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Importance of Periphyton to the Ecology of Subtropical river Ganga, India

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ABSTRACT

Periphyton is crucial for maintaining the health and function of the aquatic ecosystem. However, excessive nutrient pollution or other forms of pollution can lead to an imbalance in periphyton populations and negatively impact the overall river ecosystem. Efforts to improve the water quality of the Ganga should consider the role of periphyton and its interactions with other components of the ecosystem. These act as a link between the substrate and the water column above, allowing periphyton to influence both ecosystems. The periphyton is an essential source of food for nibbling fish such as Rita rita and Botia sp. These are important bioindicators of water quality in streams and ecological health, and they are also a link in the transportation of resources and energy along numerous food chains. Periphyton is a pollution indicator and an appropriate biotic and abiotic element in aquatic ecology. Variations in habitat factors and substrate determine the natural structure and function of streams.

KEYWORDS

Bioindicator, Aquatic ecology, Periphyton and Ganga River

Introduction

In 2008, the Ganga River was designated as a National River of India (Sanghi, R., & Kaushal, N. 2014). The Ganga River is a lotic water stream that begins in Gaumukh and flows down to Ganga Sagar over a distance of 2525 kilometres (Das, 2014)); (EMP, G., & Basin, G. R. 2012). The river receives numerous tributaries (with distinct quality, pollution load, and biota) as it flows through eleven states (Uttarakhand, Madhya Pradesh, Chhattisgarh, Bihar, Jharkhand, Rajasthan, Haryana, Himachal Pradesh, and Delhi), including the Bhilangana, Alaknanda, Ram Ganga, Kali, Yamuna, Gomti, Ghagra, Gandak, and Kosi.

The river Ganga can be divided in to three part (stretched), (Dubey *et. al.,* 2012).

1. Upper Ganga = From Gaumukh to Haridwar, it covers a distance of 294 km.
2. Middle Ganga = 1082 km distance between from Haridwar to Varanasi
3. Lower Ganga ≈ 1134 km distance from Varanasi to Ganga Sagar.

The physical and chemical characteristics of the water in the streams of Ganga River determine the biological diversity of their ecosystems. Abiotic organisms and those belonging to the biotic family coexist in separate areas, and biotic communities contribute to the preservation of these streams' ecological integrity and health by responding to their surroundings.

What is periphyton?

Periphyton refers to the community of microorganisms, algae, bacteria, fungi, and other organisms that attach and grow on surfaces submerged in aquatic environments, such as rocks, plants, and other substrates. The appearance of the periphyton layer varies greatly and can disclose a great deal about the stream's surroundings. The most common periphyton is photosynthetic microalgae which are relying on minerals for growth and reproduction.

They serve as both the structural and functional elements of aquatic ecosystems, and their importance is determined by quality rather than number. Although nomenclature for periphyton such as "biofilms," "microlayers," "aufwuchs," and "benthos" are used, periphyton is most common name used in aquatic scientific literature nowadays (Gulzar *et. al.,* 2017).

Classification of Periphyton

Based on where periphyton is found within aquatic systems, it can be classified as:

Epiphyton: Periphyton that grows on the surfaces of aquatic plants, such as leaves and stems. Epilithon: Periphyton that grows on rocks and other hard surfaces. Episammion: Periphyton that grows on sand

and sediment particles.Epipelon: Periphyton that grows on muddy substrates.

Factors affecting periphyton

Light availability, nutrient availability, water flow**,** substrate type**,** temperature**,** pH and water chemistry**,** predation and herbivory**,** competition**,** pollution and contaminants**,** seasonal changes**,** human activities**,** climate change etc. are several factors which can affect the growth and composition of periphyton communities.

Impact of anthropogenic activities on periphyton diversity

It's crucial to remember that depending on the kind of aquatic habitat, the type of human activity, and the adaptability of the periphyton community, the specific effects of human activity on periphyton diversity can change. The health and variety of periphyton communities and the ecosystems they inhabit depend on conservation and management initiatives that seek to reduce these effects. Here are several ways that human activity may affect the variety of periphyton, including pollution, habitat modification, pesticide and herbicide usage, overfishing, and changes in land use.

Present status of periphyton in Ganga River

A total of 58 genera and 114 species were reported in the middle Ganga River (EMP and GRB, 2012). A total of 93 genera of planktonic groups belonging to 75 genera of phytoplankton and 18 genera of zooplankton were recorded in the Ganga River (CIFRI, 2019). As reported by Srivastava *et. al.*, 2019, 77 Genera of periphyton in the Ganga River in which Bacillariophyceae dominated the whole Ganga, Bhagirathi, and Hooghly stretches, followed by Chlorophyceae and Cyanophyceae. Kanpur reported the highest Myxophyceae population, indicating the most polluted stretch. The dominant genera of Bacillariophyceae belong to *Navicula, Nitzschia*, *Cymbella*, *Gomphonema*, *Pinnularia*, *Cyclotella*, Chlorophyceae genera including *Scenedesmus*, *Ankistrodesmus*, *Oocystis*, *Selenastrum*, Cyanophyceae genera including *Oscillatoria*, *Phormidium*, *Merismopedia*, *Microcystis* in river Ganga. Some common taxa of periphyton are given in table 1.

Table. 1 Some examples of periphyton taxa in Ganga River

Bacillariophyceae	*C. parva*	*N. hustedtii*
Achnanthes sp.	*C. perpusilla*	*N. lancettula*
A. brevipes	*C. prostrata*	*N. mutica*
A. microcephala	*C. turgidula*	*N. radiosa*
Achnanthidium biasolettianum	*Diatoma* sp.	*N. rostellata*
A. minutissimum	*D. mesodon*	*N. rynchocephala*
Amphora sp.	*D. vulgare*	*N. stagnorum*
A. montana	*D. vulgaris*	*Nitzschia* sp.
A. ovalis	*Encyonema minutum*	*N. communis*
Anomoeoneis serians	*Fragilaria* sp.	*N. gracilis*
Asterionella formosa	*F. crotonensis*	*N. hungarica*
Aulcoseira granulata	*F. inflata*	*N. ignorata*
Caloneis silicula	*Frustulia* sp.	*Pinnularia* sp.
Cocconeis sp.	*Gomphonema* sp.	*P. gibba*
C. placentula	*G. helvaticum*	*P. subcapitata*
Cyclotella sp.	*G. minutum*	*Placoneis elegans*
C. glomerata	*Gyrosigma* sp.	*Planothidium lanceolata*
C. kuetzingiana	*G. acuminatum*	*Pleurosigma* sp.
C. meneghiniana	*G. distortum*	*Stauroneis* sp.
C. stelligera	*G. scalproides*	*Surirella* sp.
Cymbella sp.	*Mastogloia danseii*	*S. apiculata*
C. austriaca	*Melosira granulata*	*S. delicatissima*
C. delicatula	*Navicula* sp.	*S. ulna*
C. kolbei	*N. constans*	*Tabellaria* sp.
C. leavis	*N. cryptotenella*	*T. fenestrata*
Chlorophyceae	*P. duplex*	*M. tenuissima*
Chlorella sp.	*P. simplex*	*M. minima*
Chlorogonium sp.	*Scenedesmus* sp.	*Microcystis Aeruginosa*
Cladophora sp.	*S. dimorphus*	*Nostoc* sp.
Closterium sp.	*S. quadricauda*	*Oscillatoria* sp.
Cosmarium sp.	*Schizogonium* sp.	*O. limosa*
Dictyosphaerium	*Spirogyra* sp.	*Phormidium* sp.

ehrenbergianum		
Draparnaldia sp.	*Ulothrix* sp.	*Rivularia* sp.
Hydrodictyon sp.	*Zygnema* sp.	**Euglenophyceae**
Kirchneriella sp.	**Cyanophyceae**	*Euglena acus*
Oedogonium sp.	*Anabaena* sp.	*E. viridis*
Oocystis elliptica	*Coelosphaerium naegelianum*	**Xanthophyceae**
Pandorina morum	*Lyngbya* sp.	*Tribonema Bombycinum*
Pediastrum sp.	*Merismopedia glauca*	*Vaucheria* sp.
P. clathratum	**Source:** EMP G. and Basin GR., 2012	

Importance of periphyton

It plays a crucial role in aquatic environments and has several important functions:

Primary Production: Periphyton contributes significantly to primary production in aquatic ecosystems. Algae within the periphyton community photosynthesize, converting sunlight into organic matter (biomass) and producing oxygen. This production forms the base of the food web and supports the entire aquatic ecosystem.

Nutrient Cycling: Periphyton is involved in nutrient cycling within aquatic ecosystems. It assimilates nutrients such as nitrogen and phosphorus from the water, helping to regulate nutrient levels and reduce excess nutrient concentrations that could lead to water quality issues like eutrophication.

Habitat and Shelter: Periphyton provides habitat and shelter for a variety of aquatic organisms, including invertebrates, small fish, and other microorganisms. These organisms use the periphyton as a substrate for attachment, feeding, and protection from predators.

Biofiltration: Periphyton can act as a natural biofilter, helping to improve water quality by removing pollutants and suspended particles from the water. As water flows over the periphyton-covered surfaces, the microorganisms within the community capture and remove contaminants.

Carbon Sequestration: Periphyton contributes to carbon sequestration in aquatic environments by capturing and storing carbon dioxide from the atmosphere. This helps mitigate the impacts of climate change by reducing the amount of carbon dioxide in the atmosphere.

Indicator of Water Quality: The composition and abundance of periphyton can serve as an indicator of the overall health and water quality of an aquatic ecosystem. Changes in periphyton community structure may indicate shifts in environmental conditions, nutrient availability, or pollution levels.

Erosion Control: Periphyton can help stabilize substrates and reduce erosion by binding sediments together. This is particularly important in areas with fast-flowing water where erosion could otherwise cause habitat degradation.

Educational and Research Value: Periphyton provides an opportunity for scientific research and education. Studying periphyton communities can help researchers understand ecological processes, nutrient dynamics, and the effects of human activities on aquatic ecosystems.

Nutrient requirements for periphyton growth

Periphyton growth is influenced by a variety of factors, including nutrient availability. Nutrients such as nitrogen, phosphorus, and carbon play essential roles in supporting the growth and development of periphyton communities in aquatic ecosystems. However, it's important to note that specific nutrient requirements can vary depending on the type of periphyton, the ecosystem, and other environmental conditions. Here are some key nutrients and their roles in periphyton growth:

Nitrogen (N): Nitrogen is a crucial nutrient for periphyton growth, as it is a component of proteins, nucleic acids, and chlorophyll. It is necessary for various metabolic processes, including photosynthesis and enzyme activity. In aquatic systems, nitrogen can be found in different forms, including nitrate (NO3-), ammonium (NH4+), and organic nitrogen.

Phosphorus (P): Phosphorus is another essential nutrient for periphyton growth. It is a key component of nucleic acids, ATP (adenosine triphosphate), and cell membranes. Phosphorus availability often limits primary production in aquatic ecosystems, and its presence in water can stimulate periphyton growth.

Carbon (C): Carbon is a fundamental element for all life forms, and it serves as the building block for organic matter. Periphyton utilize carbon dioxide (CO2) during photosynthesis to produce carbohydrates, which provide energy for growth and reproduction.

Trace Elements: Periphyton require trace elements such as iron, manganese, zinc, and copper as cofactors for enzymes and metabolic processes. These trace elements are often obtained from the water column and sediment.

Other Nutrients: Periphyton growth may also depend on other nutrients like sulfur, potassium, calcium, and magnesium, which are involved in various biochemical processes.

It's important to maintain a balanced nutrient ratio to support healthy periphyton growth. Excessive nutrient loading, particularly nitrogen and phosphorus, can lead to overgrowth of periphyton, resulting in issues such as eutrophication, algal blooms, and oxygen depletion. Conversely, nutrient deficiency can limit periphyton growth and affect overall ecosystem productivity.

The specific nutrient requirements for periphyton can vary based on factors such as water chemistry, light availability, temperature, and the composition of the periphyton community itself. Understanding these factors and their interactions is important for managing and maintaining balanced aquatic ecosystems.

Periphyton as sources of fish food

Periphyton plays an important role in providing food for fish and other wildlife. Many different aquatic organisms, including fish, snails, chironomids, mayflies, oligochaetes, crustaceans, etc., consume periphyton as a component of their diet. Generally, periphyton are incredibly wealthy in nutrients (Dutta *et. at.*, 2018). *Labeo rohita* is a predominantly periphyton grazer, realizing excellent growth and production in periphyton-based aquaculturesystems (Ekram *et. al.*, 2001). The diatoms were also present in the gut content of the ornamental fish *Puntius conchonius*, which may be called incidental food because diatoms are attached to the periphytic algae (Bahuguna & Baluni, 2019). Periphyton is a preferable natural food for Indian major carp, Tilapia, and freshwater prawns (Chavan, & Shaikh, 2019). For nibbling fish like *Rita rita* and *Botia sp.*, periphyton is an essential food source. Fish and benthic insects prefer periphyton communities as their primary food source (Shriwastva *et.al.*, 2019).

Algae as a pollution indicator

Euglena and *Oscillatoria* are highly pollution-tolerant genera and, therefore, reliable indicators of Eutrophication similar to these genera with very high-grade points of Palmer's scale are like *Euglena viridis, Euglena gracilis, Oscillatoria limosa, Oscillatoria chlorine* and *Oscillatoria tenuis*. Additionally, he showed how algal assemblages may be utilised as markers of either clean or polluted water. Polluted water would only produce a small number of species, with one or a few dominating types, whereas clean water would sustain a wide diversity of life. Advantages of using Algae as a bioindicator: (Dora S. *et al.*, 2010), algal assemblage offers an affordable monitoring tool. ·Algae have very short life cycles and fast reproduction. ·Algae tend to be most directly affected by physical and chemical environmental conditions.

Ecological significance of the periphyton in Ganga River

Periphyton are an important indication of the health of aquatic systems because they are sensitive to non-point sources of pollution and act as a link between chemical, physical, and biotic factors in aquatic systems. Due to its short life cycles and generally static character, which allow periphyton communities to respond fast to changes in the physical and chemical components of aquatic ecosystems, periphyton is included in the majority of bio- assessment techniques. Both directly and indirectly, periphyton can play a significant role in controlling the dynamics of nutrients. Due to unplanned development and inadequate planning, expanding urbanization suddenly created large amounts of organic hazardous waste, and soil erosion contributed to enormous pollution loads and environmental deterioration.

Role of periphyton in ecology of river

Periphyton's short life cycle, rapid response to even small changes in environmental circumstances, and abundance in the littoral zones of aquatic ecosystems make it an important component of bio-manipulation monitoring. Periphyton is an essential component of the food web, the food chain, and photosynthesis. It also provides a natural food source for a variety of aquatic creatures. Fish enjoy the food found in periphyton colonies. (Srivastava K., *et. al.*, 2019).

Conclusion

Periphyton plays a most important role in biotic and abiotic component aspects of streams. They mediate many ecological interactions, and their inconsistent responses to nutrients and other abiotic factors emphasise the significance of understanding the variables that regulate the temporal and spatial dynamics of these communities in lotic aquatic ecosystems. For nibbling fish like *Rita rita* and *Botia* sp., periphyton is an essential food source. These serve as a crucial bioindicator of stream water quality and ecological health as well as a link in the transport of materials and energy along many food chains. Periphyton is abalanced biotic and abiotic component of aquatic ecology and a pollutant indicator.

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