



Studies on seasonal and topographical variations of periphyton in the rivers of Manipur

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Abstract

Seasonal and topographical variations of abundance and quality composition of periphyton at up and down stream of Imphal, Thoubal and Khuga rivers were studied from 1999-2002. It was found that periphyton population was high (3,055-53,450 u cm⁻²) and fluctuated in a wide range. Upper stretches (3053-53,450 u cm⁻²) of the rivers have higher periphyton population and showed definite seasonal fluctuation than the middle and lower stretches (3,276-16,320 u cm⁻²). Species richness was also higher in upper stretches in comparison to lower stretches of all the rivers. Bacillariophyceae dominated the periphyton population and contribution of Cyanophyceae was nominal. Shannon and Weaver species diversity index was within the favorable range and evenness value for all the rivers were near unity and reflected a stable and unpolluted aquatic environment of the rivers.

Key words

Periphyton, Species diversity index, River

Introduction

Rivers provide a system of continuous movement where any suspended particle will, often within a few days, be carried to the sea. Such a situation is far from ideal for plankton communities and makes phytoplankton a relatively minor element. So *aufwuchs* or periphytons have gained much importance in rivers compared to lakes. Periphyton is a complex matrix of algae and heterotrophic microbes attached to submerged substrata in almost all aquatic ecosystems (Boston *et al.*, 1991). Since these organisms occur in appreciable quantity in lotic environment, they have a definite role in the food chain. Their distribution and abundance varies seasonally and spatially due to multiple factors and is potentially influenced by light, temperature, current, substrate, the scouring effects of floods, water chemistry and grazing. Diatom typically comprises the majority of species within the periphyton, although blue and green algae and cyanobacteria are well represented and can dominate the biomass of the benthic autotrophs

under some circumstances (David, 1996).

The ecosystem significance and role of periphyton communities have received attention of many workers. Adequate and accurate information on the occurrence, type and seasonal fluctuation of fresh water periphyton in the rivers of northeast India is meager. Few researchers have investigated the ecology and pollution status of the rivers of the state (Vishwanath *et al.*, 2002; Dhamendra *et al.*, 2005, 2011, Rajeshwari *et al.*, 2005, Kosygin *et al.*, 2005, 2007, Singh *et al.*, 2010 etc. However, no work on the periphyton of the rivers of the state have not been done so far. This will be the first and foremost research publication on the periphyton of the rivers of Manipur. Some of the notable periphyton studies were conducted on different rivers by Gurumayum *et al.* (2000), Kawosa (2001), Singh *et al.* (2003) and Saikia and Das (2010). An ICAR project on ecological status and fishery potential of riverine fisheries resources of Arunachal Pradesh, Manipur, Meghalaya, Mizoram, Nagaland and Tripura were carried during the year

1998-2002 by CIFRI, Guwahati centre. Under this project many information regarding the quality and quantity composition of plankton periphyton and benthos, physico-chemical parameters of water and soil and phytoplankton productivity of the selected rivers of Manipur were collected. Even after the completion of a decade on the research work, there is sparse information on the ecology of the river of the state. Therefore, this research finding would help the future workers to get some valuable references in these aspects. In this regard an attempt was made to present primary information on the abundance and quality composition of periphyton communities of selected rivers of Manipur.

Materials and Methods

Three rivers of Manipur were selected for the study viz., the Imphal, the Khuga and the Thoubal. Khuga and Thoubal rivers are the tributaries of Imphal river and have two sampling stations each (KR1, KR2 and TR1 and TR2) one upstream and another downstream. Imphal river, on the other hand, has three stations (IR1, IR2 and IR3): upper, middle and downstream (Fig. 1). The Imphal river after draining all its tributaries flows out of the Indian boundary with a new name. Manipur river and meet Chindwin river in Myanmar.

The data employed in the present study were collected from 1999 to 2002. Samples from the rivers were collected seasonally *i.e.*, winter (December/January/

February), pre-monsoon (March/April/May), monsoon (June/July/August) and post-monsoon (September/October/ November) by scratching one square centimeter from the stones/boulders, which were submerged in the river water for at least two times. Counting was done by drop method taking one drop in each slide at least for five times and forms were identified up to genera with the help of Needham and Needham (1966) and Edmondson (1959).

Species diversity : Periphyton diversity was used as a bio monitoring tool to detect and evaluate the status of the water quality and calculated by applying the Shannon Weaver diversity index, H' (1963). The grading of water was as follows : Diversity index greater than 4 was clean water; between 3-4 was mildly polluted water; between 2-3 was moderately polluted water and less than 2 was heavily polluted. Evenness index (J) was calculated as per Pielou (1966).

Results and Discussion

The distributions of periphyton in different stretches of the selected rivers are presented in Table 1. Species diversity and evenness indices along with periphyton density and species richness are portrayed in Table 2. Common periphyton observed during the study are:

Khuga river : Periphyton population fluctuated between 3,055 $u\ cm^{-2}$ -9,900 $u\ cm^{-2}$ and main group encountered were Chlorophyceae, Bacillariophyceae and Cyanophyceae (Table 1). Some animal groups were also seen at upper stretch. Number of periphyton species (57) observed in upstream was higher than that of downstream (20) (Table 2).

At the upper stretch, periphyton population varied between 3,055-37,160 $u\ cm^{-2}$. Lowest periphyton density was observed during monsoon while highest density was seen during pre monsoon. Bacillariophyceae played the dominant role (57.4-76.4%) in all the seasons. Chlorophyceae showed its maximum value during pre monsoon (37.1%) whereas Cyanophyceae during monsoon (40.4%). Some lower animal groups were also seen during winter, pre and post monsoon contributing 2.2, 0.3 and 4.1% of total population. Average H' and J value were 3.6 and 0.77 respectively.

At lower stretch, periphyton populations were 9,471 $u\ cm^{-2}$, 8,860 $u\ cm^{-2}$ and 9900 for winter, pre and post monsoon. There was no monsoon sample. Bacillariophyceae was the dominant group (57.2-58.7%). The contribution of Chlorophyceae increased, and fluctuated from 38.4-40.9% whereas Cyanophyceae remained low (1.5-2.9%). No animal group was available during the study. Average H' and J values for the down stream were 3.0 and 0.74 respectively.

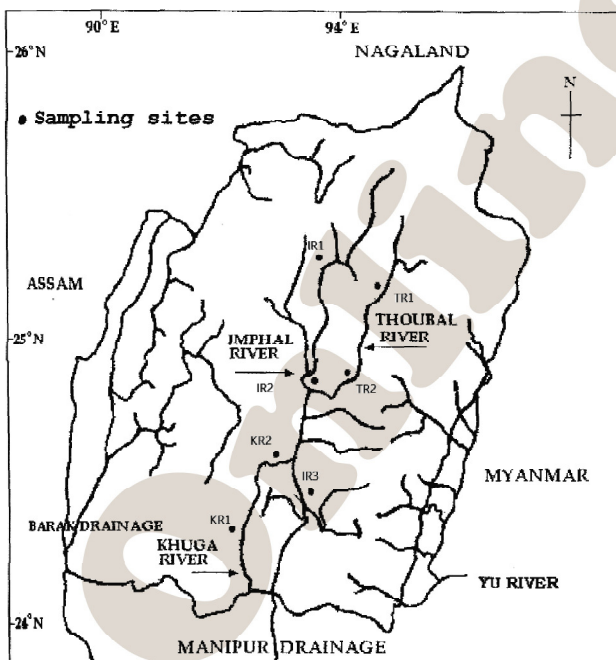


Fig. 1 : Map of Manipur showing the main drainage systems, Khuga (KR), Thoubal (TR) and Imphal (IR) with sampling sites (KR1, KR2, TR1, TR2 and IR1, IR2, IR3)

Table 1 : Seasonal distribution of periphyton (u cm²) in different stretches of Khuga, Thoubal and Imphal rivers

Rivers	Location	Season	Cyano- phyceae	Bacillario- phyceae	Chloro- phyceae	Animal group	Total periphyton
Khuga river	Upper stretch (KR1)	Winter	1,347 (3.95)	23,254 (68.3)	8,671 (25.4)	763 (2.2)	34,035
		Pre M	300 (0.8)	22,950 (61.8)	13,810 (37.1)	100 (0.3)	37,160
		M	1,235 (40.4)	1,755 (57.4)	65 (2.2)	-	3,055
	Lower stretch(KR2)	Post M	2,000 (6.1)	25,050 (76.5)	4,350 (13.3)	1,350(4.1)	32,750
		Winter	217 (2.2)	5,425 (57.2)	3,829 (40.4)	-	9,471
		Pre M	260 (2.9)	5200 (58.7)	3400 (38.4)	-	8,860
Thoubal river	Upper stretch(TR1)	M	-	-	-	-	-
		Post M	150 (1.5)	5,700 (57.6)	4,050 (40.9)	-	9,900
		Winter	275 (0.6)	27,829 (57.1)	20,634 (42.3)	-	48,738
	Lower stretch(TR2)	Pre M	300 (0.6)	26,000 (48.6)	27,150 (50.8)	-	53,450
		M	-	3,414 (69.0)	1,535 (31.0)	-	4,947
		Post M	150 (0.6)	40,250 (96.1)	1,500 (3.3)	-	41,900
Imphal river	Upper stretch(IR1)	Winter	232 (2.06)	8,249 (73.5)	2,731 (24.3)	-	11,212
		Pre M	140 (1.6)	2,700 (32.1)	5,555 (66.2)	-	8,395
		M	-	-	-	-	-
	Middle stretch(IR2)	Post M	300 (1.8)	15,600 (95.6)	315 (19)	105 (0.7)	16,320
		Winter	1,367 (7.4)	16,725 (90.5)	372 (2.0)	-	18,464
		Pre M	2,884 (10.8)	21,088 (79.5)	2,160 (8.2)	378 (1.5)	26,510
Lower stretch(IR3)	M	260 (2.9)	3,870 (43.1)	4,844 (54.0)	-	8,974	
	Post M	120 (1)	11,200 (92)	830 (7)	-	12,150	
	Winter	-	4,185 (83.9)	799 (16.0)	-	4,984	
	Pre M	-	4,570 (80.6)	1,100 (19.4)	-	5,670	
	M	-	-	-	-	-	
	Post M	-	3,780 (87.5)	540 (12.5)	-	4,320	

Figures within parenthesis indicate % composition.

To sum up, in the Khuga river, Bacillariophyceae showed overall dominance (57.4-76.5%) in the periphyton community irrespective of season and zonal variation. Contribution of Chlorophyceae increased from upper to lower stretch. Cyanophyceae was all the time low except during monsoon in upper stretch where it elevated to 40.4% in total periphyton count. Out of 57 species observed at upper stretch, five belonged to Cyanophyceae, 28 to Bacillariophyceae and 18 to Chlorophyceae. Six species of animals belonging to lower groups like rhizopods and zooflagellates were also identified. For the lower stretch, number of algal species encountered was 20, of which one belonged to Cyanophyceae, 10 to Bacillariophyceae and 9 to Chlorophyceae, respectively. There was no animal group in the periphyton count. Species diversity and evenness values were minimum during monsoon seasons and periphyton density and number of species encountered decreased along with them. Species richness and average diversity and evenness indices changed from upstream to downstream. The average value of H' and J were 3.6 and 0.77 in upstream while in downstream it decreased to 3.0 and 0.75, respectively (Table 1 and 2).

Thoubal river : In the Thoubal river, periphyton population ranged between 4,947-53,450 u cm² in upper stretch (Table 1). Bacillariophyceae dominated during winter (57.1%), monsoon (69%) and post monsoon (96.1%) seasons. During pre monsoon Chlorophyceae (50.8%) dominated over Bacillariophyceae (48.6%) and Cyanophyceae (0.6%). Chlorophyceae fluctuated in a wide range (3.3-50.8%). Cyanophyceae have equal contribution during winter, pre monsoon and post monsoon (0.6%). No animal group could be traced during the study. Number of species available decreased from winter (32) to pre monsoon (30 species) to post monsoon (21 species) and monsoon (9 species). Species diversity index and evenness index also varied according to the species richness. The H' values were maximum during winter and pre monsoon (4.6) and minimum in monsoon (3.1). The J values were 0.95, 0.94, 0.99 and 0.92 for the respective seasons. Out of 33 algal species encountered at upper stretch, 2 belonged to Cyanophyceae, 20 to Bacillariophyceae and 11 to Chlorophyceae. The average H' and J value for upper stretch were 3.9 and 0.95 respectively (Table 2).

Table 2 : Periphyton species diversity index (H') and evenness index (J) along with total periphyton count and number of species available in the three rivers of Manipur.

Rivers	Location	Seasons	Total Periphyton (u cm ⁻²)	Species diversity index (H')	Evenness index (J)	Number of species	
Khuga river	Upper stretch(KR1)	Winter	34,035	4.0	0.78	33	
		Pre M	37,160	4.0	0.79	35	
		Monsoon	3,055	2.5	0.71	12	
		Post M	32,750	4.2	0.8	41	
	Lower stretch(KR2)	Winter	48,734	3.2	0.76	18	
		Pre M	8,860	3.4	0.78	20	
		Monsoon	-	-	-	-	
		Post M	9,900	2.6	0.71	13	
Thoubal river	Upper stretch(TR1)	Winter	48,738	4.6	0.95	32	
		Pre M	53,450	4.6	0.94	30	
		Monsoon	4,947	3.1	0.99	9	
		Post M	41,900	4.0	0.92	21	
	Lower stretch(TR2)	Winter	11,212	3.0	0.72	20	
		Pre M	8,395	2.9	0.70	19	
		Monsoon	-	-	-	-	
		Post M	16,320	3.4	0.76	23	
	Imphal river	Upper stretch(IR1)	Winter	18,464	3.6	0.77	30
			Pre M	26,510	3.8	0.74	34
			Monsoon	8,974	1.7	0.73	5
			Post M	12,150	3.8	0.85	23
Middle stretch(IR2)		Winter	4989	3.4	0.94	15	
		Pre M	5,670	4.1	0.98	18	
		Monsoon	-	-	-	-	
		Post M	4320	2.7	0.90	8	
Lower stretch(IR3)		Winter	8050	3.4	0.94 (avg.)	18	
		Pre M	8040	4.2	0.80	20	
		Monsoon	3,276	1.9	0.76	22	
		Post M	7,660	4.1	0.85	5	
			3.4 (avg.)	0.87	27		
				0.83 (avg.)	30		

At lower stretch periphyton population run down (8,395 u cm⁻² - 16,320 u cm⁻²). During winter (73.5%) and post monsoon (95.6%) Bacillariophyceae played the main role where as during pre monsoon Chlorophyceae dominated over (66.2%) Bacillariophyceae (32.1%) and Cyanophyceae (1.6%). No periphytons were recorded during monsoon season. Some rhizopods were encountered during post monsoon and its contribution was 0.7% of the total count. Number of species encountered was maximum during post monsoon (23) followed by winter (20) and pre monsoon (19) and the J values changed accordingly and their average values were 3.1 and 0.72 respectively. In lower stretch, 33 species of periphyton belonging to Cyanophyceae (4), Bacillariophyceae (18) and Chlorophyceae (10) and a single species of rhizopod was observed (Table 1 and 2).

In the Thoubal river, upper stretch of the rivers (4,947-53,450 u cm⁻²) showed richer periphyton density than the lower stretch (8,395-16,320 u cm⁻²). Bacillariophyceae and Chlorophyceae have equal contribution in the total periphyton population in both the stretches. Cyanophyceae and animal population were all the time low. Contribution of Cyanophyceae increased from upper to lower stretch. Number of species available in both the stretches was same.

Imphal river : Periphyton population fluctuated between 8,974 -26,510 u cm⁻² in the upper stretch of the river. Density wise, pre monsoon showed maximum and monsoon showed lowest population of periphyton. Bacillariophyceae (43.1-92%) dominated over Chlorophyceae (2-54%) and Cyanophyceae (1-10.8%) irrespective of seasons. Some

animal groups were also encountered during pre monsoon contributing 1.5% of total population (Table 1). A total of 45 species belonging to different groups observed at upper stretch and highest number (34) was seen during pre monsoon followed by winter (30), post monsoon (23) and monsoon (5). However, value was maximum during pre and post monsoon (3.8) where as J value was found highest only during post monsoon, 0.85 (Table 2).

In the middle stretch, periphyton density was 4,984, 5,670 and 4,320 u cm^{-2} for winter, pre monsoon and post monsoon respectively. Sampling could not be done during monsoon season due to swollen river. Like upper stretch, Bacillariophyceae (80.6-87.5%) dominated over chlorophyceae (12.5-19.4%), but no Cyanophyceae and animal group was found in all the seasons (Table 1). Species richness and J values were also highest during pre monsoon where as post monsoon has the lowest value. Altogether eighteen algal species were observed in the middle stretch of the Imphal river (Table 2).

At the lower stretch periphyton population varied between 3,276-8040 u cm^{-2} and was maximum during pre monsoon and minimum during monsoon. Here also Bacillariophyceae (90-93.5%) dominated over Chlorophyceae (1.0-10%) and Cyanophyceae (1.9-5%). A species of protozoa (*Polytoma*) was observed during the study (Table 1). Value give maximum value during pre monsoon where as H' and J values were highest during post monsoon. During monsoon season, number of species encountered decreased to 5 and J value indices dropped down. However, after monsoon the number of species available again increased to 27 along with H' and J values. Altogether, 30 species belonging to different groups were identified from the lower stretch of the river (Table 2).

Over all in the Imphal river, Bacillariophyceae played a dominant role in the periphyton community irrespective of zonal variation. Periphyton showed maximum density during pre monsoon and minimum during monsoon. Both Cyanophyceae and Chlorophyceae population were lowered. However, Chlorophyceae was the dominant group during monsoon season (54%) at upper stretch. Animal population was meager and most of the time it was found absent. During monsoon, both density and species richness reduced. Number of species available declined from upper stretch (45 species) to middle stretches (18 species), however improved at lower stretch (30 species). Average H' value at upper stretch was 4.2 and middle and lower stretch had similar values (3.4) the average J values for the three stretches were 0.77, 0.94 and 0.83, respectively.

It may be referred from the present study that, periphyton population was high (3,055-53,450 u cm^{-2}) in all

the rivers and demonstrated sharp seasonal fluctuation. A much-lowered value (1441 u cm^{-2}) was observed by Singh *et al.* (2003) in an artificial lake on Arkavathi river. But Gurumayum *et al.* (2000) observed a higher value from the hill streams of Arunachal Pradesh (71,107-85,642 u cm^{-2}). During the study, Bacillariophyceae dominated in all the seasons despite zonal variation (43.1-96.1%). Dominance of diatoms corroborated with findings of Fritsch (1945) who suggested that the attachment of diatom is facilitated with the help of mucilage often secreted by them and this group can withstand variable changes of light intensity, temperature and other adversities. Similar observation was also noticed by some workers like Sukumaran *et al.* (1996), Kawosa (2001); Singh *et al.* (2003) *etc.* Periphyton density increased either during winter or pre monsoon in all the rivers irrespective of zonal variation, which were corroborated with the finding of Kawosa (2001) in a rural lake of Kashmir. Rise in periphyton population during winter season was also noticed by Singh *et al.* (2003); Sukumaran *et al.* (1996) in lotic habitats. Increased in periphyton density in upstream of rivers is an expected phenomenon where the environment is more suitable for such organisms. Gurumayum (2000) made similar observation from the upstream of the tributaries of the Brahmaputra river. Cyanophyceae population was all the time low (0-10.8%) except during monsoon in upper stretch of the Khuga river where its percentage contribution shoots up to 40.4%. Chlorophyceae fluctuated in a wide range (1-66.2%) and most of the time it was dominated by diatoms. Decreased contribution of Cyanophyceae and Chlorophyceae in periphyton population is a common phenomenon also noticed by many workers. Low nutrient value in the physico-chemical properties of the water may probably result in their lower contribution.

Animal groups were almost untraceable and observed only in some seasons of upper stretch of the Khuga and upper and lower stretches of the Imphal rivers. Sugunan (1991) also reported presence of animal groups in periphyton count from Nagarjuna sagar Reservoirs and Sukumaran *et al.* (1996) from a lentic habitat of Karnataka.

As we go from upstream to down streams, species diversity indices values decreases (Table 2). Laal *et al.* (1982) reported a much lower value (av. 2.5) from different stretches of river Ganga and also noticed variation in J values in different stretches of river Ganga, higher being reported from upstream and lower, after confluence of sewage off shoot at Sirighat Kol. In the present study, J values were near unity (0.71-0.99) and high evenness value for all the rivers reflects undisturbed environmental condition. The J value was higher in upstream of the Thoubal and the Khuga rivers where as in the Imphal river, it was just the opposite, minimum being at lower stretch (0.74) and maximum at

middle stretch (0.94). The H' value decreased during monsoon for all the stretches which were corroborated with the findings of Sugunan, (1991) on the river Krishna. Higher periphyton density, high H' value and dominance of bacillariophyceae in the upstream of the rivers suggested more towards oligotrophic condition of the rivers. Down stream decrease in periphyton density is on the line of anticipation. However, decrease in H' value along the down stream reflected a more enriched water quality in comparison to upstream. Overall high periphyton count, high H' and J' value in all the rivers showed oligotrophic condition of the rivers. Presence of lower concentration of Chlorophyceae and Cyanophyceae in the total periphyton count also supports the belief.

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