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STREAM PERIPHYTON COMMUNITY: A BRIEF REVIEW ON ECOLOGICAL IMPORTANCE AND REGULATION

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Abstract

Periphyton communities serve as vital component of stream ecosystems. These play an intermediate role between the overlaying water column and the substrate beneath and allow periphyton to affect both environments. These also act as a link in the transfer of material and energy along different food chains of streams and also act as significant bioindicators of water quality and ecological health of streams. Growth of these communities is regulated by a number of ecological factors being natural or having a certain degree of anthropogenic contribution. This brief review highlights some chief factors namely nutrients, flow velocity and various physico-chemical limnological parameters which regulate the periphyton community in streams.

Key Words: Periphyton, Ecosystem regulation, Stream, Ecology

I. INTRODUCTION

The streams are biologically rich ecosystems regulated by differentiation in physical structure and chemical nature of their water. Biotic communities maintain the ecological integrity and health of these streams by performing their respective biological niche roles and interacting with abiotic environmental factors. Streams serve as a potentially preferred habitat for countless biotic assemblages ranging from micro to macro level. Heterogenity in habitat characteristics (Whitledge and Rabeni, 2000) and substrate in streams governs its biological structure and functions.

Periphyton is the micro community living attached to the substrate inside water and thrive at the interface of underwater solid substrate and upper water column of streams by secreting mucilaginous polymeric substances, adhesive molecules and enzymes and modify bare surface to a habitable matrix with organic and inorganic material incorporation from aqueous medium upon which bacterial and algal growth occurs (Otten and Willemse, 1988). Mature communities of periphyton have a three-dimensional structure similar to that of terrestrial vegetation, with low-profile and prostrate algal taxa as the lowest layer, upright or stalked taxa as the central layer and filamentous taxa extending from the mat and forming an upper layer. Aquatic ecologists, however, have established the importance of periphyton, which act as both structural and functional components of the aquatic ecosystems and their importance in stream trophic structure is a function of quality rather than quantity (Cross *et al*., 2003).

Terminology of periphyton is variable among scientific communities of relevant scientific field. Terms such as biofilms, microlayers, aufwuchs and benthos have been used synonymously, but many of these terms have also been linked to more specific definitions varying with time and geographical reaches. Today the term most often used in the aquatic scientific literature is "Periphyton" (Wetzel, 1983). In relation to the type of substratum colonized periphyton subgroups include epiphyton (macrophytes), epixylon (wood), epilithon (stone), episammon (sandy sediments) and epipelon (muddy sediments). The periphyton are divided into two groups for taxonomic identification, the diatoms-having silica cases and can be easily identified to species while the non-diatom algae (sometimes called "soft" algae) are more difficult to identify and are more diverse and include several taxonomic orders. Periphyton include attached algae, bacteria, fungi, and protozoa that live in communities attached to bottom substratum e.g., rocks, woody debris, or vegetation. The algae are most diverse and cosmopolitan in nature and belong to about 26,000 species described in 24 classes (Bold and Wynne, 1985). Studies also reveal the dominance of bacillarophycaea among different periphyton classes in terms of diversity and density in streams (Rashid *et al*., 2010; Rashid and Pandit, 2008; Albay and Aykulu, 2002). Diatoms and other algae are photosynthetic, and depend on nutrients for growth and reproduction (Winter and Duthie, 2000).

II. ECOLOGICAL IMPORTANCE

Periphyton contributing significantly to the productivity of aquatic ecosystems (Sarwar, 1999; Pandit *et al*., 1985; Pandit, 1980 and Kaul *et al*., 1980) and serve as a vital source of energy to faunal assemblages (Hecky and Hesslein, 1995). Periphyton act an intermediate between the chemical, physical and biotic factors in aquatic systems, and thus are an important indicator of the health of aquatic systems (Lowe & Pan, 1996) due to their sensitivity to non-point pollution source. Periphyton is relatively stationary and most species have a short life cycle allowing periphyton communities to respond rapidly to perturbation in physical and chemical factors of the aquatic ecosystems (Rosen, 1995) and are used for most bio-assessment protocols. Among periphyton, diatom responses to nutrients are predictable and have been used to develop nutrient criteria in streams (Stevenson *et al*., 2008). Periphyton can both directly and indirectly serve as a major regulator of the nutrient dynamics. A direct mechanism is by uptake and assimilation by which the available nutrient pool of both water column and sediment is reduced (Hansson, 1989). Periphyton may, however, also directly enrich a relatively nutrient-poor water column by export of dissolved or particulate organic matter originally sequestered from the substrata. Indirectly the pelagic nutrient pool may be affected by photosynthetic active periphyton on the sediment, because the produced oxygen may immobilize several dissolved elements and reduce the chemical fluxes at the sediment-water interface (Hansson, 1989). Periphyton communities and their coupled metabolism typically improve the capacity of aquatic ecosystems to retain externally loaded nutrients just as they may reduce internal loading of phosphorus from sediment pools (Wetzel, 1999). Being intermediates between the overlaying water column and the substrate beneath allows periphyton to affect both environments directly or indirectly.

III. REGULATING FACTORS

Various factors (nutrient level, flow, substrate, physico-chemical parameters, disturbance, etc.) prevailing at different time and places play an important role in structure of benthic community in lotic systems (Potapova and Charles, 2002; Moura *et al*., 2007) while local environmental conditions play a more important role as compared to broad scale climatic, vegetation and geographic factors (Pan *et al*., 1996). Species in an ecosystem show varied responses to the change in local environmental conditions and their composition consequently. Species which are more resistant to environmental changes of natural or anthropogenic origin may be favoured by selection (Rocha, 1992). Any change in the intrinsic environment of species does not change the community as a whole, but due to inhibition of multiplication of some species present there, only percentage composition will be changed. This change in a community occurs only when fluctuation in changing environmental factors are within the tolerance range of the species (Pan *et al*., 1996).

Nutrient concentration: Nutrients, while being essential to the functioning of healthy aquatic ecosystems, can exert negative effects at much lower concentrations by altering trophic dynamics, increasing algal and macrophytic production (Sharpely *et al.*, 1994), increasing turbidity (via increased phytoplanktonic algal production), decreasing average dissolved oxygen (DO) concentrations, and increasing fluctuations in dissolved oxygen and pH. Such changes are caused by excessive nutrient concentrations resulting in shifts in species composition away from functional assemblages of intolerant species. Nutrient concentrations particularly Nitrogen and Phosphorus tend to be the primary limiting factors for periphytic algal growth and levels of these nutrients are largely regulated by land use practices and intensification (Biggs and Kilroy, 2004). Substantial nutrient pollution enhances periphyton biomass accumulation in streams with a stable substratum and adequate substratum irradiance, but the controlling role of nutrients in un-enriched or mildly enriched streams is not yet understood well (Dodds, 2006). According to O'Brien *et al.*, (2007) periphyton nutrient response can be represented by a curvilinear model that predicts a very strong response to nutrients at low nutrient concentrations followed by decreasing responsiveness at higher concentrations possibly due to replacement of taxa that develop only modest biomass per unit area at low nutrient concentrations by other taxa that produce more biomass accumulation but require high nutrient concentrations.

Simulated studies conducted in controlled laboratory conditions using artificial substrate have revealed that the periphyton of streams with low nutrient concentrations show widely varied responses to nutrients. According to (Dodds & Welch, 2000 and Francoeur, 2001) about 50% of nutrient manipulation simulative studies indicate no response to the addition of phosphorus (P) or nitrogen (N) together or separately. Responses of periphytic community to nutrients, are nearly equally divided between individual nitrogen (N) or phosphorus (P) limitation and colimitation by nitrogen and phosphorus. Also periphytic assemblages respond strongly for the addition of the two nutrients together than for either nutrient separately.

Nutrient enrichment tends to shift the algal community dominance away from diatoms toward filamentous and blue green algae. So a reduction in nitrogen concentrations in the absence of phosphorus reduction could stimulate production of blue-greens. Therefore, it is significant to know the substantial amounts of variance in abundance of periphytic algae as a function of concentrations and relative proportions of nitrogen and phosphorus in streams reflecting seasonal natural variability on spatial scale as well as mild degrees of anthropogenic enrichment with reference to the periphytic algal growth in the stream ecosystem.

Flow velocity: The variation in water level and velocity affect growth, relative abundance of different species of periphytic algae (Duong *et al.*, 2006) of lotic environments. Under controlled conditions change in water velocity has been shown to impact the composition and abundance of attached algal communities (Mclntire, 1966, 1968; Hynes, 1970) and similar results have been found in field observations. Lamb and Lowe (1981) proposed the effects of current velocity on the initial stages of periphyton development. Two diatom dominated communities that developed in different current regimes were found to be structurally different. Whitford and Schumaker (1961) measured higher rates of phosphorus uptake and respiration by several algal species at elevated velocity in experiments. McIntire (1966) has performed a considerable amount of artificial channel research on various aspects of lotic periphyton and comparison of algal growth in 9 and 38cm sec^{-1}, currents revealed filamentous green algal dominance in the former case and diatom dominance in the latter.

Other factors: Taxonomic diversity and abundance of periphyton depends on a range of factors like; habitat and substrate types (Biggs and Smith, 2002), physical characteristics of the substrate, such as micro-topography and orientation (Murdock and Dodds, 2007; Burkholder, 1996), light intensity (Vashihit and Sharma, 1975), grazing pressure (Munoz *et al.*, 2000), seasonality (Gurumayan, 2012), nutrient availability (Marinelarena and Di Giorgi, 2001), temperature (Bhat *et al.*, 2011; Francoeur *et al.*, 1999; Morin *et al.*, 1999; Robinson and Minshall, 1998; Kant and Kachroo, 1980; Vashihit and Sharma, 1975). In some classes of periphyton like; cyanophycaea, there is an increasing trend in their growth with higher water temperature, lower alkalinity, conductivity and hardness (Baba *et al.*, 2011).

Kant and Kachroo (1980) have established that chlorophycaea show better growth with rising temperature. Hydrogen potential of water determines the algae structure by exerting a direct physiological stress on them (Gensemer, 1991) and also strongly influences other water chemistry variables (Stumm and Morgen, 1981). According to Hynes (1970), the general trend in dominance of periphytic algae in streams is bacillarophycaea > chlorophycaea > cyanophycaea.

IV. CONCLUSION

The vital role of periphyton in structural and functional aspects of streams, their mediated processes in many ecological interactions and inconsistency in responses to nutrients and other abiotic factors as evident from the above review emphasizes the importance of knowledge of factors controlling the temporal and spatial dynamics of these communities in lotic aquatic ecosystems. Also the above factors which play a key role in regulation of periphyton need to be explored while studying stream periphyton.

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