A Review on the Distribution and Activities of Microorganisms in Freshwater Environments

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Abstract- This review explores the distribution and ecological roles of microorganisms in freshwater ecosystems. These environments support a wide array of microbial communities that are fundamental to nutrient cycling, energy transfer, and ecosystem stability. By synthesizing current research findings and methodologies, this paper highlights the spatial and temporal distribution patterns of freshwater microorganisms and examines their functional activities, such as biofilm formation, symbiotic interactions, and involvement in carbon and nutrient transformations. The review also addresses the ecological significance of these microbial communities and their responses to environmental changes, emphasizing the importance of microbial ecology in the management and conservation of freshwater resources.

Indexed Terms- Freshwater, Ecosystem, Nutrients, Microorganisms, Microbial Ecology

I. INTRODUCTION

Water, especially freshwater, is a critical component of life on Earth, covering approximately 70% of the planet's surface. It plays an essential role in supporting biological processes and sustaining ecosystems. Natural waters—whether marine or freshwater—contain dissolved salts and gases that support diverse life forms. While marine environments dominate global water volume, freshwater bodies, including rivers, lakes, and underground aquifers, are particularly vital for human use and biodiversity.

Freshwater ecosystems are facing increasing pressure due to population growth, urbanization, and pollution from agricultural and industrial activities. According to Boyd (2015), aquatic microorganisms serve as key indicators of freshwater health. These organisms contribute to the purification of water through nutrient cycling and other biochemical processes (Hong *et al*., 2018). Conversely, water quality directly affects the structure and function of these microbial communities (Yan *et al*., 2018). A deeper understanding of microbial activity in freshwater systems is therefore essential for developing sustainable environmental management practices and preserving ecosystem functionality.

Types of Waters Inhabited by Microorganisms

Microorganisms can be found in various aquatic habitats, including subterranean waters, surface waters, and bottom sediments. Each of these biotopes supports distinct microbial communities influenced by environmental conditions.

Subterranean Waters: These include groundwater, mineral springs, and thermal springs. Due to their oligotrophic nature (low in nutrients), these habitats support sparse microbial populations, typically composed of a few specialized species. Higher plants and animals are largely absent.

Surface Waters: Lakes, rivers, streams, and seas are examples of surface water bodies. These ecosystems host diverse microbial communities. In addition to native aquatic microorganisms, these waters are often influenced by microorganisms from soil and sewage, introduced through runoff and pollution.

Bottom Sediments: Bottom sediments form a transitional habitat between water and soil, often characterized by an absence of oxygen. Anaerobic microorganisms thrive here, breaking down organic matter and releasing methane and hydrogen sulfide. Common microbes in these sediments include anaerobic decomposers, cellulolytic bacteria, and chemoautotrophs.

Groups of Water Microorganisms

Microorganisms in surface water ecosystems can be classified based on their habitat and mode of life. They include plankton (suspended in the water), periphyton (attached to submerged surfaces), and benthos (residing at the bottom of the water body).

Plankton include phytoplankton, zooplankton, protozooplankton, heterotrophic bacterioplankton, and viroplankton. These organisms contribute to primary production, nutrient cycling, and microbial food webs.

Periphyton are communities of microorganisms such as algae, fungi, and bacteria attached to submerged surfaces. They are important primary producers and support complex food webs.

Benthos refers to organisms living on or in the bottom sediments of water bodies. These include bacteria, fungi, and invertebrates involved in the decomposition of organic matter and nutrient cycling.

Previous Findings

Numerous recent studies highlight how environmental factors and anthropogenic activities influence microbial community structure and function in freshwater ecosystems.

Yue *et al*. (2021) showed that thermal stratification significantly affects bacterial community distribution in reservoirs.

Chou *et al*. (2021) found that increased phosphorus loading can lead to excessive phytoplankton growth, impacting water quality.

Wen *et al*. (2021) discussed how climate change and human activity influence water level fluctuations over time.

Yuan *et al*. (2021) noted that removing Trapa improved water quality but reduced species diversity. Sun *et al*. (2021) used eDNA to trace historical changes in microbial populations.

Xiao *et al*. (2021) observed seasonal variations as a major driver of microbial dynamics in urban river systems.

Factors Affecting Growth of Microorganisms in Water

The growth and distribution of microorganisms in freshwater ecosystems are influenced by a complex interplay of physical, chemical, and biological factors. These elements not only affect microbial abundance but also shape community structure, physiological activity, and interactions within the microbial biocenosis.

Abiotic factors include light intensity, temperature, water movement, pH, salinity, dissolved gases, suspended particles, and organic and inorganic nutrients. These variables influence photosynthesis, nutrient availability, and the enzymatic activities of aquatic microorganisms.

Biotic factors consist of interactions among organisms such as competition, predation, parasitism, and mutualism. These biological interactions play crucial roles in regulating microbial community dynamics and ecosystem functions.

CONCLUSION

Freshwater ecosystems are vital to both human civilization and global biodiversity. These environments support complex microbial communities that perform essential ecological functions such as nutrient cycling, organic matter decomposition, and water purification.

Understanding the ecology of freshwater microorganisms is crucial for maintaining the health and sustainability of aquatic ecosystems. With increasing anthropogenic pressures—such as pollution, climate change, and habitat alteration—preserving microbial diversity and functionality has become more important than ever.

Insights into microbial roles and responses can guide environmental management strategies, improve water quality, and support biodiversity conservation.

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