J. Indian Inst. Sci., July–Aug., 1989, **69**, 275–283.

Periphytic algal flora of *Phragmites communis* trin.

S. G. SARWAR AND D. P. ZUTSHI*
Hydrobiology Research Laboratory, S.P. College, Srinagar 190001, Kashmir (India).

Received on April 7, 1988; Revised on September 21, 1988.

Abstract

The paper describes the distribution and community structure of periphyton on *Phragmites communis* Trin. in three Kashmir Himalayan Valley lakes. One hundred and six taxa, representing seven algal classes, were recorded, of which 62 were common to the lakes. Numerically Bacillariophyceae was dominant both in terms of the number of taxa and abundance. Its contribution to the total population density was almost always more than 50%.

Key words: Community structure, periphyton, bacillariophyceae, Kashmir Himalayan Valley lakes.

1. Introduction

The community of microscopic-attached organisms composed of algae, bacteria, fungi, protozoa and small metazoa is called periphyton (syn. aufwuchs). Such communities are responsive to environmental changes and are excellent biological indicators of the degree of eutrophication. In India less attention has been paid to the ecological role of attached algae[1-5] relative to the more easily studied phytoplankton. Even this group serves as a sort of store-house habitat for the accelerated growth in favourable seasons. From June 1982 to May 1983, a detailed qualitative and quantitative investigation was carried out on the algal component of the periphytic flora of an emergent macrophyte (*Phragmites communis* Trin.) of three Kashmir Himalayan Valley lakes—Dal, Anchar and Waskur. Features of these lakes are described elsewhere[5].

2. Material and methods

Sampling was done every month between 1000 and 1200 h IST near the reed belts of the lakes. Surface water samples, collected near the reed belts, were analysed following the methods of Mackereth[6]; APHA[7], and Golterman *et al*[8]. Since the periphyton attachment to the substrate is effected by mucilage-like polysaccharides, their removal was accomplished by a combination of agitation and acid hydrolysis with FAA (10:7:2:1::95%

*Present address: CORD, The University of Kashmir, Srinagar 190006.

ethanol:water:formalin:glacial acetic acid) following the method of Gough and Woelkerling[9]. The macrophyte material was treated with FAA, shaken vigorously for few minutes and then filtered through muslin. The macrophyte fragments, retained by the muslin, were oven-dried at 105°C till constant weight was obtained. Counting of the algal component of the periphytic forms was done every month in a Sedgwick rafter cell and the results are expressed as units per 10 mg dry weight of the macrophytic material. The general principle of quantitative expressions of units has been adopted from Tucker[10]. The community coefficient has been calculated after Taylor[11].

3. Results and discussion

Average values of various physico-chemical parameters for the three lakes are given in Table I. Major variations in these parameters are not discernible except in the case of conductivity, total alkalinity, calcium, iron and total phosphorus. Calcium and magnesium contents of Anchar and Waskur Lakes were almost double that of Dal Lake.

Sixty-two taxa out of 106 recorded from the investigated lakes were common. They belonged to six classes of algae: Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae and Cryptophyceae. In addition, Chrysophyceae was represented by *Dinobryon* sp. in Dal Lake (Table II).

The sequence of the dominance of four major algal classes was Bacillariophyceae >

Table I
Average values for various physico-chemical parameters of investigated lakes

Parameter		Lakes		
		Dal	Anchar	Waskur
Specific conductivity	$\mu s/cm^{-1}$ at 25°C	133	316	294
pH		8.4	7.9	8.4
Total alkalinity	$mgl^{-1}CaCO_3$	71.9	149.0	164.4
Chloride	mgl^{-1}	18.9	24.0	19.7
Calcium	mgl^{-1}	19.4	38.1	38.2
Magnesium	mgl^{-1}	4.1	8.8	14.0
Sodium	mgl^{-1}	3.3	5.3	5.5
Potassium	mgl^{-1}	2.0	4.0	2.3
Dissolved oxygen	mgl^{-1}	11.1	9.8	12.5
Silicate	mgl^{-1}	2.0	1.9	3.7
Iron	μgl^{-1}	144	195	179
Ammonical-nitrogen	μgl^{-1}	10	16	15
Nitrate-nitrogen	μgl^{-1}	48	91	33
Orthophosphorus	μgl^{-1}	22	23	20
Total phosphorus	μgl^{-1}	66	91	71
Sulphate	mgl^{-1}	0.2	0.9	0.7

Table II
Average abundance of periphytic taxa

	Name of the taxon	Dal lake	Anchar lake	Waskur lake
A)	Bacillariophyceae			
	Achnanthes minutissima Kutz.	F	SD	F
	Amphora bitumida Prowse	R	R	R
	A. normani Rab.	R	—	—
	A. ovalis Kutz.	F	F	F
	Asterionella formosa Hass.	—	R	—
	Ceratoneis arcus (Ehr.) Kutz.	R	R	R
	Cocconeis placentula Ehr.	SD	D	SD
	Coscinodiscus sp.	R	—	R
	Cyclotella sp.	F	F	F
	Cymatopleura solea (Breb) W. Sm.	R	—	R
	Cymbella affinis Kutz.	R	F	F
	C. lanceolata (Ehr.) Brun.	F	F	SD
	C. prostrata (Berk.) Cl.	R	R	R
	C. tumida (Breb.) Van Heurck	F	R	R
	C. turgida (Greg.) Cl.	R	F	R
	C. ventricosa (Kutz.) Meist	F	F	F
	Diatoma elongatum (Lyngb.) Ag.	F	F	F
	D. hiemale (Lyngb.) Herib.	R	—	R
	Diatomella balfouriana Grev.	F	R	F
	Diploneis elliptica (Kutz.) Cl.	R	—	—
	Epithemia sorex Kutz.	R	R	R
	Eunotia diodon Ehr.	F	R	F
	E. pectinalis (Kutz.) Rab.	F	F	SD
	Fragilaria capucina Desmaz.	SD	SD	F
	F. construens (Ehr.) Grun	SD	D	F
	F. crotonensis Kitton	SD	SD	SD
	F. vaucheriae (Kutz.) Peterson	R	R	R
	Frustulia rhomboides (Ehr.) De Toni	R	R	R
	Gomphoneis herculeanum (Ehr.) Cl.	F	F	R
	Gomphonema acuminatum Ehr. var. *coronatum* (Ehr.) W Sm.	R	R	R
	G. angustatum (Kutz.) Rab.	R	R	R
	G. augur Ehr.	R	R	R
	G. constrictum Ehr.	R	F	F
	G. geminatum Ag.	R	—	R
	G. olivaceum (Lyngb.) Kutz.	F	F	F
	G. vibrio Ehr.	—	R	—
	Gyrosigma scalproides (Rab.) Cl.	—	R	R
	Hantzschia amphioxys (Ehr.) Grun.	R	R	R
	Melosira sp.	R	R	R
	Meridion circulare (Grov.) Ag.	R	R	—
	Navicula elegantoides Hust.	R	—	R
	N. rhyncocephala Kutz.	R	R	R
	Navicula spp.	SD	SD	SD
	Nedium dubium Hust.	R	—	R
	Nitzschia spp.	SD	SD	SD

(*continued*)

Table II (*continued*)

	Name of the taxon	Dal lake	Anchar lake	Waskur lake
	Pinnularia borealis Ehr.	—	R	R
	Rhopaladia gibba (Ehr.) O. F. Mull.	F	R	F
	Stauroneis anceps Ehr.	R	R	R
	Synedra spp.	F	F	F
	Tabellaria fenestrata (Lyngb.) Kutz.	—	R	—
B)	Cyanophyceae			
	Anabaena sp.	R	R	R
	Chroococcus turgidus (Kutz.) Nag	—	R	R
	Coelosphaerium sp.	R	R	R
	Gloeotrichia pisum Thuret ex. Born. et Flah	R	—	—
	Gomphosphaeria sp.	F	R	R
	Lyngbya contorta Lemm.	R	R	—
	Merismopedia elegans A. Br.	—	R	R
	Microcystis aeruginosa Kutz.	SD	SD	SD
	Nostoc sp.	R	R	R
	Oscillatoria sp.	F	F	R
	Rivularia sp.	R	R	R
	Spirulina sp.	R	R	R
	Tolypothrix tenuis Kutz.	—	—	R
C)	Dinophyceae			
	Glenodinium sp.	F	F	R
	Peridinium sp.	F	F	F
D)	Chlorophyceae			
	Ankistrodesmus falcatus (Corda) Ralfs.	—	R	R
	Bulbochaete sp.	R	—	R
	Chaetophora sp.	F	R	—
	Characium sp.	R	R	R
	Closterium moniliforme (Bory) Ehr.	R	—	R
	Coleochaete sp.	R	R	R
	Cosmarium botrytis Menegh.	R	R	R
	C. granatum Breb.	R	R	R
	C. pseudobroomei Wolle (Hylan)	R	R	—
	C. renellei Wille	—	R	R
	C. vexatum W. West	R	R	R
	Crucigenia tetrapedia (Kirch.) W. and G. S. West	R	R	R
	Euastrum dubium Nag.	—	—	R
	Mougeotia sp.	R	R	R
	Oedogonium sp.	F	F	F
	Pediastrum duplex Meyen	—	R	R
	P. simplex var. *duodenarium* (Bailey) Rab.	R	R	R
	P tetras (Ehr.) Ralfs.	R	—	—
	Pleurotaenium sp.	R	—	R
	Scenedesmus acutiformis Sch.	R	—	—
	S. armatus (Chodat) G. M. Sm.	—	R	—
	S. bijugatus (Turp.) Kutz.	R	R	R
	S. dimorphus (Turp.) Kutz.	R	R	—
	S. obliquus (Turp.) Kutz.	R	—	R

(*continued*)

Table II (*continued*)

	Name of the taxon	Dal lake	Anchar lake	Waskur lake
	Schroederia setigera (Sch.) Lemm.	—	R	—
	Spirogyra sp.	R	R	—
	Staurastrum sp.	R	R	—
	Stigeoclonium lubricum (Dillw.) Fries	—	R	—
	S. tenue (Ag.) Kutz.	R	—	—
	Tetraedron minimum (A. Br.) Hansg.	R	R	R
	T. muticum (A. Br.) Hansg.	R	R	R
	T. regulare Kutz.	—	R	—
	T. trilobulatum (Reinsch) Hansg.	R	R	R
	Ulothrix sp.	R	R	—
	Zygnema sp.	—	R	—
E)	Chrysophyceae			
	Dinobryon sp.	R	—	—
F)	Cryptophyceae			
	Cryptomonas erosa Ehr.	R	R	R
G)	Euglenophyceae			
	Euglena sp.	R	F	R

Values:
Rare = R = 1–10
Frequent = F = 11–100
Sub-dominant = SD = 101–500
Dominant = D = 501 and above
} units/10 mg d.wt.

Cyanophyceae > Chlorophyceae > Dinophyceae. The ranges and mean values of the percentage composition of major algal classes are presented in Table III.

The investigation showed the predominance of Bacillariophyceae in the periphyton element. Similar observations were recorded by the authors on artificial and other natural substrates[3–5]. The luxuriant growth of diatoms is indicative of the fertility status of these lakes as diatoms have been shown to be sensitive to changes which may occur in aquatic environments and are often considered as reliable indicators of the condition and the quality of the waters in which they live[12–15]. One important reason for this is their rapid rate of reproduction which allows for significant increases in populations of a given species under favourable conditions while other species concurrently decrease and/or disappear. Jorgensen[16] and Vass *et al*[17] also observed high diatom contribution in the periphytic populations.

The species composition of periphyton on *P. communis* in the investigated lakes is presented in Table IV.

The numerical abundance of periphytic taxa is illustrated in fig. 1. The maximum number of taxa recorded in Dal (Nov.), Anchar (Sept.) and Waskur (Nov.) lakes was 51, 53 and 52, respectively, while their minimum number of 24, 28 and 24 was observed in May 1983.

Table III
Variations in the percentage composition of major algal classes on *Phragmites*

Algal class	Lake	Min.(%)	Max.(%)	Mean(%)
Bacillariophyceae	A	38.7	96.3	69.4
	B	66.8	98.0	83.6
	C	48.4	98.0	74.0
Cyanophyceae	A	1.1	54.7	16.0
	B	0.4	18.7	8.3
	C	0.2	37.8	15.5
Chlorophyceae	A	1.1	44.7	11.0
	B	1.3	23.8	5.9
	C	1.1	17.7	7.9
Dinophyceae	A	0.2	13.7	3.4
	B	0.04	5 4	2.1
	C	0.08	7 9	2.3

A = Dal lake; B = Anchar lake; C = Waskur lake.

Table IV
Classwise distribution of periphytic taxa

Class	Lakes		
	Dal	Anchar	Waskur
Bacillariophyceae	48	47	48
Chlorophyceae	27	27	23
Cyanophyceae	10	11	10
Dinophyceae	2	2	2
Cryptophyceae	1	1	1
Euglenophyceae	1	1	1
Chrysophyceae	1	—	—
Total	90	89	85

Cocconeis placentula, *Fragilaria* spp., *Navicula* spp. and *Oedogonium* sp. were the most dominant taxa. Their average per cent contribution to their respective classes is presented in Table V.

Amphora normani, *Cymatopleura solea*, *Diploneis elliptica*, *Gomphonema vibrio*, *Tolypothrix tenuis*, *Scenedesmus acutiformis*, *Stigeoclonium lubricum* and *Zygnema* sp. were some of the rare taxa recorded on *Phragmites*.

In Dal Lake, the population density showed wide fluctuations in the initial months till it attained a peak of 10,466u/10mgd.wt. in November 1982. It was mainly constituted by *Fragilaria* spp. and *Oedogonium* sp. Thereafter, the density remained more or less constant till it registered its lowest value of 627u/10mg in May 1983. On the other hand, in Anchar lake, the value was very high in June 1982 which was mainly contributed by *Cocconeis*

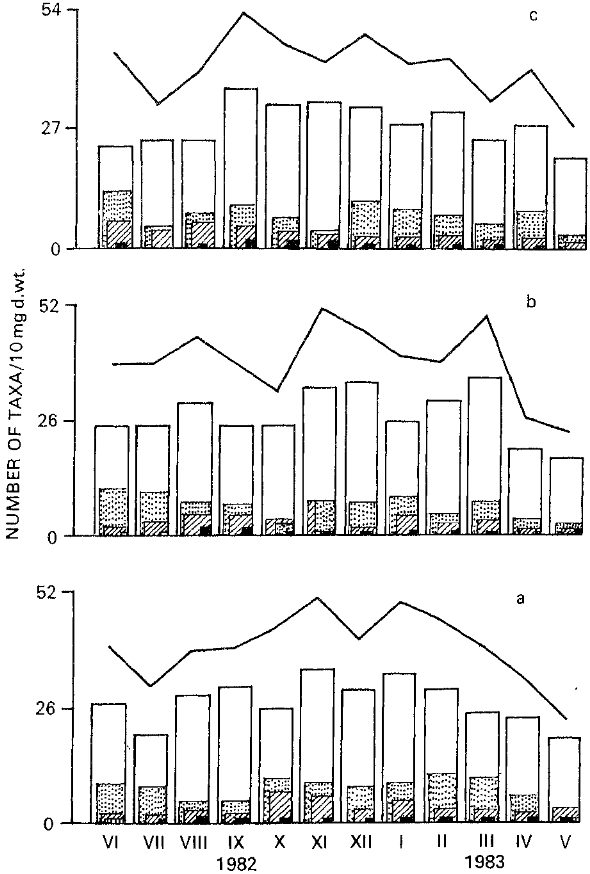

FIG. 1. Time variations in the number of taxa on *Phragmites*. a = Dal lake; b = Waskur lake; c = Anchar lake. —— Total number of taxa.

Bacillariophyceae; Chlorophyceae; Cyanophyceae; Dinophyceae; Chrysophyceae; Cryptophyceae.

Table V
Average per cent contribution of dominant genera to their respective classes

Genus	Lakes		
	Dal	Anchar	Waskur
Cocconeis	9.0	12.5	15.6
Fragilaria	31.5	34.2	18.4
Navicula	10.0	12.1	7.6
Oedogonium	36.5	28.3	25.6

placentula. In the subsequent months the values were relatively low recording the lowest value of 670 u/10 mg d.wt. in October 1982. In November 1982, the values showed abrupt rise to register a minor peak of 6,062 u/10 mg d.wt. It was mainly contributed by *Fragilaria* spp. and *Oedogonium* sp. Thereafter, the abundance values gradually decreased till April 1983 when it once again showed an abrupt rise to form a major peak of 9,702 u/10 mg d.wt. It was mainly contributed by *Fragilaria* spp. In the subsequent month, it once again registered a sharp decline to 942 u/10 mg d.wt. In Waskur lake, the population density ranged from 650 (October 1982) to 3,850u/10 mg d.wt. (June 1982). On monthly basis wide fluctuations were not observed. The peaks in June 1982 and May 1983 were mainly constituted by *Cocconeis placentula*.

Variations in the population density were non-significant. Similar results were also observed on other natural substrates[5]. The evaluated F value was less than the critical F value (3.26 and 3.27) at 5% level of significance with 2 and 33 degrees of freedom.

The community coefficient values of periphyton on *Phragmites* varied from 22.77% in August 1982 to 31.81% in November 1982 ($\bar{x}$: 26.41; S.D. + 2.71). The similarity between the periphyton colonising *Phragmites* and the phytoplankton of these lakes is a clear indication of their interchangeable nature. Kashmir lakes support a luxuriant macrophytic growth. The periphytic forms are released into the lake waters from the luxuriant macrophytic vegetation due to water currents and anthropogenic activities. It is highly probable that these forms occur in the plankton 'accidentally' after they are washed off or get detached from their substrates. Pieczynska[18] also reported high exchangeability between plankton and periphyton as the latter are loosely associated with the substrate.

Lake to lake variations of periphyton on this substrate did not depict any significant variations. This may be attributed to almost similar physico-chemical characteristics of the lake waters. Variations in some parameters like conductivity, total alkalinity, total phosphorus and calcium content of these lakes result in the variability of species composition and population density.

Acknowledgements

Thanks are due to the Principal, S.P. College, Srinagar and the Director, CORD, University of Kashmir, for providing laboratory facilities. This study was made possible by a Teacher Fellowship to SGS by the UGC.

References

1. SINGH, C. S — Studies on bottom-living diatoms of a freshwater fish pond, *J Bombay Nat. Hist. Soc.*, 1970, **67**, 443–452.
2. PHILIPOSE, M. T., NANDY, A. C., CHAKRABORTY, D. P AND RAMAKRISHNA, K. V — Studies on the distribution in time and space of the periphyton of a perennial pond at Cuttack, India, *Bull. Cent. Inland Fish. Res. Inst.*, 1976, **21**, 43.
3. SARWAR, S. G. — Species composition and seasonal variations of Periphyton on *Ceratophyllum demersusm* Linn. in Waskur lake, Kashmir, *Geobios New Rep.*, 1987, **6**, 114–118.
4. SARWAR, S. G. AND ZUTSHI, D. P. — Primary productivity of periphyton, *Geobios*, 1987, **14**, 127–129.
5. SARWAR, S. G. AND ZUTSHI, D. P. — Studies on periphyton population of Himalayan lakes. 1. Species composition and community structure on natural and artificial substrates, *Proc. Indian Natn. Sci. Acad.*, 1987, **53**, 239–243.
6. MACKERETH, F. J. H. — *Water analysis for limnologists*, 1963, Vol 21, pp. 1–70. Freshwater Biol. Assoc.
7. *Standard methods for the examination of water, sewage and industrial wastes*, APHA, New York, 1971.
8. GOLTERMAN, H. L., CLYMO, R. S. AND OHNSTAD, N. A. M. — *Methods for physical and chemical analysis of freshwaters*, IBP Handbook No. 8, Blackwell, 1978.
9. GOUGH, S B. AND WOELKERLING, W. J. — On the removal and quantification of algal aufwuchs from macrophyte hosts, *Hydrobiologia*, 1976, **48**, 203–207.
10. TUCKER, A. — The relation of phytoplankton periodicity to the nature of physico-chemical environment with special reference to phosphorus, *Am Midl Nat.*, 1957, **57**, 300–370.
11. TAYLOR, W. W. — The planktonic crustaceans of Moncoe Lake; Monroe Country, W.Va., *Proc. West Virginia Acad. Sci.*, 1974, **46**, 223–229.
12. PATRICK, R. — The structure of diatom communities under varying ecological conditions, *Ann. N.Y. Acad. Sci.*, 1963, **108**, 359–365.
13. PATRICK, R. — The structure of diatom communities in similar ecological conditions, *Am. Nat.*, 1968, **102**, 173–183.
14. CAIRNS, J. JR., KAESLAER, R. L. AND PATRICK, R. — Occurrence and distribution of diatoms and other algae in the Upper Potomac River, *Notulae Natur*, 1970, **436**, 1–12.
15. CAIRNS, J. JR., LANZA, G. R. AND PARKER, B. C. — Pollution related structural and functional changes in aquatic communities with emphasis on freshwater algae and protozoa, *Proc. Acad. Nat. Sci. Phil.*, 1972, **124**, 79–127.
16. JORGENSEN, C. H. — Diatom periodicity and silicon assimilation, *Densk Bot. Arkiv.*, 1957, **18**, 1–54.
17. VASS, K. K., BHANOT, K. K. AND GHOSH, A. N. — Periphyton production in 2 ponds of brackish water farm at Kakdwip, West Bengal, India, *J. Inland Fish. Soc. India*, 1978, **10**, 32–38.
18. PIECZYNSKA, E. — Investigations on colonization of new substrates by nematodes (Nematoda) and some other periphyton organisms, *Ekol. Pol.*, 1964, **12**, 185–234.