various infectious diseases in humans, animals, and plants, leading to ecological and epidemiological problems. From this perspective, the role of microorganisms in the environment is dual in nature—characterized by both beneficial and harmful impacts. The relevance of this topic lies in the fact that current global environmental issues—such as environmental pollution, climate change, and the loss of biodiversity—are directly linked to microbial activity. Modern scientific research is expanding the possibilities of using microorganisms effectively in biotechnology, environmental protection, bioremediation, and industrial processes. At the same time, the increasing emergence and re-emergence of infectious diseases makes the in-depth study of microorganisms even more urgent. Thus, studying the importance of microorganisms in the environment is of significant scientific and practical value not only for fundamental biology and ecology but also for medicine, agriculture, and environmental protection.

MATERIALS AND METHODS

In this study, comprehensive microbiological, ecological, and statistical methods were used to assess the importance of microorganisms in the environment. Soil, water, and air samples were selected as the objects of the research. Samples were collected from ecologically diverse areas, including agricultural lands, industrial zones, and natural water bodies, in compliance with standard sanitary and hygienic regulations.

Sampling methods:

Soil samples were collected from a depth of 5–20 cm using sterile instruments. Water samples were collected in sterile glass containers and delivered to the laboratory within 2–4 hours. Air samples were obtained using the sedimentation method as well as special aerobiological equipment.



Microbiological Examination Methods:

Classical microbiological methods were used to identify microorganisms and assess their quantity in the collected samples. Nutrient media such as meat-peptone agar (MPA), Endo medium, Sabouraud medium, and other selective and differential media were utilized. The microorganisms were incubated at a temperature of 28–37°C for 24–72 hours. Preliminary identification was carried out based on colony morphology, color, shape, and growth characteristics.

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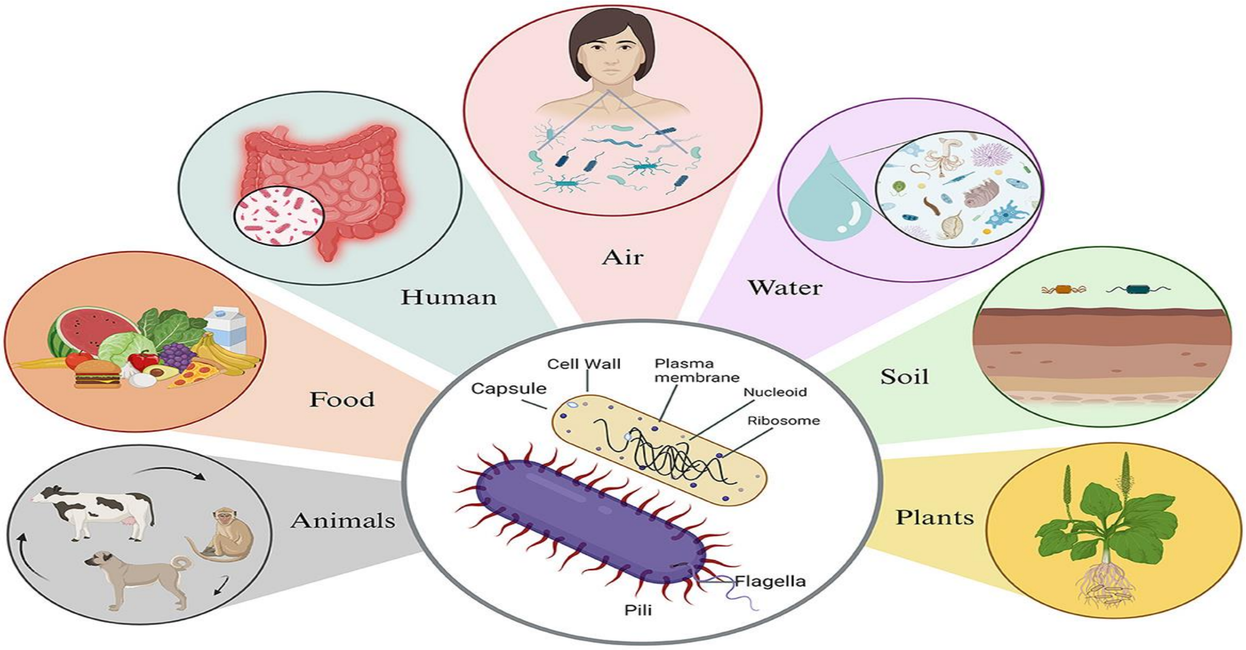
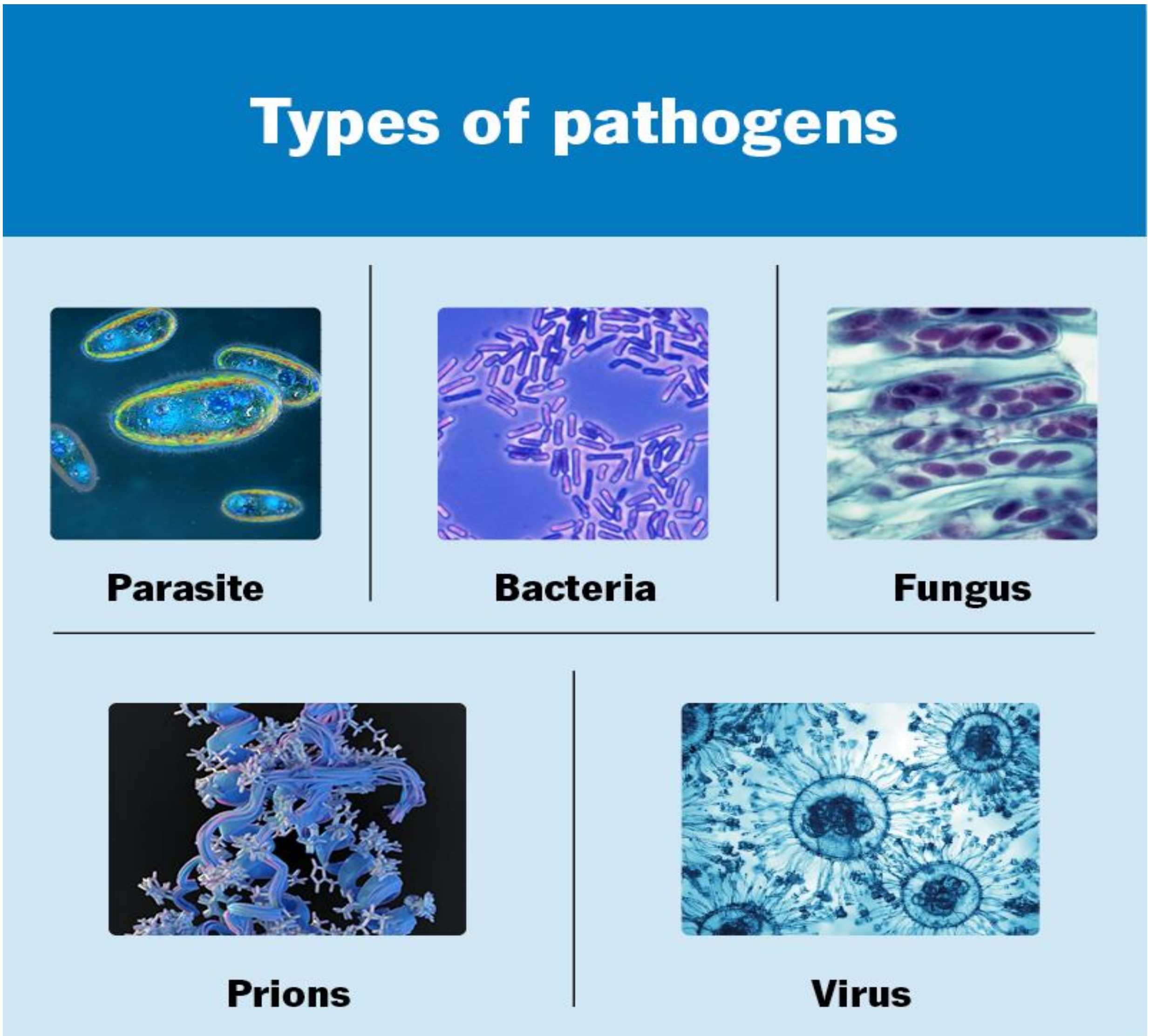


Microscopic Analysis:

Prepared slides were stained using the Gram staining method, allowing bacteria to be classified into Gram-positive and Gram-negative groups. Fungi were identified under the microscope based on their morphological characteristics.



Biochemical and Ecological Analysis:

The metabolic activity (enzymatic properties) of microorganisms was assessed using catalase, oxidase, and carbohydrate fermentation tests. In addition, the role of microorganisms in nutrient cycling—particularly nitrogen fixation, nitrification, and the biodegradation of organic substances—was studied under laboratory conditions.

Statistical Analysis:

The obtained results were analyzed using mathematical and statistical methods. The number of microorganisms was expressed as mean value (M) and standard deviation (±m). The reliability of the results was evaluated using Student's t-test ($p < 0.05$ was considered statistically significant). All data obtained during the study were systematically processed and analyzed in accordance with modern methodological guidelines in microbiology and ecology.

RESULTS

The conducted microbiological studies revealed that microorganisms are widely distributed across various environmental components (soil, water, and air), and their quantity and composition vary significantly depending on environmental conditions. In particular, a higher number of microorganisms was observed in environments rich in organic matter. Soil samples showed the highest concentration of microorganisms, which can be explained by the abundance of nutrients and moisture content in soil. In water samples, the number of microorganisms was found to depend on the level of pollution. Although microorganisms were present in lower numbers in air, their presence was noted as an important indicator for assessing environmental sanitary conditions. Furthermore, the study of ecological functions of microorganisms experimentally confirmed their active participation in the decomposition of organic matter, nitrogen cycling (ammonification, nitrification), and natural self-purification processes of water. In particular, the significant role of saprophytic bacteria and fungi in biodegradation processes was observed.

Table 1. Number of microorganisms in environmental samples (CFU/ml or CFU/g)

Environment type	Number of microorganisms (mean)	Main representatives of microflora
Soil	$(3.5 \pm 0.4) \times 10^6$ CFU/g	Bacillus spp., Actinomyces, fungi
Water	$(2.1 \pm 0.3) \times 10^4$ CFU/ml	Escherichia coli, Pseudomonas spp.
Air	$(1.3 \pm 0.2) \times 10^3$ CFU/m³	Micrococcus spp., Staphylococcus spp.

The results showed that the number of microorganisms in soil is significantly higher compared to other environments, confirming that soil is their primary habitat. Microorganisms in water and air environments vary mainly depending on external factors, including anthropogenic pollution.

Table 2. Ecological functions of microorganisms and their significance

Microorganism group	Ecological function	Significance
Saprophytic bacteria	Decompose organic matter	Increase soil fertility
Nitrifying bacteria	Convert ammonia to nitrates	Ensure nitrogen cycling
Nitrogen-fixing bacteria	Fix atmospheric nitrogen	Source of nitrogen for plants
Fungi	Participate in biodegradation	Important in environmental cleanup

Pathogenic bacteria	Cause diseases	Create epidemiological risks

The analysis also demonstrated that microbial activity in the environment is a key factor in maintaining ecological balance. Despite the predominance of beneficial functions, the presence of certain pathogenic species necessitates strengthening sanitary and hygienic measures.

DISCUSSION

The results of the study once again confirm that the role of microorganisms in the environment is extensive and multifaceted. The findings are consistent with modern theories in microbiology and ecology, which recognize microorganisms as key participants in matter and energy cycles within the biosphere. The high number of microorganisms in soil indicates their leading role in organic matter decomposition and humus formation. As identified in the study, saprophytic bacteria and actinomycetes dominate the soil microbiocenosis, forming the microbiological basis of soil fertility. As noted in the literature, these microorganisms produce essential mineral substances required for plant growth and facilitate their absorption. At the same time, bacteria involved in nitrogen fixation and nitrification play a crucial role in maintaining nitrogen balance in soil. Results obtained from aquatic environments showed that the quantity and composition of microorganisms are directly related to the level of water pollution. The detection of conditionally pathogenic and indicator microorganisms (such as coliform bacteria) serves as an important criterion for assessing the sanitary condition of water bodies. This confirms the importance of microbiological monitoring in modern environmental control systems. Although fewer microorganisms were detected in the air, their presence is significant from an epidemiological perspective. Airborne transmission of infections is closely linked to air microflora, making air quality monitoring an essential part of sanitary-hygienic systems.

It is important to emphasize the balance between the beneficial and harmful aspects of microorganisms. On one hand, they ensure ecological stability, decompose organic waste, and contribute to the restoration of natural resources. On the other hand, pathogenic forms can cause diseases in humans, animals, and plants, leading to serious medical and economic consequences. Modern research is expanding new applications of microorganisms, particularly in biotechnology, bioremediation, and industrial microbiology. These findings highlight the importance of not only controlling microorganisms but also using them effectively and purposefully. Their potential in reducing environmental pollution and solving ecological problems is especially significant. Thus, the results and their analysis demonstrate that microorganisms play a fundamentally and practically important role in the environment. Future research should focus on deeper molecular-biological and ecological studies to identify new microbial properties and implement them in practice.

CONCLUSION

The results of the study clearly demonstrate the importance of microorganisms in the environment. Microorganisms actively participate in matter and energy cycles in ecological systems, particularly in carbon, nitrogen, and sulfur cycles. They decompose organic matter and enhance soil fertility. In aquatic environments, they ensure natural self-purification processes, while in the air they have epidemiological significance. The beneficial effects of microorganisms are crucial for maintaining ecological stability and restoring natural resources, whereas pathogenic forms pose risks to humans, animals, and plants. Therefore, ecological and sanitary control of microorganisms, as well as their effective application in biotechnology and bioremediation, remains highly relevant. In general, the study confirms the invaluable fundamental and practical role of microorganisms in the environment and highlights the need for further in-depth research into their ecological and medical aspects.

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