ECOLOGIA BALKANICA

2013, Vol. 5, Issue 1 June 2013 pp. 9-19

Ecological Study of Periphytic Algal Community of Doodh Ganga and Khansha-Mansha Streams of Yusmarg Forests: A Health Resort of Kashmir Valley, India.

Rafia Rashid, Rouf Ahmad Bhat*, Ashok K. Pandit, Samiullah Bhat

Department of Environmental Science/Centre of Research for Development, University of Kashmir, Srinagar-190 006, INDIA.
* Corresponding author: rufi.bhat@gmail.com

Abstract. The present study on Doodh Ganga and Khansha-Mansha streams of Yusmarg forests deals with the general ecological studies on periphytic algal community in terms of species composition and density. During the present investigation the periphytic algal community of Doodh Ganga and Khansha-Mansha streams were represented by 30 taxa which belonged to 4 major classes namely Bacillariophyceae (14), Chlorophyceae (11), Cyanophyceae (4) and Euglenophyceae (1). The most common periphytic species encountered across all the sites included *Closterium* sp., *Zygnema* sp., *Amphora* sp., *Cymbella* sp., *Epithemia* sp., *Fragilaria* sp., *Navicula* sp., *Synedra* sp., *Tabellaria* sp., *Lyngbya* sp. and *Phormidium* sp. Among the two streams, Doodh Ganga showed large number of taxa (45) and Khansha-Mansha was having 37 taxa of periphyton. Bacillariophyceae was the dominant group both in diversity and density and included 14 taxa contributing 57% of total periphytic algal population. Cyanophyceae forming the second dominant class was represented by 4 genera comprising 22% of the total periphytic algae .Chlorophyceae ranked third in its dominance pattern with 11 genera forming 20% of all the periphytic algae. Euglenophyceae was represented by only one species of *Euglena* sp. forming 1% of all the periphytic algae and found only at site2 (Doodh Ganga downstream).Amongst the study sites the highest (5.69) value of Shannon Weiner Index was found at Doodh Ganga upstream while as lowest (4.38) at Khansha-Mansha downstream. The primary conclusion is that the streams, having crystal clear water, and are free from pollution as Chlorophyceae are better represented in both the streams. Further, as a result of less anthropogenic pressures the quality of water is fairly good.

Key words: Periphyton, Doodh Ganga, Khansha-Mansha, Bacillariophyceae, Chlorophyceae, Cyanophyceae, Yusmarg.

Introduction

Periphyton comprises the organisms living on the substrate. Its assemblages show variations in their nutritional quality. Evidences have suggested that the importance of periphyton in stream food webs is a function of quality than quantity (CROSS *et al*., 2003). The periphyton community are found to deplete nutrients from waterways, assuming no additional inputs, and communities vary compositionally with nutrient concentrations (MARINELARENA & GIORGI, 2001).And their community structure, species composition, and succession respond to environmental conditions and thus can be used to classify waterways merged substrate (DENECOLA *et al.,* 2004; WARGO & HOLT, 2004). These

include both the attached forms and the organisms associated therewith. Periphyton play a significant role in the functioning of aquatic ecosystem, producing significant standing crops and hence contribute much to the productivity of fresh water ecosystems (KAUL *et al*., 1980; PANDIT, 1980, 1984; PANDIT *et al*., 1985; SARWAR, 1999). Besides being a major contributor of carbon (energy) fixation, the periphytic algae form a major source of food for fish and waterfowl (PETERS *et al*., 1968; DENNY *et al*., 1978) and are the life of environment of invertebrates and also the commercial fish (PANDIT *et al*., 1985). The periphyton is useful as biological indicators of pollution as they are mostly sessile and hence cannot avoid contact with the waste effluents. Ecological variables such as nutrient supply, light availability, physical disturbance, and grazing are found to drive or limit algal production in streams and have been studied extensively, both through correlative and experimental approach (WEHR & SHEATH, 2003).In view of the significant role which periphyton play in aquatic ecosystems, the present study was undertaken to assess the status of periphytic algal community in the streams of Yusmarg forests in terms of the species composition and difference in diversity and population density of periphytic flora.

Material and Methods

Study area and site description. Yusmarg is developing Tourist Health resort approximately 47 km from the southwest of Srinagar and lies in the Budgam district of valley of Kashmir, India. It lies between the geographical coordinates of 33°49'42"N Latitudes and 74°39'5"E longitudes and at an elevation of 2712 m a. s. l. Situated amidst Sang-i-Safed valley drained by mighty Doodh Ganga river, it is reputed for having some unique spring flowers and highest mountain peaks in PirPanjal range like Tatakoti 4725 m (a.s.l), Romesh Thong 5000 m (a.s.l) and Sunset Peak 4746 m (a.s.l). It has the potential to be the gateway of some potentially valuable tourist destinations in its South, West and East including Dodpathri, Nilnag, Bargah and Tosaimaidan. In order to assess the present status of periphytic algal community in two different streams of Yusmarg forests namely Doodh Ganga and Khansha-Mansha, four sites viz., site1 (Doodh Ganga upstream), site2 (Doodh Ganga downstream), site3 (Khansha-Mansha upstream) and site4 (Khansha-Manshsha downstream) were selected.

Site 1 (Doodh Ganga upstream). It is located between the geographical co-ordinates of 33° 50' 34.4" N latitude and 74° 39' 12.4" E longitude and at an altitude 2304 m (a.s.l). This site has a large flow of water which form white foam. The water is clear and the bottom consisting boulders and large cobbles with diameter of greater than 0.25 m and 0.256-0.128 m respectively.

Site 2 (Doodh Ganga downstream). This site is located between geographical co-ordinates of 33° 50' 41.2" N latitude and 74° 39' 24.7" E longitude and at an altitude 2264m (a.s.l). It has large discharge of water and bottom is covered wholly and solely with cobbles and pebbles.

Site 3 (Khansha-Mansha upstream). It is located between geographical co-ordinates of 33° 49' 38.9" N latitude and 74° 39' 41.7" E longitude and at an altitude 2414m (a.s.l), dominated by cobbles and pebbles.

Site 4 (Khansha-Manshsha downstream). This site is located downstream of Khansha-Mansha near the entrance of the Sadarmauj reservoir and lies between the geographical coordinates of 33° 49' 39.7" N latitude and 74° 39' 57.2" E longitude and at an altitude 2364m (a.s.l). Bottom is mainly composed of sand, cobbles and small pebbles. The study area and sites are depicted in Fig. 1.

Sample collection, laboratory analysis and methods. The sampling was carried on monthly based from May to December 2010 at four selected sites. The samples were collected by scraping 5cm^2 surface areas of stones and boulders using blade and brushes. The samples were washed into a tray and then transferred into a vial of suitable volume and preserved in 4% formalin and stored in small vials having capacity of 50ml. The process of identification was carried out under the microscope with the standard works of

(PRESCOTT, 1939; 1951; COX, 1996; EDMONDSON, 1992; A.P.H.A., 1998 and BIGGS & KILROY, 2000). Sedgwick- Rafter cell of 1 ml capacity was used for counting of the individuals.

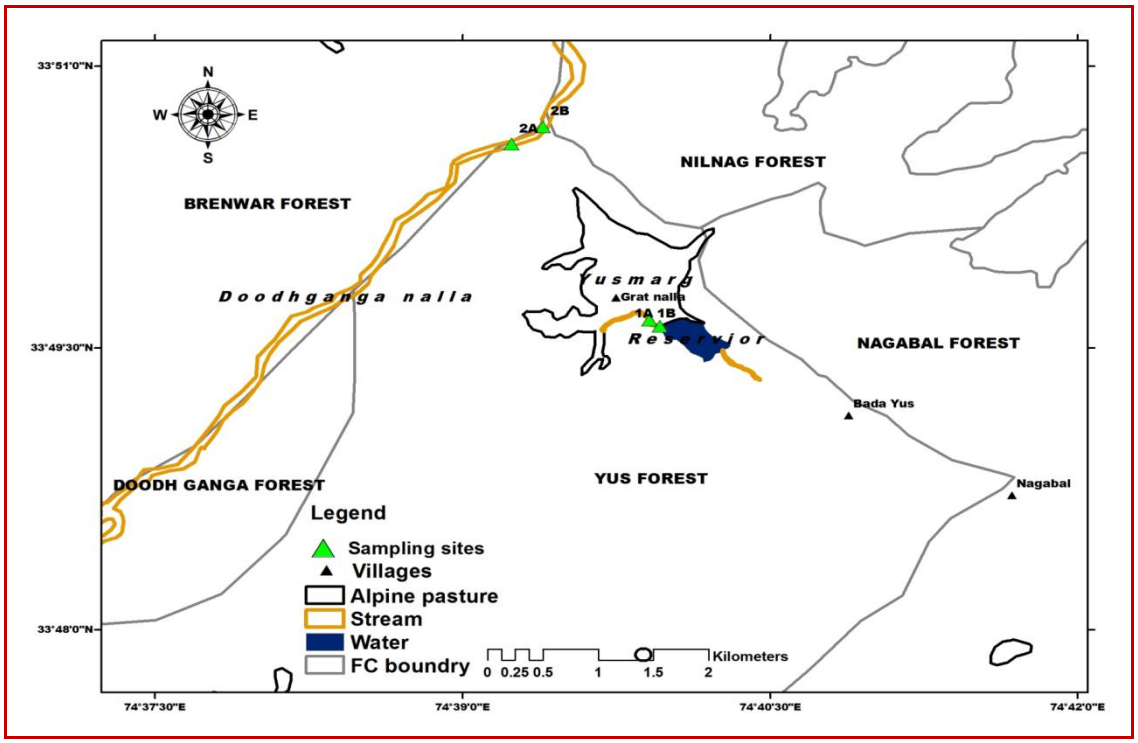

Fig.1. Map of study area and study sites (Note: 2A=Site1, 2B=Site2, 1A=Site3 and 1B=Site4).

Results

Species Composition. The periphytic algal community of Doodh Ganga and Khansha-Mansha streams were represented by 30 taxa, which belonged to 4 major classes namely Bacillariophyceae (14), Chlorophyceae (11), Cyanophyceae (4) and Euglenophyceae (1). The most common periphytic species encountered across all the sites included *Closterium* sp., *Zygnema* sp., *Amphora* sp., *Cymbella* sp., *Epithemia* sp., *Fragilaria* sp., *Navicula* sp., *Synedra* sp., *Tabellaria* sp., *Lyngbya* sp. and *Phormidium* sp. (Table 1, Fig.2). Comparative analysis revealed that at site 1 Bacillariophyceae Chlorophyceae and Cyanophyceae, contributed 13, 8, and 4 respectively. At site 2 10 taxa belonged to Bacillariophyceae 5 to Chlorophyceae, 4 to Cyanophyceae, and 1 to Euglenophyceae. At site 3 10 taxa belonged to Bacillariophyceae, 6 to Chlorophyceae and 2 to Cyanophyceae. Almost Similar contributions were noticed to algal community at site four having Bacillariophyceae (11), Chlorophyceae (5) and Cyanophyceae (3). The present study revealed that among the two streams, Doodh Ganga showed large number of taxa (45) as against Khansha-Mansha having 37 taxa of periphyton. Amongst the 30 species listed, the maximum number of species was noted at site 1, followed by site 2, site 4, and decreasing to the minimum of 18 species at site 3. Among the various periphytic classes, Bacillariophyceae dominated both qualitatively and quantitatively at each site, followed by Chlorophyceae and Cyanophyceae whereas Euglenophyceae was only found at site 2 (Doodh Ganga downstream) being represented by only one species with very low population.

Density

Bacillariophyceae. The population density of Bacillariophyceae varied from a low of 1275 ind./cm^2 at site 2 in December to a high of 4760 ind./cm^2 at site 1 in June. However, the mean density was maintained at its lowest ebb (2209.5 ind./cm^2) at site 2 against

the highest (3588.5 ind./cm^2) being obtained at site 1. Genera like *Cymbella* sp,*Navicula* sp. and *Tabellaria* sp. were the major contributors to the overall density (Table 2, Fig. 3).

Table 1: Population density (Ind/cm^2) of Periphytic flora at different sites of two streams flowing in Yusmarg forests.

S.No.	Genera	Site	Density (Ind/cm^2)					
			May	June	November	December	Mean	S.D
Family : Chlorophyceae								
1	*Closterium* sp.	1	370	400	260	240	317.5	79.32
		2	350	410	210	200	292.5	104.04
		3	260	300	210	190	240	49.67
		4	350	410	210	200	292.5	104.04
2	*Cosmarium* sp.	1	180	190	110	90	142.5	49.91
		2	350	410	210	200	292.5	104.04
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
3	*Chlorella* sp.	1	0	0	0	0	0	0
		2	330	390	190	160	267.5	110.26
		3	210	230	105	**0**	181.67	67.14
		4	330	390	190	160	267.5	110.26
4	*Cladophora* sp.	1	0	0	0	0	0	0
		2	0	0	0	0	0	0
		3	150	200	90	80	130	55.98
		4	0	0	0	0	0	0
5	*Geminela* sp	1	200	210	120	110	160	52.28
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
6	*Microspora* sp.	1	190	200	100	90	145	58.02
		2	170	200	100	90	140	53.54
		3	0	0	0	0	0	0
		4	170	200	100	90	140	53.54
7	*Oedogonium* sp.	1	200	220	140	125	171.25	45.89
		2	0	0	0	0	0	0
		3	210	250	110	90	165	77.24
		4	0	0	0	0	0	0
8	*Scenedesmus* sp.	1	180	205	120	106	152.75	47.36
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
9	*Ulothrix* sp.	1	300	370	220	210	275	75.05
		2	250	298	160	120	207	81.46
		3	0	0	0	0	0	0
		4	250	298	160	120	207	81.46
10	*Volvox sp.*	1	0	0	0	0	0	0
		2	0	0	0	0	0	0
		3	150	180	90	81	125.25	47.65
		4	0	0	0	0	0	0
11	*Zygnema* sp.	1	250	300	190	176	229	57.18
		2	200	210	110	105	156.25	56.47
		3	150	200	100	80	132.5	53.77
		4	200	210	110	105	156.25	56.47
Total			**5950**	**6881**	**3715**	**3218**	**4986.42**	**1732.04**

Family: Bacillariophyceae								
12	*Amphora* sp.	1	200	300	120	108	182	88.63
		2	220	256	110	100	171.5	78.28
		3	250	270	140	110	192.5	79.32
		4	260	300	200	180	235	55.07
13	*Bacillaria paradoxa*	1	180	250	112	100	160.5	69.28
		2	200	240	105	94	159.75	71.6
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
14	*Cymbella* sp.	1	210	250	145	130	183.75	56.18
		2	380	410	200	142	283	132.04
		3	500	600	300	250	412.5	165.2
		4	620	750	410	380	540	176.07
15	*Diatoma* sp.	1	240	270	185	160	213.75	50.22
		2	0	0	0	0	0	0
		3	220	260	190	170	210	39.16
		4	210	250	150	120	182.5	58.52
16	*Epithemia* sp.	1	180	220	110	100	152.5	57.37
		2	160	250	90	80	145	78.53
		3	230	255	130	110	181.25	71.92
		4	290	310	160	140	225	87.37
17	*Eunotia* sp.	1	280	330	200	180	247.5	69.94
		2	0	0	0	0	0	0
		3	210	240	120	0	190	62.45
		4	220	250	140	110	180	65.83
18	*Fragilaria* sp.	1	170	200	120	100	147.5	45.73
		2	230	390	167	120	226.75	117.79
		3	350	400	200	170	280	112.25
		4	310	350	200	180	260	82.86
19	*Frustulia* sp.	1	0	0	0	0	0	0
		2	0	0	0	0	0	0
		3	210	220	95	80	151.25	73.97
		4	150	170	90	70	120	47.61
20	*Gomphonema* sp.	1	680	750	500	480	602.5	133.26
		2	230	300	150	110	197.5	84.6
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
21	*Mastagloia* sp.	1	0	0	0	0	0	0
		2	110	140	80	60	97.5	35
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
22	*Navicula* sp.	1	170	190	110	102	143	43.61
		2	440	600	270	231	385.25	169.5
		3	400	500	210	190	325	150.22
		4	320	400	210	190	280	98.32
23	*Nitzchia* sp.	1	170	190	110	102	143	43.61
		2	0	0	0	0	0	0
		3	0	0	0	0	0	0
		4	180	210	85	74	137.25	67.95
24	*Synedra* sp.	1	260	300	186	166	228	62.75
		2	230	305	180	150	216.25	67.75
		3	210	250	100	80	160	82.86
		4	200	220	100	90	152.5	67.02
25	*Tabellaria* sp.	1	670	700	550	500	605	95.39
		2	420	490	210	188	327	150.81

		3	350	400	220	200	292.5	97.76
		4	340	390	250	220	300	78.74
Total			**12060**	**14326**	**7710**	**6617**	**10225.8**	**3622.34**
Family: Cyanophyceae								
26	*Calothrix* sp.	1	310	380	200	180	267.5	94.29
		2	260	300	170	120	212.5	82.21
		3	0	0	0	0	0	0
		4	350	400	210	190	287.5	103.4
27	*Lyngbya* sp.	1	600	650	480	420	537.5	105.94
		2	381	410	200	180	292.75	119.51
		3	300	350	190	170	252.5	86.55
		4	320	350	200	185	263.75	83.4
28	*Oscillatoria* sp.	1	320	370	250	230	292.5	64.48
		2	410	490	280	230	352.5	118.99
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
29	*Phormidium* sp.	1	400	450	322	300	390.66	64.5
		2	380	410	260	220	317.5	91.79
		3	400	410	300	280	347.5	67.02
		4	400	430	310	290	357.5	68.01
Total			**4831**	**5400**	**3372**	**2995**	**4172.16**	**1150.09**
Family: Euglenophyceae								
30	*Euglena* sp.	1	0	0	0	0	0	0
		2	211	310	100	96	179.25	102.17
		3	0	0	0	0	0	0
		4	0	0	0	0	0	0
Total			**211**	**310**	**100**	**96**	**179.25**	**102.17**

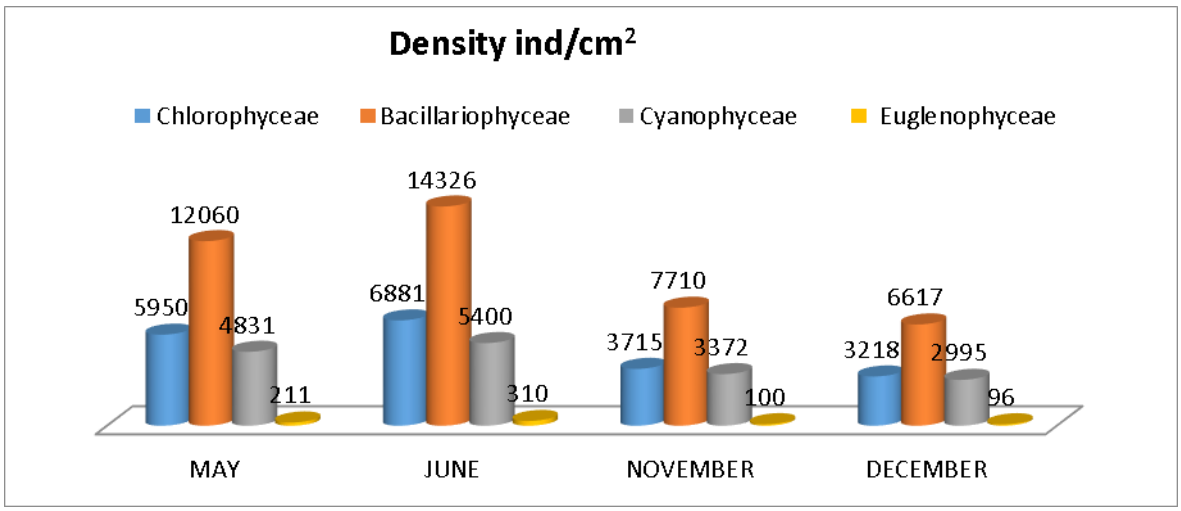

Fig 2. Spatial Variations in mean density (Ind./cm²) of periphytic flora at different sites during study period.

*Chlorophyceae.*Among the sites studied the population density of Chlorophyceae fluctuated from a minimum of 515 ind./cm² at site 2 and 4 in December to a maximum of 2095ind./cm²at site 1 in June. The highest mean population density of Chlorophyceae was noticeable at site 1 (1593 ind./cm²) and lowest (795,75 ind./cm²) was registered at site 2 and 4. The life-forms which contributed their major share in the overall

density of Chlorophyceae were *Zygnema* sp. *Closterium* sp. *Chlorella* sp. and *Ulothrix* sp. (Table 2, Fig. 3).

Cyanophyceae. The population density of Cyanophyceae reached its highest peak (1850 ind./cm²) at Site 1 in June while as the lowest (450 ind./cm²) was obtained at site 3 in December. However, on spatial basis the group depicted maximum mean population (1488.16 ind./cm²) at site 1 against its minimum (600 ind./cm²) at site 3. Taxa like *Phormidium* sp., *Lyngbya* sp. and *Oscillatoria* sp. were the most dominant species contributing the major portion to the overall density of cyanophyceae group (Table 2, Fig 3).

Euglenophyceae. Euglenophyceae was represented by lone species of *Euglena* sp., being recorded at Site 2 and attaining an overall a very low population (highest of 310 ind./cm² in June and lowest of 96 ind./cm² in December).

Relative density. Bacillariophyceae, dominating both in diversity (Table 3) as well as in density, was comprised of 14 taxa forming 57% of total periphytic algal population in the studied area (Fig. 4). Cyanophyceae formed the second dominant class representing 4 genera and making 22% of total periphytic algal population. Chlorophyceae ranked third in the order of dominance and registered 11 genera forming 20% of the periphytic algal population of the stream. Euglinophyceae was represented by lone taxa being restricted to only Doodh Ganga downstream. The diversity of different algal classes did not vary much among the sites yet, the density showed remarkable variations ranged from a maximum (6669.66 ind./cm²) at site 1 to a minimum (3969.42 ind./cm²) at site 3. The Shannon- Weiner index value incorporates both taxa richness and evenness of number of individuals in each taxa. Highest (5.69) value of diversity index was maintained for Doodh Ganga upstream in comparison to Khansha-Mansha downstream (4.38). In general, the index also showed that the diversity of Doodh Ganga stream is greater than the Khansha-Mansha stream.

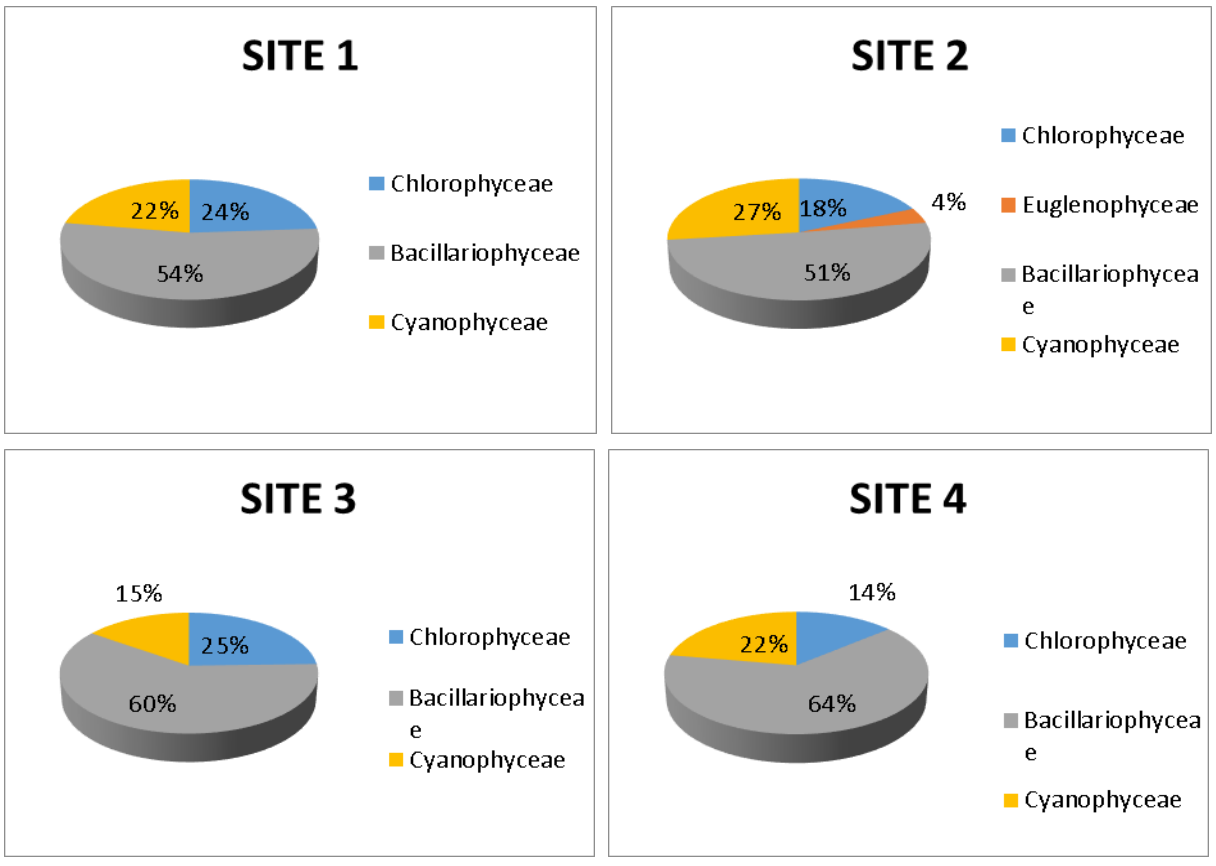

Fig. 3. Relative density of different classes of periphyton at four sites.

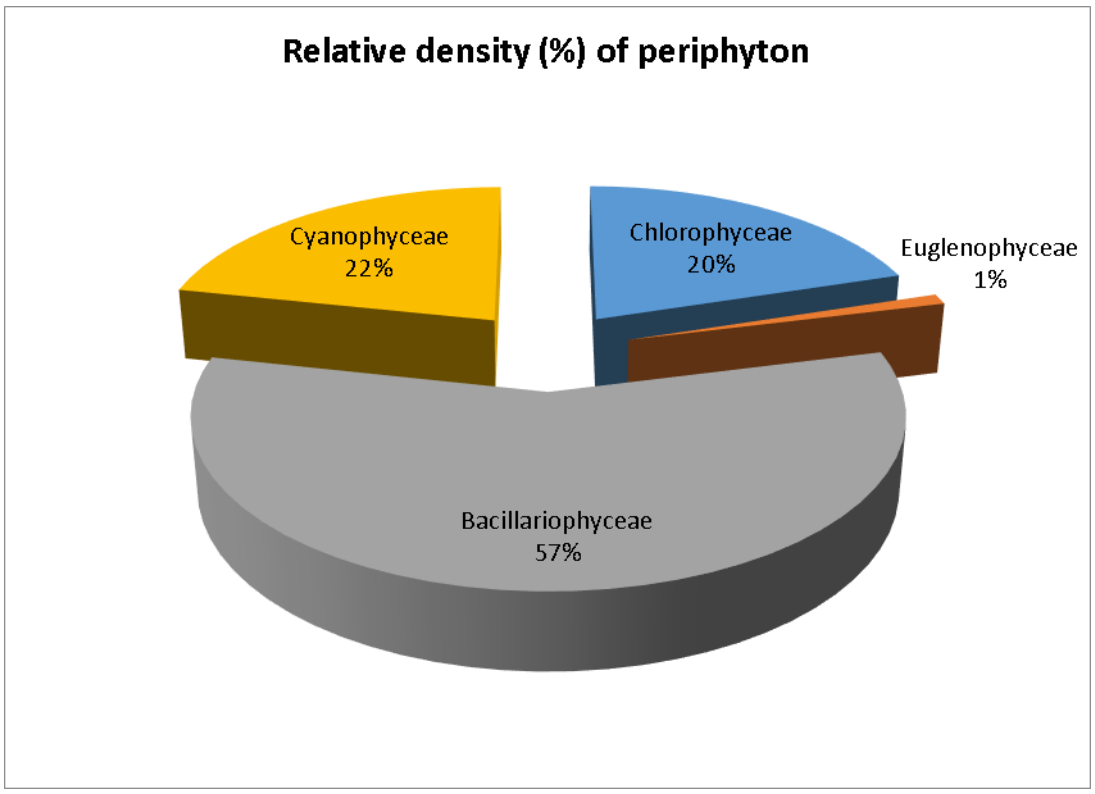

Fig 4. Overall relative density of periphyton at different sites at Yusmarg.

Table 2. Spatio-temporal variation in density (Ind./cm²) of periphytic flora at different sites of two streams flowing in Yusmarg Forests.

S.No.	Class	Site	Density (Ind./cm²)				
			May	June	November	December	Mean
1	**Chlorophyceae**	1	1870	2095	1260	1147	1593
		2	970	1118	580	515	795.75
		3	1130	1360	705	521	974.42
		4	970	1118	580	515	795.75
2	**Bacillariophyceae**	1	3940	4760	2948	2706	3588.5
		2	2620	3381	1562	1275	2209.5
		3	2930	3395	1705	1360	2395
		4	3100	3600	1995	1754	2612.25
3	**Cyanophyceae**	1	1630	1850	1252	830	1488.16
		2	1431	1610	910	750	1175.25
		3	700	760	490	450	600
		4	1070	1180	720	665	908.75
4	**Euglenophyceae**	1	0	0	0	0	0
		2	211	310	100	96	179.25
		3	0	0	0	0	0
		4	0	0	0	0	0

Table 3. Shannon-Weiner Diversity index of periphyton.

SITES	S.W Diversity index
Doodh Ganga upstream	5.69
Doodh Ganga downstream	5.17
Khansha- Mansha upstream	5.06
Khansha -Mansha downstream	4.38

Discussion

Bacillariophyceae was found the most dominant taxa in terms of density as well as diversity, being represented by 14 taxa, followed by Chlorophyceae(11), Cyanophyceae (4) Euglenophyceae (1). The quantitative increase of Cyanophyceae is attributable to the relatively higher temperature and lower values of conductivity, alkalinity and hardness (BHAT *et.al*., 2011).The growth and abundance of Chlorophyceae in the present study also reflects the oligotrophic nature of the Doodh Ganga and Khansha- Mansha streams as also reported earlier in river sindh (BHAT *et.al*., 2011; BABA *et.al*., 2011; RASHID & PANDIT, 2008). Bacillariophyceae has been reported to be dominant among periphytic flora in a number of streams studied for periphyton composition (RASHID & PANDIT, 2008; ALLAN, 1997; ALBAY & AYKULU, 2002; MOORE, 1979). Dominance of Bacillariophyceae may be attributed to the presence of good concentration of SiO_2 in water bodies which probably helps in the frustule formation (WETZEL & LINKINS, 1991) and its ability to thrive well in cold waters (RAO, 1955; SARWAR & ZUTSHI, 1988). Diatom communities have been extensively used in the assessment of past and present ecological conditions in the aquatic habitats in which they live (STOEMER & SMOL, 1999). Their indicative utility resides in that sediments and many species form characteristic assemblages under different trophic or diversely contaminated conditions (LANGE & BERTALOT, 1979; PATRICK, 1949; PATRICK, 1951). Diatoms to some extent in streams of Kashmir Himalaya have been poorly studied and a review of the literature reveals that only a fraction of this literature is purely taxonomic in nature, which hinders the potential use of diatoms for bio indication or bio monitoring. Only a few articles have focused on the diatoms from the bio indication point of view which are insufficient to cover vast and extensive array of habitats in Kashmir Himalaya.

Cymbella sp. and *Navicula* sp. dominated at all the study sites. The dominance of diatoms which are good colonizers of bottom stones seems to be favoured by low temperature and high light penetration (VASISHIT & SHARMA, 1975). In terms of abundance, Bacillariophyceae was the most dominant followed by Chlorophyceae and Cyanophyceae which is generally the trend found in the lotic system (HYNES, 1970). On monthly basis the maximum density of periphyton was obtained in the month of June at all the study sites. This may be attributed to the warm conditions and more light intensity as the growth and abundance of Chlorophyceae during warm water periods and at sites having high light intensity may be related to its excessive reproduction. KANT & KACHROO, 1980) reported that rise in temperature provides optimum conditions for the growth and reproduction of Chlorophyceae. In terms of relative density, Chlorophyceae and Cyanophyceae were better represented in both streams; the most probable reason for the greater proportions of Chlorophyceae may be attributed to the clear water in the

studied streams, which provide better light conditions for the growth of group (ALLAN, 1995). The seasonality of periphytic flora is found to be governed by many factors especially discharge, light and the release and availability of plant nutrients. In general, there was a seasonal trend in the periphytic algae with lowest periphyton density usually recorded during cold months and the highest in warmer months.

Conclusions

The periphytic flora of Doodh Ganga and Khansha - Mansha streams is diverse and comprises a variety of cosmopolitan species adapted to alkaline habitats. The streams having crystal clear water are free from pollution as indicated by modest contributions of Chlorophyceae in both the streams. The streams are experiencing less anthropogenic pressures and hence quality of water is seemingly fairly good. This study shows that the periphytic flora can vary in response to discharge and substrate sampled. The myriad of factors governing the growth and abundance of periphytic flora at a variety of scales suggests that the variance at temporal scale in species composition is more interesting and this feature deserves further investigation with greater replication and extended sampling to evolve a holistic picture of the stream ecosystem.

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Received: 11.10.2012
Accepted: 26.05.2013

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University of Plovdiv Publishing House