International Journal of Academic Research and Development
ISSN: 2455-4197
Impact Factor: RJIF 5.22
www.academicsjournal.com
Volume 3; Special Issue 1; February 2018; Page No. 09-13

The study of periphyton diversity and macro-benthic faunas in the wetlands of upper Brahmaputra valley, Assam

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Abstract
Periphyton contributes a major share of food for many aquatic animals including fish. The study of periphyton communities has the added advantage in relation to the increasing eutrophication of aquatic environments as they are one of the best biological indicators of the water quality because of their tremendous adaptive qualities and universal distribution. The periphyton samples were collected by rock scrapings from different points every month. The data were finally pooled together to obtain a representative sample. The samples were thoroughly centrifuged to obtain the sediment biomass. It is then transferred to a measuring cylinder and made the volume of the sample to 100 ml. from this sample 1 ml was drawn and the counting was done with the aid of a Sedgwick Rafter plankton counting cell. For macrobenthic study sediment samples were collected monthly. The submerged plants were collected in plastic bags immerged in 4% formalin and identified by Needham *et.al* (1962) and Patil and Gouder (1989). Molluscan shells collected washed preserved and identified by Fernando (1963) and Patil and Gouder (1989).Diptera, Oligocheata, insect species, chironomidaes, gastropods, Pelecypoda etc. were found in the study areas. This paper deals with the study of periphyton and their relation with macrobenthic population from 2011 onwards.

Keywords: aquatic environments, sediment biomass

Introduction
The periphytons occupy a specialized ecological niche and are important biota of lakes and streams. These periphytons are neither rooted vegetation nor have any rhizoidal system to hold any object but are the specialized group of organisms capable to adhere over the submerged substrate by their own secretion and due to this characteristic the periphytic community is largely dominated by the greater abundance of diatom (Fritsch 1979) [5]. These periphytons contribute a major share of food for many aquatic animals including fish. The study of periphytic communities has the added advantage in relation to the increasing eutrophication of aquatic environments as they are one of the best biological indicators of the water quality because of their tremendous adaptive qualities and universal distribution.

Denbow and Davis (1989) [2] reviewed the role of benthic invertebrates in state and federal water quality monitoring programme revealed as management plan of lakes and reservoirs for proper ecological balance in aquatic ecosystem. The aquatic insects constitute a fraction of about 4 % of the total insect population. They are the major food item of some fishes. Some aquatic insects are larval forms and compete with fish food. The aquatic insects serve as indicators of several ecological characteristics.

The functional categories of macro-invertebrates include shredders, collectors, grazer, and predators. The small invertebrates found to live on the surface of plants and stones. So, more the plants, more the invertebrates. Some of the invertebrates feed on plants. The plants also protect them in particular phase of life-cycle.

Study Area
a) Garudharia Wetland
It is an oxbow shaped wetland with $27^0$26 'N latitude 94^0 52'E longitude. It is situated about 3 km north–west from NH-37 of Dibrugarh District, Assam. The wetland has a total area of 32.13 hectares. The minimum and maximum depths are 2.6 m and 4.9 m respectively.

b) Maijan Wetland
It is an open Wetland with 27^0 32 ' N latitude and 94^0 58 ' E longitudes. The breadth of the connecting channel to river Brahmaputra is 600 m and the area is 87.07 hectares. The minimum and maximum depths are 3.8 m and 6.4 m respectively.

Materials and Method
The periphytic samples were collected by rock scrapings from different points every month. The data were finally pooled together to obtain a representative sample. The samples were thoroughly centrifuged to obtain the sediment biomass. It is then transferred to a measuring cylinder and made the volume of the sample to 100 ml. from this sample 1 ml was drawn and the counting was done with the aid of a Sedwick Rafter plankton counting cell. The community structure of periphyton revealed the dominance of bacillariophyceaen flora.

The benthic samples were collected from five stations by Ekman's Dredge (15.2 x 15.2 cm). Separation of benthic organism from the sediment samples were done by using sieve of no. 44 mesh size following the extraction techniques given by Hullings and Gray (1971). Statistical analysis was done by

SPSS software programme. The submerged plants were collected in plastic bags immerged in 4% formalin and identified by Needham *et.al* (1962) and Patil and Gouder (1989). Molluscan shells collected, washed, preserved and identified by Fernando (1963) and Patil and Gouder (1989).

Objectives

1. Study of the periphyton diversity in the wetlands.
2. Study of the macrobenthic diversity in the wetlands.
3. Study of correlation of Periphyton and macrobenthic community with physico-Chemical parameters.

Observation and Result

a) Periphyton

The study of periphyton reveals that Baccilariophyceae is dominant over the other species of periphyton in both the wetlands (table 1). It shows that higher numbers of periphyton species are found in Maijan beel than the Garudharia Beel it may be because of the high dissolved oxygen content in Maijan than Garudharia.

Table 1: Average periphyton population (u/l)

Total periphyton		Bacill.		Chlor.		Myxo.		Misc. Algae		Animals	
		No.	%	No.	%	No.	%	No.	%	No.	%
Maijan 2012-13(annual)	3040	2046	67.3	305	10.0	350	11.5	194	6.3	145	4.7
Maijan 2013-14	3077	1972	64.0	414	13.4	384	12.4	163	5.2	145	4.7
Biannual variation Maijan 2012-14	3059	2009	65.6	360	11.7	367	11.9	179	5.8	145	4.7
Garudharia 2012-13(annual)	3023	1953	64.6	409	13.5	386	12.7	155	5.1	120	3.9
Garudharia 2013-14	1884	1108	58.8	321	17	264	14.0	117	6.2	74	3.9
Biannual variation Garudharia 2012-14	2454	1531	62.3	365	14.8	325	13.2	136	5.5	97	3.9

Bacill= Bacillariophyceae Chloro= Chlorophyceae, Myxo.= Myxophyceae

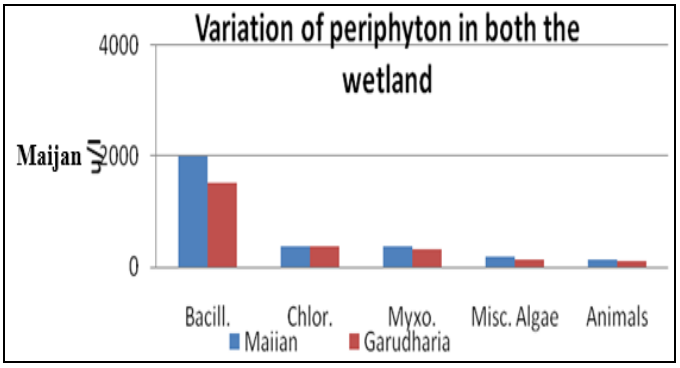

Fig 1: Biannual variation of periphyton of both the wetlands from 2012-14

Wetland: correlation between physico-chemical parameters (X) and Periphyton community (Y)

The percentage relationship (i.e correlation) that exists between Periphyton(Y) (dependent variable) and Air temperature (X_1) (independent variable) is 72%, that with Water temperature (X_2) is 81%, with pH (X_3) is 54%, with D.O (X_4) it is 31%, with FCO_2 (X_5) is 37%, with Alkalinity (X_6) it is negatively correlated (-)47 %, with Total hardness (X_7) is 88%, with Chloride (X_8) it is negatively correlated (-)79%, with Fluoride (X_9) is 86%, with Phosphate (X_{10}) is 87%, Ammonia (X_{11}) is 80%, with Total iron (X_{12}) is 83% and with Nitrate (X_{13}) is 86%.

Again from regression studies, it is seen that with a unit increase in Air temperature(X_1), Periphyton (Y) will be increased by 0.53 units i.e for a 100 percent increase in Air temperature(X_1), Periphyton (Y) will be increased by 53%. Similarly, Periphyton(Y) will be increased by 62% with Water temperature (X_2) increase, 39% with pH (X_3) increase, 67% with increase in D.O (X_4), 58% with FCO_2 (X_5) increase, (-)69% with decrease in Alkalinity (X_6), 77% with Total hardness (X_7) increase, (-)52% with decrease in Chloride (X_8), 63% with Fluoride (X_9) increase, 46% with Phosphate (X_{10}) increase, 34% with Ammonia (X_{11}) increase, 57% with Total iron (X_{12}) increase, 56% with Nitrate (X_{13}) increase.

Test of significance shows significant values of Periphyton with Air temperature, Water temperature, pH, D.O, Alkalinity, Total hardness, Chloride, Ammonia and Nitrate.

Garudharia wetland: correlation between physico-chemical parameters (X) and periphyton community (Y)

The percentage relationship (i.e correlation) that exists between Periphyton(Y) (dependent variable) and Air temperature (X_1) (independent variable) is 70%, that with Water temperature (X_2) is 86%, with pH (X_3) is 57%, with D.O (X_4) it is 36%, with FCO_2 (X_5) is 84%, with Alkalinity (X_6) it is negatively correlated (-)56 %, with Total hardness (X_7) is 36%, with Chloride (X_8) it is negatively correlated (-)74%, with Fluoride (X_9) is 76%, with Phosphate (X_{10}) is 58%, Ammonia (X_{11}) is 63%, with Total iron (X_{12}) is 60% and with Nitrate (X_{13}) is 62%.

Again from regression studies, it is seen that with a unit increase in Air temperature(X_1), Periphyton(Y) will be increased by 0.56 units i.e for a 100 percent increase in Air temperature(X_1), Periphyton(Y) will be increased by 56%. Similarly, Periphyton(Y) will be increased by 61% with Water temperature (X_2) increase, 45% with pH (X_3) increase, 60% with increase in D.O (X_4), 56% with FCO_2 (X_5) increase, (-)72% with decrease in Alkalinity (X_6), 73% with Total hardness (X_7) increase, (-)49% with decrease in Chloride (X_8), 60% with Fluoride (X_9) increase, 49% with Phosphate (X_{10}) increase, 32% with Ammonia (X_{11}) increase, 54% with Total iron (X_{12}) increase, 49% with Nitrate (X_{13}) increase.

Test of significance shows significant values of Periphyton with Air temperature, Water temperature, pH, D.O, Alkalinity, Total hardness, Chloride, Ammonia and Nitrate.

b) Macrobenthic Organisms

The contribution of bivalves to the community of benthic invertebrates was relatively higher in Garudharia beel (55 u/m^2) as compared to Maijan beel (45 u/m^2). While the abundance of gastropods was marginally higher (390 u/m^2) in

Maijan as compared to Garudharia (336 u/m^2).
The annual average of macrobenthic organisms in Maijan was higher (533 u/m^2) during the second year than third year (479 u/m^2) of observation while Garudharia was higher (483 u/m^2) during the third year than second year (453 u/m^2) of observation. The trend of abundance followed a sequence of Gastropods > Bivalves > Crab & Prawn > Others > Oligocheates > Chironomids in Maijan and of Gastropods > Bivalves > Others > Crab & Prawn > Oligocheates > Chironomids in Garudharia during the study period
The pattern of seasonal abundance of macrobenthic organisms differed with seasons. The occurrence of benthic organisms declined in the monsoon season and was seen highest in post monsoon season in both years. The population indicated gradual increase immediately after monsoon.

The gastropod population in Maijan remained dominant over all groups of organisms with an average contribution to the tune of 78.4% followed by bivalves (8.4%), Crab and prawn (5.2%), others (5.2%), Oligocheates (1.5%) and chironomids (1.1%) in the 2012-13. In 2013-14, the average size of gastropods was 75.5%, bivalves 9.1%, Crab and prawn 5.8%, others 4.1%, Oligocheates 3.1% and chironomids 1.6%.
The dominant gastropod population in Garudharia with an average contribution of 76.3% to the community size over-shadowed all other groups of organisms. Bivalves (7.9%) contributed the next followed by, others (6.1%), Crab and prawn (5.9%), oligocheates (1.9%) and chironomids (1.5%) in the 2012-13. During 2013-14, the average size of gastropods was 67.4%, bivalves 15.3%, Crab and prawn 6.6%, Oligocheates 4.5%, others 3.3%, and chironomids 2.2%.

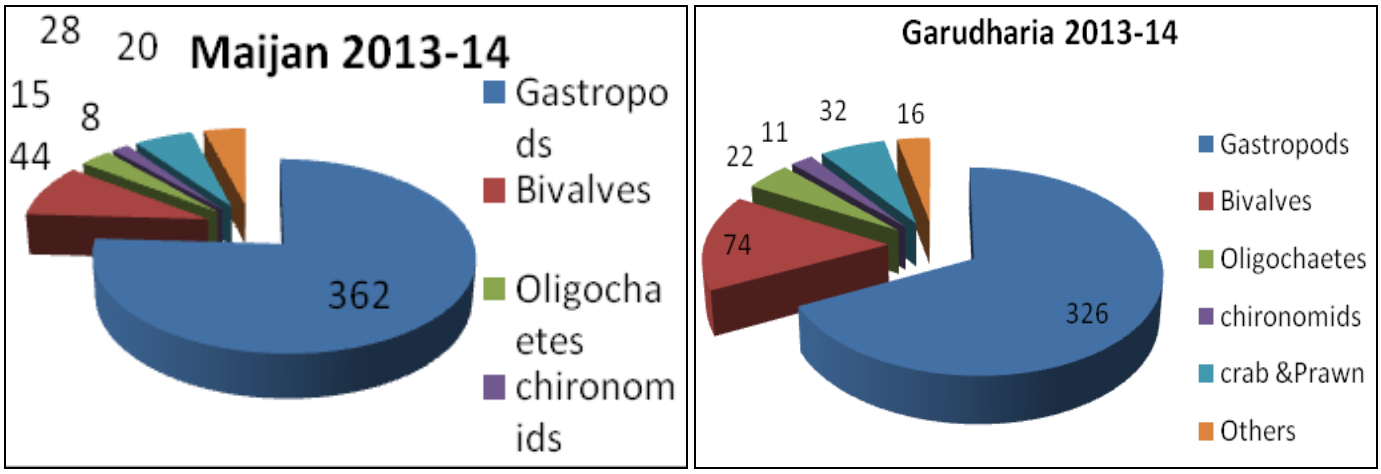

Fig 2: Quality composition (%) of benthic communities in both the wetlands (2012-2014).

Maijan Beel: Correlation of physico-chemical parameters (X) with Macrobenthic community (Y)
The percentage relationship (i.e correlation) that exists between Macrobenthic community (Y) (dependent variable) and bottom oxygen (X_1) (independent variable) is 82%, that with total hardness (X_2) is 80%, with soil organic carbon (X_3) is 61% and with alkalinity (X_4) is 79%.
The regression study shows that with a unit increase in bottom oxygen (X_1), Macrobenthic community (Y) will increase by 0.64 units. i. e for a 100 percent increase in bottom oxygen (X_1), Macrobenthic community (Y) will be increased by 64%. Similarly, Macrobenthic community (Y) will be increased by 68% with total hardness (X_2) increase, 48% with soil organic carbon (X_3) increase and 60% with alkalinity (X_4) increase.
Test of significance shows significant values of Macrobenthic community with bottom oxygen, total hardness and alkalinity.

Garudharia: Correlation of physico-chemical parameters (X) with Macrobenthic community (Y)
The percentage relationship (i.e correlation) that exists between Macrobenthic community (Y) (dependent variable) and bottom oxygen (X_1) (independent variable) is 76%, that with total hardness (X_2) is 82%, with soil organic carbon (X_3) is 87% and with alkalinity (X_4) is 69%.
The regression study shows that with a unit increase in bottom oxygen (X_1), Macrobenthic community (Y) will increase by 0.63 units. i. e for a 100 percent increase in bottom oxygen (X_1), Macrobenthic community (Y) will be increased by 63%. Similarly, Macrobenthic community (Y) will be increased by 72% with total hardness (X_2) increase, 54% with soil organic carbon (X_3) increase and 62% with alkalinity (X_4) increase.
Test of significance shows significant values of Macrobenthic community with bottom oxygen, total hardness and alkalinity.

Diversity of macrobenthic organisms:
A total of 23 species of benthic macro invertebrates could be identified and listed. *Tubifex sp.* and *Anopheles sp.* are recorded more in Garudharia than in Maijan. *Pila globosa* and *Lymnaea acuminate* were abundantly encountered gastropods. *Tubifex sp* and *Limnodrilus hoffmeisteri* were fairly abundant oligochates. Chirononid larvae were also recorded fairly from both the wetlands. *Helobdella sp.*, *Pheretima postuma* and *Pristina aequiseta* are commonly found in both the wetlands. The category of others includes May-fly, Dragon-fly nymph, Mosquito larvae etc. Crab and prawn (*Machrobracium rosenbergii* and *M. malcomsonii*) were also recorded abundantly from both the wetlands.

Table 2: Species composition of Benthic Macro-invertebrates of both the beel from 2012-13.

S. No.	Macro-invertebrate fauna		Life- Form
Phylum: Annelida			
1.	Family: Tubicidae	*Tubifex sp.*	Zb. FFO
2.		*Limnodrilus hoffmeisteri* (Claparede,1862)	
3.	Family: Hirudinaria (Leech)	*Helobdella sp.*	Zb
4.		*Hirudo sp.*	FFO
5.	Family: Lumbricidae (Earthworm)	*Pheretima postuma*	FFO
6.		*Pristina aequiseta*	FFO
Phylum: Arthropoda Class: Insecta			
7.	Order: Ephemeroptera	*Ephimera*	*Zb, FFO,*
8.	Order: Odonata	*Libullula*	FFo, Zb., NP
9.	Order: Diptera	*Chironomus circumdatus*(Keiffer)	FFO
10.		*Anopheles sp.*	FFO
11.		*Culex sp.*	FFO
12.	Order: Hemiptera	*Gerris*	NP
13.		*Notonecta*	NP
14.		*Ranatra* (water-scorpion)	NP
15.		*Laccotrephes* (Nepa)	NP
16.		*Lithoceros* (Belostoma)	NP
17.	Decapoda	*Cancer pagurus*	Zb
18.		*Machrobracium rosenbergii*	Zb
19.		*M. malcomsoni*	Zp
Phylum: Mollusca Class: Gastropoda			
20.	Order: Mesogastropoda	*Pila globosa*	Zb
21.		*Lymnaea acuminate*	Zb
22.	Order: Pelecydoda	*Parryyesia flavidens assamensis* (Bivalves)	Zb
23.		*Unio*	Zb

Zb: zoobenthos; FFO: Fish Food Organism; NP: Destructive to Nursery Ponds

Table 3: Biannual variation of Macrobenthic population (u/m^2) of Maijan & Garudharia Beel

year	Total	Gastropods		Bivalves		Oligocheates		Chironomids		crab &Prawn		Others	
		No.	%	No.	%	No.	%	No.	%	No	%	No.	%
Maijan 2012-14	506	390	77	45	8.8	12	2.3	7	1.3	24	4.7	28	5.5
Garudharia 2012-14	468	336	71.7	55	11.7	16	3.4	9	1.9	30	6.4	22	4.7

Discussion

The periphytic communities occupy a special niche and are the best indicators of water quality. It is because of this fact that many workers have studied periphyton in relation to water pollution (Hutchinson. 1957) [1]. It may be so because the community structure of periphyton is largely regulated by the greater abundance of Bacillariophyceae flora and the organisms of this group are capable of thriving a wide range of water quality conditions. A perusal of the data revealed that the abundance and fluctuation of the periphytic community was found to be regulated both by density independent and density dependent factors. A pH range of 7.5 to 8 is best suited for the luxuriant growth of periphyton in general. Temperature was found to be most important factor bringing considerable changes in the size and quality of the periphytic community. In general a temperature range of 5 – 25ºC was best suited. However requirement of temperature varies from species to species. The nutrients like phosphate and nitrate available in the suspended media may be having some role in the regulation of community structure but nothing could be established in the present study. Since the haptobenthos are facultative autotrophs, the available nutrients in the media are of little significance.

Conclusion

The result indicates that the study areas to be eutrophic. Presence of minimum number of chironomids and polychaetes and more number of gastropod and bivalves at the study areas indicate pollution free nature of the wetlands. The study areas includes many diverse insects among them are nymph of may-flies; dragon- flies, mosquito larva etc are common. The nymphs and larva of most of these insects feed on bottom debris, plankton and other micro-organisms while they form food for carnivorous fish. Oligocheates like Hirudinea, Limnodrillus, Tubifex species, Chironomids are dominated on soft clayey soil. The chironomids construct a U-shaped burrow and is typically regarded as filter feeder.

The result also states the presence of more periphyton in Maijan than Garudharia which indicates that the water quality of Maijan which is connected to River Brahmaputra is better than that of Garudharia.

The annual mean production of benthic organism at the study area remained 5750 unit/m^2. The total benthos depicted a direct correlation with organic carbon; bottom total hardness and bottom water dissolved oxygen are found to be significant at 5 % level of significance.

The co- relation studies with biotic and abiotic parameters

shows the status and the importance of the every minute species that indicates the proper health of the aquatic ecosystem.

The study reveals that test of significance shows significant values of Macrobenthic and periphyton community with physico-chemical parameters of both the wetlands.

Acknowledgement

This research work was supported financially by U.G.C (University Grant Commission) in the form of Major Research Project to the author is gratefully acknowledged. The author is also grateful to Ms. Habiba Khanam, Research fellow, UGC MRP, D.H.S.K. College, Dibrugarh, Assam for her help.

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