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PERSPECTIVE

The hidden role of microorganisms in ecosystem health

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Microorganisms, despite their microscopic size, play an indispensable role in maintaining ecosystem health and stability. Their functions extend beyond simple decomposition and nutrient cycling, contributing to processes such as soil fertility, climate regulation and disease suppression. This article delves into the critical, often overlooked, contributions of microorganisms to ecosystem health, exploring their roles in nutrient cycling, symbiotic relationships, disease resistance and environmental sustainability. By understanding the vast and intricate networks of microbial interactions, we can better appreciate their influence on both natural and human-altered ecosystems. The article also highlights current research trends and the challenges in studying microbial ecosystems, emphasizing the need for a more holistic approach to conservation and environmental management.

Keywords: Microorganisms, Ecosystem health, Soil fertility, Nutrient cycling, Symbiosis, Biodiversity, Environmental sustainability, Microbial communities, Climate regulation.

Introduction

Ecosystem health is traditionally assessed by examining visible and measurable parameters such as species biodiversity, water quality and the overall condition of habitats. However, beneath the surface of these obvious indicators lies a vast and intricate world of microorganisms that profoundly influences the ecological processes that sustain life on Earth. Microorganisms are ubiquitous across all environments, from the soil beneath our feet to the depths of the oceans and their collective role in ecosystem health cannot be overstated. Historically, microorganisms were often viewed as pathogens or environmental contaminants. However, in recent decades, scientific research has uncovered the vast range of positive impacts these tiny organisms have on ecosystem functioning. Microbes facilitate nutrient cycling, promote plant growth, maintain soil health and contribute to the resilience of ecosystems in the face of environmental stressors (Montoliu-Nerin M, et al. 2021). This seeks to illuminate the hidden role of microorganisms in supporting ecosystem health. We will explore the critical functions that microorganisms perform in nutrient cycling, symbiosis, disease suppression and their contributions to global processes such as climate regulation. Additionally, we will discuss the interconnectedness of microbial communities, the implications of microbial biodiversity for ecosystem stability and the threats posed by environmental degradation to these essential microorganisms.

Description

One of the most vital functions microorganisms perform is in nutrient cycling. In both terrestrial and aquatic ecosystems, microorganisms such as bacteria, fungi and archaea are responsible for breaking down organic matter and transforming it into forms that plants and other organisms can use. Without these microbial processes, the earth would quickly become overwhelmed by dead organic material and essential nutrients like nitrogen, phosphorus and carbon would be locked away in inaccessible forms. Nitrogen is an essential nutrient for all living organisms, as it is a key component of amino acids and nucleic acids (Chen EC, et al. 2018). However, atmospheric nitrogen (N_2) is inert and unavailable to most plants and animals. Nitrogen-fixing bacteria, such as Rhizobium, form symbiotic relationships with leguminous plants to convert atmospheric nitrogen into ammonia, which plants can absorb and utilize. Other microbes, such as nitrifying bacteria, further process nitrogen compounds into forms like nitrites and nitrates, which are also critical to plant growth. Denitrifying bacteria, in turn, reduce nitrates back into nitrogen gas, completing the cycle. Microorganisms are also crucial to the breakdown of organic carbon compounds. Fungi, bacteria and certain protists decompose plant material, turning it into simple sugars, amino acids and other organic molecules. These processes release carbon dioxide (CO_2) into the atmosphere, which is subsequently taken up by plants during photosynthesis. The cycling of carbon through microbial activity helps regulate atmospheric CO_2 levels, making microorganisms key players in climate regulation (Janos DP, 2007).

Phosphorus, an essential nutrient for all organisms, is often a limiting factor in ecosystems. Microbial activity is crucial in the release of phosphorus from mineral sources, transforming it into bioavailable forms. Likewise, sulfur bacteria play a role in sulfur cycling, aiding in the conversion of sulfur compounds, which are important for protein synthesis and other biological processes. Microorganisms play an indispensable role in promoting plant growth through various forms of symbiosis. Mycorrhizal fungi, for example, form mutually beneficial associations with plant roots. These fungi extend the root system of plants by creating an underground network that increases the surface area for nutrient and water absorption. In exchange, the plant provides carbohydrates to the fungi. This relationship is essential for the growth of many plant species, especially in nutrient-poor soils. In addition to mycorrhizal fungi, nitrogen-fixing bacteria such as Rhizobium form symbiotic relationships with legumes. The bacteria reside in nodules on the plant roots, where they convert atmospheric nitrogen into a usable form for the plant (Sawers RJ, 2008). In return, the plant supplies the bacteria with organic compounds produced through photosynthesis. This symbiotic relationship not only benefits the plants and microorganisms but also contributes to the overall health of the ecosystem by increasing soil nitrogen levels.

Microorganisms also contribute to ecosystem health by suppressing plant and animal diseases. Soil-borne pathogens, such as Fusarium and Phytophthora, can devastate crops and natural vegetation. However, beneficial microorganisms in the soil, including bacteria and fungi, can outcompete or inhibit these pathogens through various mechanisms such as producing antimicrobial compounds, occupying ecological niches, or inducing systemic resistance in plants. The use of beneficial microorganisms as biocontrol agents has gained popularity in sustainable agriculture. For example, Bacillus subtilis and Trichoderma species are used to prevent plant diseases by competing with pathogens for nutrients and space or by producing toxins that directly inhibit pathogen growth. This natural approach to pest and disease control reduces the reliance on chemical pesticides and fosters a more resilient and balanced ecosystem. In animals, microorganisms play a crucial role in digestion and immune function (Martin F, et al. 2016). The gut microbiome of mammals, for example, is composed of trillions of bacteria, fungi and archaea that aid in breaking down complex foods, synthesizing vitamins and protecting against harmful pathogens. Disruption of the gut microbiome, often caused by antibiotics or poor diet, can lead to diseases like inflammatory bowel disease or obesity.

Conclusion

Microorganisms are the unsung heroes of ecosystem health. Their roles in nutrient cycling, plant growth, disease suppression and climate regulation are foundational to the stability and resilience of ecosystems. However, the degradation of microbial habitats and the loss of microbial diversity due to human activities pose significant challenges to ecosystem functioning. It is crucial that we recognize and protect the vital contributions of microorganisms to the health of our planet. Moving forward, more research is needed to better understand microbial interactions and develop strategies to mitigate the impacts of environmental degradation on these critical organisms. To preserve ecosystem health and ensure the sustainability of our natural resources, we must adopt a more holistic approach to conservation—one that acknowledges the importance of microorganisms and fosters practices that promote microbial biodiversity and resilience. Only through a deeper understanding of the hidden world of microorganisms can we hope to address the complex environmental challenges of the future.

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Conflict of Interest

The authors declare no conflict of interest.

References

Montoliu-Nerin, M., Sánchez-García, M., Bergin, C., Kutschera, V. E., Johannesson, H., Bever, J. D., Rosling, A. (2021). In-depth phylogenomic analysis of arbuscular mycorrhizal fungi based on a comprehensive set of de novo genome assemblies. Frontiers in Fungal Biology 2:716385.

Chen, E. C., Morin, E., Beaudet, D., Noel, J., Yildirir, G., Ndikumana, S., Corradi, N. (2018). High intraspecific genome diversity in the model arbuscular mycorrhizal symbiont *Rhizophagus irregularis*. New Phytologist 220:1161-1171.

Janos, D. P. (2007). Plant responsiveness to mycorrhizas differs from dependence upon mycorrhizas. Mycorrhiza 17:75-91.

Sawers, R. J., Gutjahr, C., Paszkowski, U. (2008). Cereal mycorrhiza: An ancient symbiosis in modern agriculture. Trends in Plant Science 13:93-97.

Martin, F., Kohler, A., Murat, C., Veneault-Fourrey, C., Hibbett, D. S. (2016). Unearthing the roots of ectomycorrhizal symbioses. Nature Reviews Microbiology 14:760-773.

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