Monitoring phytoplankton diversity in the hill stream Chandrabhaga of Garhwal Himalaya

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Abstract

Phytoplanktonic diversity and abundance of hill stream Chandrabhaga have been monitored for the present study from October 2000 to September 2001. A total of 31 genera of phytoplankton belonging to the families Bacillariophyceae, Chlorophyceae and Cyanophyceae were identified. These comprised of diatoms (95%), green algae (2.8%), blue green algae (1.6%) and miscellaneous (0.8%). The diversity of phytoplankton was found to be maximum during winter and minimum in monsoon. The study revealed that water current, water temperature and turbidity influenced the diversity of phytoplankton. [Life Science Journal. 2007;4(1):80 – 84] (ISSN: 1097 – 8135).

Keywords: phytoplankton; algae; hill stream; Chandrabhaga; Himalaya

1 Introduction

The ultimate aim of ecology is to study the interaction of organisms with their environment and the other organisms living in it (Wilson, 1992; Krebs, 2001). Riverine ecosystems are the integral and important component of freshwater ecosystems. However, the mountain fluvial ecosystem is unique as well as distinct in all aspects. The Chandrabhaga is a typical perennial hill stream and is one of the many tributaries of upper Ganges. The entire stretch of the stream has rich riparian vegetation for providing conducive environment for the growth of aquatic organisms. Many studies in the headwater streams have shown that the freshwater contain representatives of benthic flora and fauna, washed up from the streambed. Continuous downstream movement of clear water with much dissolved and suspended matter characterize these streams. The limnological parameter of freshwater bodies is of great significance, as these play a vital role in restricting the distribution of any species within a certain range of ecosystem habitat. High mountain lakes have attracted the interest of limnologists for a long time, mainly because of their extreme climatic and physicochemical conditions. Despite the large amount of literature available on the spatial and temporal variations in phytoplankton in lakes, little information is available on their distribution in hill stream. The phytoplankton of high altitude cold water are most distinct than those of any other type of aquatic habitat and include a large percentage of species which are restricted to this particular habitat. These provide the main food item of fishes directly or indirectly and can be used as indicator of the trophic phase of water body. Phytoplankton abundance is controlled by several physicochemical factors of water. The dominant genera in algal groupings change not only spatially but seasonally as physical, chemical and biological conditions change in water body. A general pattern of seasonal succession of phytoplankton has been correlated with environmental factors of many lakes. According to Crayton and Sommerfield (1979), phytoplankton abundance and species richness appeared to be influenced by high turbidity, water velocity, fluctuating water level and age of water.

Many species of river phytoplankton reproduce prolifically in rivers and achieve biomass levels of 250 μg chlorophyll (Friedrich and Viehweg, 1984; Gliwicz *et al*, 1985; Reynolds, 1988, 1994; Reynolds *et al*, 1994). Diatoms usually dominate in the plankton of rivers and streams, particularly in winter. Pereniation of phytoplankton in rivers arises from surviving periphytic and benthic populations (Reynolds and Descy, 1996). The present investigation was aimed at determining quantitative composition of phytoplankton in the hill stream Chandrabhaga.

2 Investigated Area

The Chandrabhaga catchment is one of the micro-

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watersheds of the river Alaknanda in the Pauri Garhwal district of Uttaranchal. Chandrabhaga stream originates from the Chandrabadni area (2,278 m above m. s. l.) and make confluence with the river Alaknanda at Bagwan (500 m above m. s. l.). The study area is located between latitude 30° 13′ 15″ – 30° 18′ 20″ N and longitude 78° 36′20″ – 78° 40′18″ E.

Three sampling sites, one each in all the three zones (upper, middle and lower) of the hill stream Chandrabhaga were selected. The first sampling site (S_1) was selected at Pataun (940 m above m. s. l.). This site was a riffle zone and downstream to the source of the stream. The substrata of this site constituted mostly of cobbles and pebbles and only few big boulders were found in the area. The second site (S_2) was selected at Bhatgaon (720 m above m. s. l.) in the middle stretch of stream. This site was the pool section of the river. The substrata at this site were constituted of pebbles with sand and clay. The third sampling site (S_3) was selected at Bagwan (500 m above m. s. l.) just before the confluence with the river Chandrabhaga. This site was a riffle zone with sparsity vegetation. The general vegetation of the study area shows the dry climate of the region. The Chandrabhaga stream is the fourth order stream and has two third order streams except few first order streams having their discharge through perennial springs which is used by the local inhabitants.

3 Materials and Methods

Monthly sampling was conducted during the period of October 1999 – September 2000 from all the three sampling sites for recording physicochemical variables and phytoplankton density. The water (100 litres) was sieved through number 20 plankton net, concentrated into a 60 ml vial and preserved in 5% formaldehyde. 60 ml of samples were concentrated to 20 ml by centrifugation. A Hensen-Stempel pipette was used to take 1 ml aliquots into four Sedgewick Rafter counting chambers. Each cell was then examined under microscope for identification and counting. The phytoplankton identification was done following Welch and Ward and Whipple.

Water temperature was recorded with a centigrade (0 – 110 ℃) thermometer. The mean velocity was measured using electromagnetic current meter (Model-PVM-2A). pH was determined by pH meter on the spot and in the laboratory by control dynamics pH meter (Model-APX15/C), while turbidity was measured with the help of Metzer digital turbidity meter. The physicochemical parameters were monitored following Apha.

4 Results

4.1 Aquatic environment

Monthly variations in physicochemical attributes have been presented in Table 1. The air temperature was found to be maximum in the month of September (25.3 ± 2.30) and minimum (16.5 ± 2.2) in January. Maximum water temperature was recorded in June (27 ± 1) and minimum (14.1 ± 2.02) in the month of January. Water current remained high throughout the year but it attained the peak value (2.77 ± 1.77) during monsoon months (July-August) due to frequent flash floods.

Dissolved oxygen was found maximum during the winter months. Turbidity, free carbon dioxide, nitrates, total dissolved solids and phosphates showed a decreasing trend from October to January and then started increasing up to August. Nitrate concentration (0.07 ± 0.002) and phosphate concentration (1 ± 0.01) were recorded high in winter months. Sodium and potassium contents in the hill stream Chandrabhaga showed an irregular trend in their concentrations.

4.2 Taxonomic diversity

A total of 31 genera of phytoplankton belonging to the families Bacillariophyceae (18 genera), Chlorophyceae (8 genera) and Cyanophyceae (5 genera) were recorded during the period of investigation (Table 2). The largest and most diverse group was the Bacillariophyceae (diatoms) which contributed 95.9% of the total phytoplankton. *Achnanthes*, *Cymbella*, *Navicula*, *Amphora*, *Nitzschia* and *Fragilara* was the dominant genera among diatoms and was present throughout the year. While other diatoms like *Cocconeis*, *Diatoma*, *Gomphonema* and *Synedra* started appearing from autumn to winter and were absent in monsoon. Few genera like *Frustulia*, *Gyrosigma*, *Stauroneis* and *Tabellaria* occurred irregularly.

Green algae (Chlorophyceae) contributed 2.65% of the total phytoplankton. The important genera of green algae recorded were *Spirogyra*, *Ulothrix*, *Zygnema*, *Cladophora*, *Closterium*, *Cosmarium* and *Gonatozygon* and blue green algae (Cyanophyceae) by *Anabaema*, *Nostoc*, *Oscillatoria*, *Polycystic* and *Rivularia* were less in abundance during monsoon due to increased turbulence which consequently leads to detachment of algal filaments from the substratum. Similar observations were made by Sehgal (1992) in river Beas, Dobriyal and Singh (1988) in river Mandakini, Kala and Sharma (2001) in river Alaknanda.

Seasonal density of phytoplankton dwelling in the hill stream Chandrabhaga are presented in Table 3. In the hill stream river Chandrabhaga maximum phytoplankton density was observed in winter (1,009 units/l) when turbidity (14.6 ± 13.3 NTU) and water velocity (0.67 ± 0.53 m/s) were low. The minimum mean value of phytoplankton (75.88 units/l) was recorded during monsoon month which may be due to high turbidity (93.3 ± 35.11 NTU) and high water velocity (2.77 ± 1.77 m/s).

Winter maxima of phytoplankton have also been recorded by Chakraborty *et al* (1959) and Pahwa and Mehrotra (1966) in river Jamuna and Ganga. Kohler (1993) on river spree has indicated that in majority of rivers diatoms dominated among the algal communities.

Table 1. Physicochemical characteristics of the aquatic environment of the river Chandrabhaga during the period of October 2000 – September 2001

	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep
Air temperature (℃)	23.3 ± 2.3	20.6 ± 2.08	16.6 ± 1.15	16.5 ± 2.2	17.1 ± 1.6	20.1 ± 0.76	25 ± 1.73	30.3 ± 2.08	31.5 ± 2.12	27.6 ± 1.52	24.3 ± 1.52	25.3 ± 2.30
Water temperature (℃)	20.5 ± 0.5	18.8 ± 0.76	14.6 ± 1.15	14.1 ± 2.02	14.6 ± 2.11	17 ± 1	21.3 ± 2.08	24.6 ± 1.15	27 ± 1	24.3 ± 0.57	22.3 ± 0.57	21.6 ± 0.57
Water current (m/s)	1.3 ± 0.97	0.99 ± 0.89	0.67 ± 0.53	0.74 ± 0.38	0.71 ± 0.27	0.88 ± 0.42	1.04 ± 0.66	1.48 ± 0.82	1.99 ± 1.19	2.39 ± 1.38	2.77 ± 1.77	1.9 ± 1.4
Hydro median Depth (m)	0.71 ± 0.58	0.73 ± 0.67	0.69 ± 0.66	0.62 ± 0.7	0.54 ± 0.62	0.55 ± 0.72	0.65 ± 0.94	0.59 ± 0.85	0.79 ± 1.16	1.15 ± 1.21	1.14 ± 1.16	0.75 ± 0.59
Transparency (m)	0.42 ± 0.11	0.43 ± 0.25	0.32 ± 0.11	0.28 ± 0.12	0.28 ± 0.18	0.32 ± 0.32	0.39 ± 0.48	0.39 ± 0.5	0.34 ± 0.38	0.47 ± 0.18	0.32 ± 0.17	0.37 ± 0.16
Turbidity (NTU)	36 ± 32.18	53.3 ± 51.3	14.6 ± 13.3	18.6 ± 3.21	33.3 ± 7.57	28.3 ± 19.5	44.3 ± 14.3	30.3 ± 35.2	22.3 ± 9.29	50.6 ± 10.06	93.3 ± 35.11	58 ± 28.47
pH	7.9 ± 0.1	8 ± 0.17	8 ± 0.1	8.1 ± 0.26	8.06 ± 0.15	8.01 ± 0.1	8.13 ± 0.12	7.73 ± 0.2	8.13 ± 0.05	8.06 ± 0.28	7.87 ± 0.12	7.93 ± 0.15
Alkalinity (mg/l)	155 ± 13.2	159 ± 1	160 ± 0	156.6 ± 2.88	153.3 ± 2.88	151.6 ± 5.77	181.6 ± 7.63	202.3 ± 11.01	217.6 ± 7.5	221.6 ± 17.5	178.3 ± 16.07	165 ± 5
TDS (mg/l)	112.3 ± 15.69	126.6 ± 47.25	109.3 ± 31	121.2 ± 52.78	106 ± 29.44	144.6 ± 48.01	126.6 ± 15.27	144 ± 34.17	149.3 ± 26.85	155.6 ± 27.6	171 ± 35.67	113.3 ± 13.3
D.O. (mg/l)	12.3 ± 2.02	13.6 ± 1.65	14.5 ± 1.1	14.6 ± 1.2	13.6 ± 1.04	12.43 ± 1.2	13.13 ± 0.8	12.5 ± 1.5	11.16 ± 0.28	11.06 ± 0.92	10.93 ± 1.2	12.16 ± 1.25
Free CO_2 (mg/l)	0.2 ± 0.13	0.23 ± 0.05	0.23 ± 0.02	0.24 ± 0.04	0.4 ± 0.1	0.22 ± 0.14	0.11 ± 0.14	0.21 ± 0.18	0.16 ± 0.14	0.18 ± 0.16	0.27 ± 0.02	0.18 ± 0.05
Nitrates (mg/l)	0.05 ± 0.005	0.06 ± 0.005	0.07 ± 0.002	0.06 ± 0.02	0.05 ± 0.004	0.03 ± 0.005	0.02 ± 0.002	0.03 ± 0.006	0.06 ± 0.007	0.06 ± 0.003	0.04 ± 0.007	0.03 ± 0.005
Phosphates (mg/l)	0.07 ± 0.008	0.07 ± 0.003	0.08 ± 0.003	1 ± 0.01	0.08 ± 0.002	0.08 ± 0.002	0.11 ± 0.005	0.09 ± 0.002	0.11 ± 0.01	0.2 ± 0.01	0.17 ± 0.007	0.12 ± 0.01
Sodium (mg/l)	5.26 ± 1.05	4.36 ± 0.5	2.86 ± 0.8	1.73 ± 1.5	6.6 ± 3.9	9.3 ± 0.9	9 ± 0.51	8.06 ± 0.57	8.06 ± 0.57	7.4 ± 0	5.2 ± 0.45	3.86 ± 0.28
Potassium (mg/l)	1.33 ± 0.22	1.16 ± 1.02	1.38 ± 0.56	1.36 ± 0.75	1.71 ± 0.27	1.07 ± 0.93	1.12 ± 1	1.18 ± 0.99	0.49 ± 0.78	0.88 ± 0.77	1.24 ± 0.41	0.91 ± 0.95

5 Discussion

In the fluvial ecosystem of Chandrabhaga, several factors were known to influence the distribution of aquatic floral diversity. In the hill streams water temperature, flow and substrate composition may be considered as the major factor controlling the phytoplankton communities (Wetzel, 1983). Factors controlling phytoplankton growth includes light, temperature, water current, substrate, water chemistry and invertebrate grazing, all these factors have potential effects on periphytonic populations (Whitton, 1975; Hynes, 1971; Biggs, 1996). Phytoplanktons are sensitive to velocity and turbulence of flow in the streams, thus inhibiting the development of new plankton and suppress any existing organisms discharged from associated lentic waters. Thus agitated water of rithron in the Chandrabahaga support little plankton at S_1 and S_3 while maximum density is recorded at S_2 the pool section of the stream. Welcomme (1985) also gave similar observations.

According to Hynes water movement, turbidity, temperature and nutrients are the main environmental factors which control the abundance of plankton. Turbidity has a negative impact on the growth of plankton in the river Chandrabhaga. Similar observations have been recorded by Hynes (1971) in Volga River. Ellis states that erosive silt in the rivers acts as an opaque screen to all wavelengths of light not allowing the phytoplankton to carry out photosynthesis. Chandler (1937) and Cushing (1965) report that mechanical destruction of plankton occurs by the grinding action of water heavily laden with silt. Chankraborty *et al* (1959) reported low densities in fast flow areas and high densities in slow flow areas. Turbidity and water current are the detrimental factor which limits the plankton growth during monsoon. Increased density in winter is due to high transparency and high dissolved oxygen. Thus, there is a combined effect of all the physicochemical factors on the density of phytoplankton in river Chandrabhaga.

The freshwater must be recognized as the blood of society (Wetzel, 2000), despite the extensive discussion and evolution of human needs for water of reasonable quality, it is essential to know how aquatic ecosystem function in order to manage them successfully. Management of stream must be determined in consideration of its significance for conservation on the basis of which management priorities and objectives need to be clearly spelt out.

Table 2. Diversity and seasonal abundance of phytoplankton dwelling the river Chandrabhaga

Taxon	Winter	Summer	Monsoon	Autumn
Bacillariophyceae				
Achnanthes affinis	+ + +	+ +	+	+
A. bisoletiana	+ +	+	−	+
A. brevipes	+		−	−
A. clevei	+ +	+ +	+	−
A. exilis	+	+	+	−
A. fragilareoides	+ + +	+ +	+ +	+
A. lanceolata	+	+	−	−
A. lanceolata f. capitata	+	+	−	−
A. lanceolata var elliptica	+	+	+	−
A. lanceolata var rostrata	+	+ +	−	−
A. ovalis	+	+	−	−
Calonies bacillum	+ +	−	−	+
C. silicula	+	−	−	+
C. beccariana	+ +	−	−	−
Ceratoneis arcus	+ +	+	−	−
Cocconeis placentula	+ +	+ +	−	−
C. pediculus	+	−	−	+
Cyclotella glomerata	+	−	−	−
Cymatopleura spp	+	+	−	−
Cymbella affinis	+ + +	+	+	−
C. lacustris	+	−	−	−
C. parva	+ +	+	−	−
C. turgida	+	+	+	+
Diatoma anceps	+ + +	+ +	−	+
D. vulgare	+ +	+	−	−
Eunotia arcus	+ +	+	+	−
E. pectinalis	+	−	+	+
Frazilaria capucina	+ + +	+	+ +	−
F. intermedia	+ + +	−	+	−
F. lapponica	+ + +	−	−	−
F. pinnata	+ + +	−	+ +	−
Gomphonema gracile	+	−	+	+
G. longiceps	+ + +	−	+	+
G. subtile	+	+	+	−
Hantzschia spp	+ + +	+ +	−	−
Meridion circulare	+ +	−	−	−
Navicula bacillum	+ +	−	+	−
N. radiosa	+ + +	+	−	−
N. rostellata	+	+	−	+
Nitzschia amphibia	+ + +	+	−	−
N. capitella	+ +	−	−	−
N. denticulata	+ +	+	−	−
N. dissipata	+	+ +	−	+
N. hantzschiana	+ +	−	−	+
N. hybrida	+	+	+	−
N. linearis	+ +	+	−	−
Synedra acus	+ +	+ + +	−	−
S. rumpens	+ +	−	−	−
S. ulna	+ +	+ +	−	+
Chlorophyceae				
Cladophora glomerata	+ +	+ +	−	−
Closterium spp	+	+ +	+	+
Cosmarium spp	+ +	+ +	+	+ +
Hydrodictyon	+	+ +	+	+
Microspora	+ +	+	−	−
Protococcus	+	+	−	−
Spirogyra	+ +	+ +	+	+
Gonatozygon	+ +	+	−	−
Stegeclonium staganatila	+ +	+	+	+ +
Tetraspora	+ +	−	−	−
Ulothrix zonata	+ +	+ +	−	−
Zygnema	+ + +	−	−	−
Cyanophyceae				
Anabaena spp	−	+	+	+
Nostoc spp	+	+ +	+	−
Oscillatoria spp	+ +	+ +	−	+
Polycystis spp	+	+	−	−
Rivularia spp	−	+ +	+	−

+ + + : Abundant; + + : Common; + : Rare; − : Absent

Table 3. Seasonal density of phytoplankton at S_1, S_2 and S_3 of river Chandrabhaga recorded during October 2000 to September 2001

Sites	Phytoplankton	Oct 2000 – Sept 2001			
		Winter	Summer	Monsoon	Autumn
S_1	Bacillariophyceae	1795	1213	85	203
	Chlorophyceae	37	36	45	5
	Cyanophyceae	7	3	19	2
		613 ± 1023.75	417.33 ± 689.26	49.66 ± 33.24	70 ± 115.19
S_2	Bacillariophyceae	4830	2988	318	608
	Chlorophyceae	103	103	28	9
	Cyanophyceae	42	13	32	1
		1658.33 ± 2746.91	1034.66 ± 1692.23	126 ± 166.28	206 ± 348.16
S_3	Bacillariophyceae	2230	1761	110	309
	Chlorophyceae	33	45	30	11
	Cyanophyceae	10	6	16	3
		757.66 ± 1275.13	604 ± 1002.18	52 ± 50.71	107.66 ± 174.40
Mean ± SD		1009.66 ± 566.39	685.33 ± 316.59	75.88 ± 43.41	127.88 ± 70.21

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