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Species richness and diversity of epilithic diatom communities on different natural substrates in the coldwater river Alaknanda

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While the major Indian river systems are grossly polluted, the Himalayan rivers are at present in a pristine state (Singh *et al.* 1994). With large number of multipurpose river valley projects proposed on many of these rivers, consequent urbanization, organic load generated from human habitation and the pressures of tourism are bound to stress the riverine environment. Sufficient data base needs to be generated so that the quality of river water can be maintained and water as a precious commodity can be managed. The present study is one such attempt to understand the nature of biological communities in a pristine Himalayan river, the Alaknanda, a parent tributary of the Ganga river system. The river has glacier at its source and hence its water remains cold (<20°C).

In uplands, the diatoms account for 70-90% of phytobenthos in the river Ganga and its tributaries (Negi 1993; Nautiyal 1996). In the torrential fast-flowing rivers diatoms colonise all the available substrata and are used as the biological indicators of water quality (Eloranta 1994; Fukushima *et al.* 1994; Lobo *et al.* 1995). Various aspects of their community structure have been used for such studies, indices being just one of them. However, information on these aspects are not available for the Himalayan rivers in the Garhwal region, especially the Alaknanda. This study was conducted with a view to generate information on the species richness and diversity of epilithic diatom communities occurring on the stone and rock substrates. The similarity of epilithic communities on these substrates was also assessed.

For the collection of diatom samples at regular monthly intervals a sampling site was selected on the left bank of the river Alaknanda, at Srinagar Garhwal (altitude 500 m; latitude 30°10 –15 N, longitude 78°45 –50 E). The site located on the outskirts of the town had a cliff-like topography and on the left bank rocks were the only substratum available for colonization. Few large or small stones (boulders >256 mm) with prismatic (sharp) edges were also present. The river was deep along the banks. Epilithic diatoms were sampled at regular monthly intervals from September 1991 to May 1992. Sampling was not undertaken from June to August as the substrate becomes inaccessible due to flooding. The sampling was restricted to shallow waters (<1 foot). The epilithic samples were obtained by scraping an area of 6 cm^2 from the stone and rock surfaces. Two replicates of samples were taken from each substrate and integrated before further analysis. The volume of the sample varied from 3-5 ml. The samples were then processed in the laboratory according to Brun's method (Sarode & Kamat 1984). After preparing the permanent mounts in Canada balsam of the sampled diatoms, the slides were examined under the phase-contrast microscope at x 1500.

The following indices were computed:

1. Species richness index - d' (Margalef 1957)

$$d' = S\text{-}1/\log_e N$$

where S is the number of species and N, the number of individuals.

2. Species diversity index-H (Shannon & Weaver 1960)

$$H = - \text{ pi log pi}$$

where pi is ni/N, ni being the number of individuals of one species and N the total number of organisms.

For computing the value of ni 300-400 diatom cells were identified and counted in the successive fields and recorded as density (cells mm^{-2}). The density thus computed was verified by making Sedgewick-Rafter cell counts for total diatom density according to Trivedy & Goel (1985). The similarity index was computed according to Sorensen (1948):

$$SIMI = 2C/A+B$$

where A and B are the number of taxa found on each substrate and C is the number of taxa common to A and B. A t-test was performed to assess significance of differences in these indices on both the substrates (Sokal & Rohlf 1973).

Among the two substrates under observation for the epilithic community, the stone harboured 132 taxa as compared with 86 taxa found on the rock substrate. The diatom community on both the substrates was represented by 173 taxa. Among the various diatom genera the highest number of taxa belonged to *Navicula* on both the substrates (stones-27; rocks-24). *Nizschia* with 20 taxa ranked second to *Navicula* on stony substrate. *Gomphonema* and *Achnanthes* were found to be represented by 19 taxa each while *Cymbella* with 17 and *Synedra* with 15 taxa on the stone substrate. The diatom community on the rocks exhibited a slightly different pattern. *Cymbella* and *Nitzschia* with 17 taxa ranked 2nd while *Gomphonema* and *Synedra* were represented by 15 and 10 taxa each. Studies on the Shannon species diversity index (H) and Margalef index (d') revealed that the H ranged from 1.86-2.72 while d' from 1.89-9.3 in case of the stone substrate and 1.17-2.97 and 2.68-8.65, respectively in case of the rock substrate (Table 1). Generally the peak for both indices in these communities occurred during March or April and the fall during September/November. It was found that 90.78% of the taxa (79 out of 86) found on the rocks were present on the stones also. However, some taxa were specific to rocks only. The coefficient of similarity between these substrates was computed to be 0.696.

The study on epilithic diatom communities occurring on the stones and rock substrates revealed higher number of taxa on the former (132) as compared with the later (86). While *Navicula* was the dominant genus by virtue of highest number of species on both the substrates, *Nizschia* with 20 taxa and *Achnanthes* alongwith *Gomphonema* with 19 spp on the stone substrate, were ranked second and third, respectively. On the rock substrate *Cymbella* and *Nitzschia* were next to *Navicula* and the species of *Achnanthes* were very few. On comparing the diatom taxa found on these substrates it was found that 90.78% of the taxa found on the rocks were found on the stones also. Thus all epilithic taxa occurring on the rocks colonise the stones also. Yet some taxa were specific to stones only. The coefficient of similarity (0.696) seemed to support this observation. The species richness as indicated by the Margalef index showed relatively more fluctuations on the stony substrate (1.89-9.3) as compared with the rock substrate (2.68-8.65). Lesser fluctuations on the rock substrate indicated greater stability of the community owing to fewer environmental extremes as also stated by Squires & Saoud (1986). Since the species richness did not differ statistically, there was not much differ-

Table 1. Monthly variations in Margalef species richness and Shannon species diversity index for the epilithic diatom community on the stone and rock substrates.

Months	Species richness		Species diversity index	
	Stone	Rock	Stone	Rock
September	1.89	5.14	2.03	2.16
October	8.09	5.37	2.44	2.97
November	7.37	6.49	2.56	1.38
December	7.76	3.23	2.65	1.17
January	5.38	3.89	2.23	1.12
February	9.30	5.07	2.21	1.57
March	8.75	7.57	2.72	1.24
April	7.37	8.65	2.59	2.71
May	3.13	2.68	1.86	2.13

ence among the two substrates. However, there was significant difference ($P<0.1$) in species diversity among the two substrates. The species diversity of the epilithic community occurring on the stones was relatively higher (1.86-2.72) than for the community occurring on rocks (1.17-2.97). These values if compared with other studies suggest relatively lesser richness and diversity (H). Species diversity ranging from 1.0-3.2 (Squires & Sinnu 1984) and 0.65-3.57 (Squires & Saoud 1986) in the upstream areas of the Damour appear to be relatively higher.

On the basis of these and other studies it can be safely concluded that the epilithic diatom communities on stone and rock substrate were diverse. The stony substrate seems to harbour diverse diatom community, because its almost round surface which is submerged in water from all directions provides larger area for colonization. The rocks on the other hand provide only the upper surface as they are an integral part of the mountain morphometry constituting the left bank at the sampling station. The stones thus appear to be a preferred substrate as compared with rocks.

The species richness and diversity index also indicate pristine nature of the river Alaknanda. According to Wilhm & Dorris (1966), a relationship exists between H and pollution status of sampling sites; >3 – clean water, 1-3 moderately polluted, <1 heavily polluted. Staub *et al.* (1970) proposed a different scale of pollution in terms of species diversity index, which is a modified one and states negative correlation between H and pollution; 3-4.5 slight, 2-3 light, 1-2 moderate, 0-1 heavy pollution.

If this scale is taken into consideration then the index might indicate moderate to light pollution in the river Alaknanda. However, such scales do not seem to have wide applicability (Eloranta 1994). The environmental variables including the nature of substrate seem to play an important role in determining the species richness and diversity in a river.

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