Journal of Research & Development , Vol. 6 (2006) ISSN 0972-5407

Periphytic Algal Community in Relation to the Physico-Chemical Features of Seven Water bodies of Ladakh Region, J&K

Haroon Ul Rashid and Ashok K. Pandit
Aquatic Ecology Laboratory, P.G. Department of Environmental Science, The University of Kashmir, Srinagar 190006, J&K

ABSTRACT

Periphytic floral communities of seven waterbodies of Ladakh were studied in relation to the physico-chemical properties of the water during September, 2005. The physico-chemical characteristics of water of Pangong Tso lake were much different from rest of the water bodies and so was the periphytic algal community. Diatoms were the most abundant periphyton at all the study sites. The Sorensen Similarity Coefficient calculated was maximum (75.86%) for the waterbodies with similar physico-chemical characteristics of water.

Keywords: Periphyton, diatoms, water chemistry, Ladakh

INTRODUCTION

Ladakh, a land like no other, is bound by two of the world's mightiest mountain ranges, the Greater Himalaya and the Karakoram. It is often called as the "Roof of the World". The high altitude cold desert of Ladakh, which is geologically a young land, formed a million years ago, is mostly formed of physically weathered rocks and granite dust. All the waterbodies of Ladakh including the mighty River Indus and its tributaries are fed by the snowmelt water of glaciers. Ladakh being in the rain shadow zone of the Greater Himalaya experiences scanty rains.

Ladakh region, having a difficult terrain and being inaccessible for the most of the year, has received little attention of ecologists and limnologists, even though the region is endowed with diverse types of waterbodies like lakes, wetlands, hot springs, ponds and rivers. The limnological work done in this part of the world is scanty with only a few reports available

(Hutchinson, 1933; 1936; 1937; Mir and Suri, 1975; Baudo *et al.*, 1998; Gopal *et al.*, 2002). The present investigation is related to the periphytic algal composition and water chemistry of seven water bodies of Ladakh. Although the periphyton have been studied for a long time on a worldwide scale, but still only a few publications have appeared related to periphyton of the Kashmir valley (Pandit, 1983; Sarwar and Zutshi, 1987; Wanganeo and Wanganeo, 1991; Pandit and Pandit, 1996; Pandit, 1996; Bhat and Yousuf, 2002). Noteworthy is the extensive review article which covers almost every aspect of periphyton ecology (Pandit, 2002).

STUDY SITES

Seven water bodies were sampled including rivers (Suru, Indus and Shyok), a stream (Burma Nalla), an un-named freshwater lake (FLNP*) 8km before Pangong Tso Lake, a spring fed wetland (Shuktuk wetland) and a brackish water lake (Pangong Tso). The description of the water bodies is given below (Table 1).

Table 1. Description of the sampled water bodies of Ladakh

Site No.	Name of the Water body	Altitude (m) a.s.l	Sampling location	Bottom Substrate
I	River Suru	3450	Panikhar (Suru valley)	Boulders, gravel and sand
II	River Indus	3500	Sindhu Darshan (Leh)	Boulders and gravel
III	River Shyok	2900	Khalsar (Nubra valley)	Boulders and gravel
IV	Burma Nalla	--	Tangtse	Boulders
V	FLNP*	4350	8 km before Pangong Tso	Sharp edged stones and mud
VI	Shuktuk wetland	2750	Diskit (Nubra valley)	Muddy
VII	Pangong Tso Lake	4290	Westernmost end of the lake (Indo - China Border)	Gravel, sand and mud

FLNP* = Freshwater Lake Near Pangong Tso

MATERIAL AND METHODS

The sampling in different waterbodies was carried out from 16th to 27th of September, 2005. The water samples were collected in one liter polyethylene bottles by dipping them below the water surface. Temperature, pH and conductivity was recorded at the site and other chemical parameters were analyzed according to Mackereth (1963).

Golterman and Clymo (1969) and APHA (1998).

The periphytic samples were collected by scrapping the substrate (stones primarily) by a scalpel and washing the scrapped material into a tray and finally the washed material was transferred to a container (Biggs and Kilroy, 2000) and preserved in 4% formalin (APHA, 1998). The standard taxonomic works of Edmondson (1959) and Cox (1996) were used to facilitate the identification of periphytic samples. In order to check the species similarity between various waterbodies the Sorensen Similarity Coefficient (Sorensen, 1948) was calculated.

RESULTS AND DISCUSSION

The physico-chemical characteristics of water of different waterbodies showed remarkable differences (Table 2). All the major ions were found in very high concentrations in Pangong Tso lake. The reason for high levels of nutrients in Pangong Tso is that it is a closed drainage type lake with no outlet channels. The water evaporates and the dissolved nutrients get accumulated, making the lake water salty. The accumulation of the nutrients year after year will result in changing the water chemistry of the lake. The higher values of nutrients recorded for Pangong Tso are supported by the findings of Gopal *et al.* (2002), who worked on the limnological characteristics of the water bodies of SE Ladakh (Rupshu).

Amongst the rivers, Indus was seen to be nutrient enriched as compared to the other two rivers (Suru and Shyok). The higher concentration of nutrients in River Indus may be related to the rock types of its catchment area and also to the accumulation of nutrients as the river drains a much larger catchment area than other two rivers, and hence enrichment. Burma Nalla, FLNP and Shuktuk wetland recorded higher levels of various nutrients than the three main rivers which can be related to the geology of the area and also to the higher residence time of water in these water bodies especially the latter two which results in the accumulation of various nutrients.

The various periphytic taxa found in the present study are given in Table 3. The study revealed that there was a considerable difference in the periphytic algal species composition of the waterbodies (Pangong Tso and otherwater bodies) that differed in physico-chemical parameters of water. Also the water bodies (River Suru and River Shyok) having similar physico-chemical properties had similar periphytic algal composition. This is supported by the findings of Lindstrom *et al.* (2004) and Eilers (2005) who reported a prominent spatial variation in species composition and diversity, which showed a close correlation with water temperature and nutrient concentration.

 ISSN 0972-5407

Table 2. Physico-chemical characteristics of water of various water bodies of Ladakh

S. No.	Parameter	River Suru (I)	River Indus (II)	River Shyok (III)	Burma Nalla (IV)	FLNP (V)	Shuktuk Wetland (VI)	Pangong Tso Lake (VII)
01	Water Temperature (°C)	11.0	16.0	12.5	14.0	20.5	17.0	22.0
02	pH	8.25	8.60	8.94	8.62	8.70	8.43	9.42
03	Conductivity (μScm^{-1})	94	172	73	218	230	216	9977
04	Total hardness (mgL^{-1})	60	92	58	128	124	148	2060
05	Bicarbonate alkalinity (mgL^{-1})	70	90	40	122	88	110	1280
06	Carbonate alkalinity (mgL^{-1})	0.0	7.0	5.0	9.2	6.0	3.4	540.0
07	Ca^{++} (mgL^{-1})	17.84	28.24	18.48	35.28	40.32	38.64	697.20
08	Mg^{++} (mgL^{-1})	3.75	5.20	2.90	9.73	5.64	12.50	77.12
09	Chloride (mgL^{-1})	6.3	17.1	6.5	15.0	14.7	19.3	513
10	Na^{+} (mgL^{-1})	2.4	13.9	1.4	11.2	15.5	14.8	1600
11	K^{+} (mgL^{-1})	1.0	2.7	0.6	4.7	6.0	6.2	296
12	NO_3^{-2} (μgL^{-1})	350	355	295	290	510	108	--
13	NO_2 (μgL^{-1})	Tr	Tr	Tr	Tr	Tr	Tr	--
14	NH_4^{+} (μgL^{-1})	133	147	140	145	168	140	185
15	Available Phosphorus (μgL^{-1})	89	46	15	23	24	30	83
16	Iron (μgL^{-1})	887	894	300	455	105	100	106

Tr = Traces

Compared to other lotic water bodies studied, Burma Nalla had a much denser periphytic algal growth. The low discharge seems to boost the periphytic growth in Burma Nalla. The statement is supported by the findings of Reisen (1976) and Albay and Aykulu (2002). Further, the higher discharges in the major rivers may have limited the growth of periphyton because of higher shear stress (Biggs, 1996; Nikora *et al*., 1997).

All the water bodies studied seemed to differ in their periphytic algal community structure from each other. Every waterbody differed from the other in physiographic features like altitude and stream order and also in nutrient concentration and temperature. Although Pangong Tso had extremely high concentrations of various nutrients, still the least numbers (8) of periphytic algal species were recorded from this water body. Likewise only 12 algal species were recorded from FLNP. The green algae, *Ulothrix* sp. and *Zygnema* sp. were seen to occur in abundance in low conductivity waters of Suru and Shyok rivers while as *Cladophora* sp. was found to grow better in high conductivity waters of Burma Nalla, River Indus and Shuktuk wetland. Similar results were observed by Biggs and Price (1987). Kim and Richardson (2000) held that the concentrations of various chemical elements of a water body depict its trophic state and the primary production in oligotrophic water bodies may be inhibited by low concentration of nitrogen and phosphorus. However, the present investigation revealed that nitrogen and phosphorus are not the only limiting factors for the periphytic algal growth as the shear stress of water and physiography are equally important.

Overall 54 algal taxa were recorded from all the seven water bodies (Table 3) and the highest diversity was observed in Shuktuk wetland with 25 periphytic algal taxa, followed by River Indus (21). Pangong Tso lake recorded the least number (8) of the periphytic algae including one unidentified filamentous algal taxon and one unidentified diatom species. Only one species of Cyanophyceae was recorded in the present study compared to 9 species of Chlorophyceae and 44 species of Bacillariophyceae.

As the sampling for the present study was done in September, 2005, the diatoms were seen to be the dominant algae in all the water bodies (Table 3). The observations are supported by the results of Albay and Aykulu (2002) who, in their study, found the diatom taxa accounting a record high of 92.3% of the periphytic community in September. Also Ali *et al*. (2003), while working on the biodiversity of River Indus in Pakistan, found the diatoms to be the second most dominant group as planktons after Chlorophyceae.

Table 3. Distribution and occurrence pattern of periphytic algae in various water bodies of Ladakh

S. No.	Periphyton taxa	River Suru	River Indus	River Shyok	Burma Nalla	FLNP	Shuktuk Wetland	Pangong Tso Lake
Cyanophyceae								
01	*Oscillatoris sp.*		++				++	
	Total Cyanophyceae	0	1	0	0	0	1	0
Chlorophyceae								
01	*Cladophora* sp.		++		+++		+++	
02	*Closterium* sp.	+	+	+				
03	*Cosmarium monomazum*		+				++	
04	*Cosmarium* sp.		+	++				
05	*Schizogonium* sp.	+						
06	*Spirogyra* sp.	++	+				++	
07	*Ulothrix* sp.	+++	+	++				
08	*Zygnema* sp.	++	+++					+
09	Unidentified filament							+++
	Total Chlorophyceae	5	6	4	1	0	4	1
Bacillariophyceae								
01	*Achnanthedium lanceolatum*						+	
02	*Amphipleura* sp.						+	
03	*Amphora* sp.	+		+			++	
04	*Calonies* sp.		++					+
05	*Cavinula* sp.						++	
06	*Cocconeis* sp.					+		
07	*Cymatopleura elliptica*					+	++	
08	*C. solea*					+	+	
09	*Cymatopleura* sp.				+			
10	*Cymbella affinis*			+	+++			
11	*C. amphicephala*		+					
12	*C. aspera*	+++	++		+++			
13	*C. cistula*	++		++	++	+		
14	*C. gaeumannii*		+	++				
15	*C. lanceolata*	+++	+++	+++		++	+++	
16	*Diatoma elongatum*	++		++	+++	+	+++	
17	*D. moniliformis*							+
18	*D. tenuis*							+
19	*D. vulgaris*		+		++	+		
20	*Diatomella* sp.						+	

21	*Frustulia* sp.		++		+++	++	++	
22	*Gomphonema* sp.	++		++				
23	*G. truncatum*							++
24	*Gyrosigma acuminatum*						++	
25	*Gyrosigma* sp.					+		
26	*Hanaea arcus*		+					
27	*Martyana* sp.				+++			
28	*Navicula cryptocephala*		+					
29	*N. radiosa*						++	
30	*N. schoenfeldii*				+			
31	*Navicula spp.*	+++	++	++	+++	+	+++	
32	*Neidium binodis*	++		++			+	
33	*Nitzschia sigmoidea*					+	++	
34	*Nitzschia* sp.					+		
35	*Pinnularia major*						+++	
36	*P. nobilis*						++	
37	*Pinnularia* sp.		++	+		++		++
38	*P. viridis*		+					
39	*Sellaphora* sp.		+					
40	*Stauroneis phoenicenteron*						+	
41	*Synedra acus*						+	
42	*S. ulna*	++	++	++	+++		+++	+++
43	*Tabellaria* sp.				+++			
44	*Unidentified Diatom species*							+++
	Total Bacillariophyceae	9	14	11	13	12	20	7
	Total algal species	14	21	15	14	12	25	8

+ = rare ++ = moderate abundance +++ = dominant

The Similarity Coefficient revealed the maximum similarity (75.86%) of the periphytic algal species between River Suru and River Shyok (Table 4). The least similarity (6.06%) was calculated for Shuktuk wetland and Pangong Tso lake. The physico-chemical characteristics of Suru and Shyok rivers were quite similar but unlike Pangong Tso and Shuktuk wetland for that matter, and hence it can be inferred that the species composition of the periphytic algae is controlled by water chemistry of a water body

Table 4. Calculated values (%) of Sorensen Similarity Coefficient for various waterbodies

	River Suru	River Indus	River Shyok	Burma Nalla	FLNP	Shuktuk wetland	Pangong Tso Lake
River Suru	100.00						
River Indus	40.00	100.00					
River Shyok	75.86	38.88	100.00				
Burma Nalla	35.71	40.00	34.48	100.00			
FLNP	30.76	30.30	37.03	38.46	100.00		
Shuktuk wetland	41.02	34.78	35.00	25.64	37.83	100.00	
Pangong Tso Lake	9.09	20.68	17.39	9.09	10.00	6.06	100.00

ACKNOWLEDGEMENTS

The authors like to thank Prof. A. R. Yousuf, Head, Department of Environmental Science for providing the necessary laboratory facilities. The first author is in particular thankful to Prof. Yousuf for permitting the author to go for the collection trip to Ladakh. The authors also thank the M.Sc. 4th Semester students (2005) of Environmental Science for their help during the collection trip.

REFERENCES

Albay, M. and Aykulu, G. 2002. Invertebrate grazer-epiphytic algae interactions on submerged macrophytes in a mesotrophic Turkish lake. *E.U. Jour. Fish. Aquat. Sci.*, **19** (12): 247-258

Ali, M. Salam, A., Jamshaid, S. and Zahra, T. 2003. Studies on biodiversity in relation to seasonal variations in water of River Indus at Ghazi Ghatt, Punjab, Pakistan. *Pakistan Journal of Biological Sciences*, **6** (21): 1840-1844

A. P. H. A. 1998. *Standard Methods for Examination of Water and Wastewater*. 20th Ed. American Public Health Association, Washington, D.C.

Baudo, R., Tartari, G. and Munawar, M. (eds). 1998. *Top of the World Environmental Research: Mount Everest Himalayan Ecosystem*. Backhuys Publishers, Leiden

Bhat, F. A. and Yousuf, A. R. 2002. Ecology of periphytic community of seven springs of Kashmir. *J. Res. Dev.*, **2**: 47-59

Biggs, B. J. F. 1996. Hydraulic habitat of plants in streams. *Regulated Rivers: Research and Management*, **12:** 131-144

Biggs, B. J. F. and Kilroy, C. 2000. *Stream Periphyton Monitoring Manual*. The New Zealand Ministry for the Environment, NIWA, Christchurch.

Biggs, B. J. F. and Price, G. M. 1987. A survey of filamentous algal proliferations in New Zealand rivers. *New Zealand Journal of Marine and Freshwater Research*, **21:** 175-191

Cox, E. J. 1996. *Identification of Fresheater Diatoms from Live Material*. Chapman and Hall, London, Weinheim, N.Y., Tokyo, Melbourne, Madras

Edmondson, W. T. 1959. *Freshwater Biology*, John Wiley, New York

Eilers, J. M. 2005. *Periphyton in Selected Sites of the Klamath River, California*, MaxDepth Aquatics Inc., Bend, Oregon

Golterman, H. L. and Clymo, R. S. 1969. *Methods of Chemical Analysis for Freshwaters*. IBP Handbook No. 8, Blackwell Scientific Publications, Oxford

Gopal, B., Chauhan, M. and Zutshi, D. P. 2002. High altitude lakes of Ladakh: changes since the Yale North India expedition. *Verh. Internat. Verein. Limnol.*, **28:** 519- 523

Hutchinson, G. E. 1933. Limnological studies at high altitudes in Ladakh. *Nature*, **132:** 136

Hutchinson, G. E. 1936. *The Clear Mirror. A Pattern of Life in Goa and in Indian Tibet*. Cambridge

Hutchinson, G. E. 1937. Limnological studies in Indian Tibet. *Int. Rev. Gesamten Hydrobiol.*, **35**: 134 - 177

Kim, M. A. and Richardson, J. S. 2000. Effects of light and nutrients on grazer periphyton interactions. p. 497-501. In: *Proceedings of a Conference on the Biology and Management of Species and Habitats at Risk*, Vol. II (L.M. Darling, ed.), Ministry of Environment, Lands and Parks, Victoria, B.C., and University College of the Cariboo, Kamloops, B.C.

Lindstrom, E. A., Johansen, S. W. and Saloranta, T. 2004. Periphyton in running waters long term studies of natural variation. *Hydrobiologia*, **521 (1-3):** 68-86

Mackereth, F. J. H. 1963. *Some Methods of Water Analysis for Limnologists*. Freshwater Biol. Assoc. Sci. Publ. No. 21

Mir, A. M. and Suri, B. L. 1975. Phytoplankton of Ladakh. *Geobios*, **2 (6):** 199-200

Nikora, V. I., Goring, D. G. and Biggs, B. J. F. 1997. On stream periphyton turbulence interactions. *New Zealand Journal of Marine and Freshwater Research*, **13:** 435- 448

Pandit, A. K. 2002. Current research trends in limnological studies on periphyton. *J. Res. Dev.*, **2:** 149- 209

Pandit, A. K. 1996. Trophic structure of benthic community in some typical wetlands of Kashmir Himalaya. p. 369 400. In: *Assessment of Water Pollution* (S.R. Misra, ed.), APH Publishing Corporation, New Delhi

Pandit, A. K. and Pandit, S. N. 1996. Ecological studies of periphyton of two lakes of Kashmir Himalaya. p. 175-199. In: *Assessment of Water Pollution* (S.R. Misra, ed.), APH Publishing Corporation, New Delhi

Pandit, S. N 1983. *Ecological studies of periphyton in two lake ecosystems of Kashmir*. M. Phil. Dissertation, University of Kashmir, Srinagar

Reisen, W. K. 1976. The ecology of Honey Creek: temporal patterns of the travertine periphyton and selected physico-chemical parameters, and *Myriophyllum* community productivity. *Proc. Okla. Acad. Sci.*, **56:** 69-74

Sarwar, S. G and Zutshi, D. P. 1987. Studies on periphyton population of Himalayan lakes. I. Species composition and community structure on natural and artificial substrates. *Proc. Indian Natn. Sci. Acad. B.* **55 (3):** 173-176

Sorensen, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content and its application to analyses of the vegetation on Danish commons. *Kong. Danish Vidensk. Selsk. Biol. Skr. (Copenhagen)*, **5:** 1-34

Wanganeo, A. and Wanganeo, R. 1991. Algal population of Kashmir Himalaya. *Arch. Hydrobiol.*, **121** (2): 219- 223