

Short Communication

Composition and Diversity of Phytobenthic Communities Downstream to a Hydroelectric Dam on River Alaknanda in Garhwal Himalayan Region of Uttarakhand, India

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ABSTRACT

The present work to study the composition and diversity of phytobenthic communities was conducted at downstream to a 330 MW hydroelectric dam, constructed on River Alaknanda, Uttarakhand. In the present study, a total of 48 genera of phytobenthos belonging to 23 families of 9 orders and 5 classes were recorded. The Chlorophyceae and Bacillariophyceae were the most dominant class respectively. Among the genus, *Gomphonema* and *Navicula* were the predominant genera that suggest the organic pollution at downstream to dam. Habitat heterogeneity reflects the increased density, diversity and richness of the phytobenthic communities downstream to dam.

Key Words: Phytobenthos; Pollution; Dam.

INTRODUCTION

Phytobenthos are enormously significant for the understanding of any aquatic ecosystem as it is the main source of primary productivity. Besides, their importance as a food source for aquatic fauna, they also been used as biological indicators for assessment of water quality (Lobo et al. 1995). Construction of dams on rivers has noteworthy effects on aquatic habitats (Poff and Hart 2002), and periphyton species composition can be influenced by river regulation, due to the changes in habitat and flow conditions leading to alternation in their distribution and composition. It has been suggested that river regulation might results to a loss of susceptible and endemic species along with the introduction of those species which were absent earlier (Poff and Zimmerman 2010, Andrus et al. 2013).

At present, the numbers of dams are proposed on River Alaknanda, expecting to influence the river's

channel morphology along with the biological integrity of this aquatic system. The present work aims to study the phytobenthic assemblages downstream to dam on River Alaknanda in the Garhwal region of Uttarakhand state.

STUDY AREA

The study was conducted at downstream to a 330 MW hydroelectric dam on River Alaknanda, Uttarakhand. The sampling area extended from 30°13'10.63" N-30°13'42.76" N and 78°47'22.12" E-78°49'01.02" E. Sampling for phytobenthos was done at three selected sites near the township of Srikot, Chauras and Srinagar, respectively. The sampling site at Srikot (540.41 m asl) was 3.1 Km downstream to dam on the left bank of river Alaknanda. At Chauras (533.70 m asl) the site was about 5.2 km downstream to dam on the right bank of

river. The sampling site at Srinagar (530.96 m asl) was about 7.2 km downstream to dam on left bank of River Alaknanda (Figure 1).

METHODS

Regular sampling of periphyton was done at the sampling sites at every 15 days interval from January 2019 to March 2019. The samples were collected from the submerged stones or substrate (APHA 2005) and then were preserved in 90% alcohol. Identification of periphyton was done by using different keys (Needham and Needham 1962, Sarode and Kamat 1984). Identification was done with the help of Olympus stereo zoom binocular microscope. The quantitative analysis of periphyton was done with the help of Sedgwick-Rafter counting cell and their density expressed as individuals per square meter was computed as:

$$\text{Density (Ind. m}^{-2}\text{)} = \frac{\text{Number of periphyton /ml} \times \text{Dilution}}{\text{Area}}$$

DATA ANALYSIS

The Shannon-Wiener species diversity index (Shannon and Wiener 1963), Species richness index (Margalef 1956) and Evenness were calculated using PAST 1.73 (Hammer et al. 2001). Analysis of variance (ANOVA) to analyze the significance of variation of phytobenthic taxa at various sampling sites was done using SPSS 20.

RESULTS

During the present study, a total of 48 genera of phytobenthos belonging to 23 families of nine orders and 5 classes were recorded. The Chlorophyceae was the most dominant class (23 genera) followed by Bacillariophyceae (21 genera), Myxophyceae (2 genera) whereas Xanthophyceae and Desmidiaceae were represented by single genus each (Table 1). The maximum genera of phytobenthic communities were recorded from Chauras with 42 genera followed by

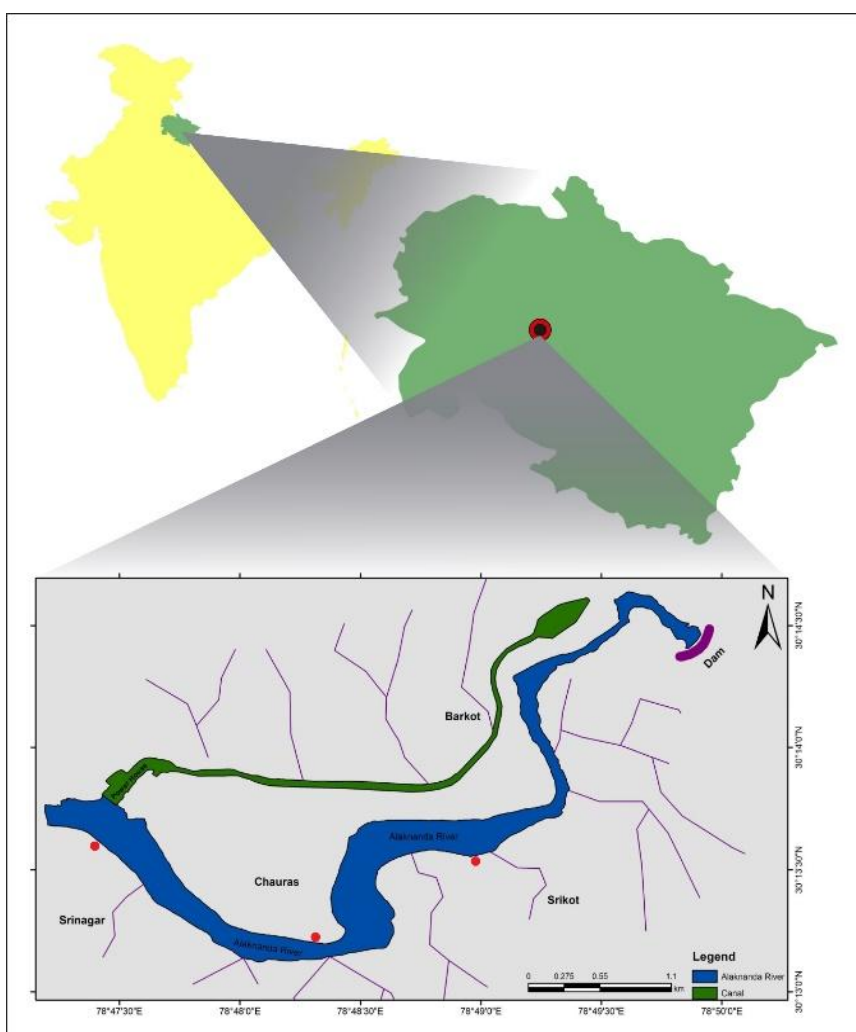


Figure 1. Location map of the selected sampling sites on River Alaknanda.

Srikot and Srinagar with 39 and 35 genera respectively (Table 1).

The total density of phytobenthos was recorded maximum (65991.25±290.90) at Srinagar and was least (37891.04±163.71) at Chauras, during the study period (Table 2). Among the genera *Gomphonema* and *Navicula*

were predominant, while *Pediastrum* represents the least density during present study. Analysis of variance (ANOVA) for the recorded phytobenthos suggested that density of 32 genera vary significantly ($p < 0.05$) between all the sampling sites (Table 2).

The percentage composition of phytobenthos

Table 1. Checklist and Occurrence of phytobenthos at selected sampling sites during the present study.

Phylum	Class	Order	Family	Genus	Srikot	Chauras	Srinagar	
Algae	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	<i>Polycystis</i>	+	+	+	
				<i>Oscillatoria</i>	+	-	-	
	Chlorophyceae	Chlorococcaeas	Coelastraeae	<i>Coelastrum</i>	+	+	-	
				Hydrodictyaceae	<i>Pediastrum</i>	+	+	-
			Oocystaceae	<i>Ankistrodesmus</i>	+	+	-	
				<i>Dactylococcus</i>	-	-	+	
			Scenedesmaceae	<i>Crucigenia</i>	-	+	+	
				Zygnematales	Mesotaeniaceae	<i>Gonatozygon</i>	+	+
			<i>Roya</i>			-	+	-
			<i>Netrium</i>		+	+	+	
			Desmidiaceae		<i>Closterium</i>	+	+	+
				<i>Cosmarium</i>	+	+	-	
		Zygnemataceae	<i>Spirogyra</i>	+	+	+		
			<i>Sirogonium</i>	-	-	+		
			<i>Zygnema</i>	+	+	+		
			<i>Mougeotia</i>	+	+	+		
			Ulotrichales	Ulotrichasceae	<i>Ulothrix</i>	+	+	+
					Microsporaceae	<i>Microspora</i>	+	+
		<i>Chaetophora</i>		-	+	+		
		<i>Stigeoclonium</i>		+	-	-		
		Protococcaeaea	<i>Protococcus</i>	+	+	+		
			Schizogoniales	Schizogoniaceae	<i>Schizogonium</i>	+	+	+
	Oedogoniales	Oedogoniaceae			<i>Oedogonium</i>	+	+	+
	Cladophorales	Cladophoraceae	<i>Cladophora</i>	+	-	-		
			<i>Rhizoclonium</i>	+	+	+		
	Xanthophyceae	Heterotrichales	Tribonemataceae	<i>Tribonema</i>	+	-	+	
				<i>Genicularia</i>	+	+	+	
	Desmidiaceae	Bacillariales	Coscinodiscaceae	<i>Melosira</i>	+	+	-	
				<i>Cyclotella</i>	+	+	+	
	Bacillariophyceae	Fragilariaceae	Fragilariaceae	<i>Tabellaria</i>	+	+	+	
				<i>Diatoma</i>	+	+	+	
			<i>Meridion</i>	+	+	+		
<i>Fragilaria</i>			+	+	+			
Achnantheoideae			<i>Syndera</i>	+	+	+		
			<i>Cocconeis</i>	+	+	+		
Naviculaceae			<i>Achnanthes</i>	+	+	+		
			<i>Anomoeonis</i>	-	+	-		
			<i>Brebissonia</i>	-	+	-		
			<i>Caloneis</i>	-	+	-		
		<i>Frustulia</i>	+	+	+			
		<i>Gyrosigma</i>	+	+	+			
		<i>Navicula</i>	+	+	+			
		<i>Neidium</i>	-	+	-			
Ghomphonemaceae		<i>Stauroneis</i>	+	+	+			
Cymbellaceae		<i>Gomphonema</i>	+	+	+			
		<i>Cymbella</i>	+	+	+			
Nitzschiaceae		<i>Amphora</i>	+	+	+			
		<i>Nitzschia</i>	+	+	+			

revealed that Bacillariophyceae was the most abundant class at all the three sampling sites followed by Chlorophyceae and Myxophyceae respectively (Figure 2). The Shannon-Wiener diversity index and

evenness index were minimum at Srikot, the closest site at down-stream to dam, while the Margalef's richness index ranged between 3.98 and 4.41 at Srinagar and Chauras respectively (Table 3).

Table 2. Density (Ind.m⁻²) and analysis of variance (p values) of various taxa of phytobenthos at selected sampling sites during the present study (Density±SE).

Genus	Srikot	Chauras	Srinagar	p values
<i>Polycystis</i>	997.81±302.45	213.13±151.40	2273.33±254.43	0.000
<i>Oscillatoria</i>	24.22±16.27	–	–	0.076
<i>Coelastrum</i>	382.66±171.81	484.38±146.51	–	0.071
<i>Pediastrum</i>	881.56±186.67	16.15±11.14	–	0.000
<i>Ankistrodesmus</i>	465.00±196.09	19.38±19.38	–	0.001
<i>Dactylococcus</i>	–	–	51.67±51.67	0.038
<i>Crucigenia</i>	–	109.79±109.79	2144.17±157.14	0.000
<i>Gonatozygon</i>	1075.31±145.31	1252.92±450.82	1614.58±237.12	0.621
<i>Roya</i>	–	387.50±67.79	–	0.000
<i>Netrium</i>	1554.84±617.03	371.35±127.85	1201.25±769.49	0.017
<i>Closterium</i>	208.28±110.32	332.60±82.54	904.17±478.44	0.003
<i>Cosmarium</i>	2291.09±381.95	1007.50±252.62	–	0.000
<i>Spirogyra</i>	135.63±63.00	584.48±143.37	206.67±136.70	0.007
<i>Sirogonium</i>	–	–	465.00±307.57	0.000
<i>Zygnema</i>	62.97±52.78	500.52±61.54	516.67±207.87	0.000
<i>Mougeotia</i>	155.00±77.15	77.50±42.93	64.58±64.58	0.396
<i>Ulothrix</i>	678.13±279.24	1340.10±180.59	852.50±146.71	0.005
<i>Microspora</i>	828.28±144.98	752.40±140.00	1059.17±56.30	0.386
<i>Chaetophora</i>	–	54.90±34.55	38.75±38.75	0.345
<i>Stigeoclonium</i>	48.44±38.58	–	–	0.278
<i>Protococcus</i>	595.78±235.93	839.58±157.28	387.50±387.50	0.268
<i>Schizogonium</i>	96.88±37.34	22.60±16.84	258.33±136.70	0.003
<i>Oedogonium</i>	319.69±54.68	381.04±74.02	645.83±152.29	0.043
<i>Cladophora</i>	213.13±90.88	–	–	0.001
<i>Rhizoclonium</i>	24.22±16.27	219.58±67.51	193.75±193.75	0.016
<i>Tribonema</i>	33.91±24.77	–	180.83±180.83	0.005
<i>Genicularia</i>	324.53±118.75	64.58±34.51	284.17±157.14	0.010
<i>Melosira</i>	77.50±52.81	316.46±111.95	–	0.019
<i>Cyclotella</i>	4620.94±429.06	1724.38±157.22	3190.42±145.56	0.000
<i>Tabellaria</i>	1162.50±359.73	103.33±72.23	3552.08±492.87	0.000
<i>Diatoma</i>	1830.94±413.01	2179.69±252.98	2182.92±471.59	0.701
<i>Meridion</i>	1356.25±431.94	1194.79±394.36	4120.42±279.73	0.000
<i>Fragilaria</i>	3100.00±721.05	991.35±230.56	3358.33±261.22	0.000
<i>Syndera</i>	3351.88±431.56	1995.63±228.03	4004.17±718.82	0.000
<i>Cocconeis</i>	348.75±109.36	248.65±111.70	2144.17±157.14	0.000
<i>Achnanthes</i>	3642.50±647.29	2460.63±290.82	3771.67±766.67	0.038
<i>Anomoeonis</i>	–	19.38±19.38	–	0.617
<i>Brebissonia</i>	–	38.75±38.75	–	0.617
<i>Caloneis</i>	–	25.83±25.83	–	0.617
<i>Frustulia</i>	1811.56±235.68	2089.27±367.44	2002.08±903.34	0.833
<i>Gyrosigma</i>	67.81±44.99	448.85±150.64	477.92±477.92	0.028
<i>Navicula</i>	5439.53±669.21	4239.90±350.16	4960.00±645.32	0.034
<i>Neidium</i>	–	106.56±73.76	–	0.252
<i>Stauroneis</i>	3506.88±613.57	1317.50±183.81	4081.67±492.87	0.000
<i>Gomphonema</i>	5536.41±827.29	2573.65±449.49	5231.25±1076.90	0.000
<i>Cymbella</i>	3032.19±364.08	3112.92±422.34	4740.42±493.38	0.028
<i>Amphora</i>	92.03±61.24	177.60±124.97	219.58±219.58	0.666
<i>Nitzschia</i>	4092.97±588.63	3493.96±298.90	4611.25±549.38	0.095
Total Density (Ind. m ⁻²)	54467.97±260.62	37891.04±163.71	65991.25±290.90	

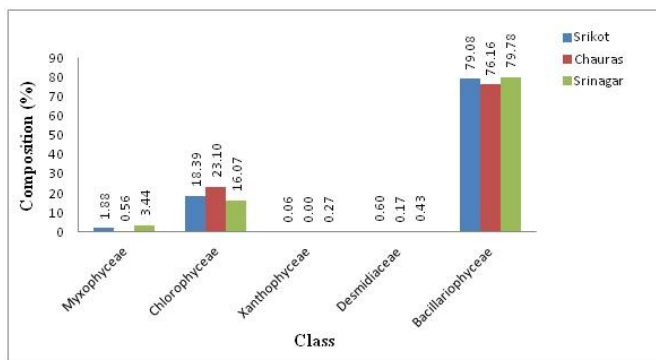


Figure 2. Percentage composition of phytobenthos at selected sampling sites during the present study.

Table 3. *Shannon-Wiener diversity index (\bar{H}), Evenness index (e) and Margalef's richness index (d') at different sampling sites during the present study.*

Indices	Srikot	Chauras	Srinagar
\bar{H}	3.05	3.14	3.12
e	0.54	0.55	0.65
d'	4.07	4.41	3.98

DISCUSSION

During the present study Bacillariophyceae and Chlorophyceae were dominant at downstream to dam, being the major primary producers they are of great ecological significance (Sharma et al. 2008). Filamentous algal growth also provides habitat and shelters for benthic macroinvertebrates (Bergey et al. 2010). The regulated reduced flow and low sediment discharge from upstream resulted in the higher occurrence of periphytic algae at downstream to dam (Smolar-Žvanut and Mikoš 2014). As phytobenthos has been used as biological indicators, the genus *Navicula*, *Nitzschia* and *Cylotella* were suggested as the pollution tolerant genera of diatoms, and the dominance of *Gomphonema*, *Navicula* and *Nitzschia* suggests the organic pollution at downstream to dam (Polst et al. 2018).

The substratum composition is important factor which governs the distribution and assemblages of the phytobenthic community. As evident in the present study density was maximum at Srinagar with gravels, pebbles and cobbles as main substratum, while diversity and richness were maximum at Chauras with sand, gravels and cobbles as substratum composition, indicating that heterogeneous habitat supports the diversification of phytobenthic communities. River regulation might also provide new habitats to the species which were earlier

absent in the river (Growth and Growth 2001, Sharma et al. 2008, Nautiyal et al. 2018).

CONCLUSIONS

The present study suggests that water regulation by hydroelectric dam critically affects the distribution and assemblages of phytobenthos. Some taxa may be favoured while others became reduced due to the modified flow pattern of the river and the diversification in the substratum composition. The distribution and composition of phytobenthic communities downstream to dam can be further utilized as indicators for monitoring and restoration studies in future.

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Author's contribution: P. Singh collected the data, analysed it and drafted the manuscript. P. Sharma contributed to data collection and samples identification. N. Swami and J.S. Rana helped in statistical analysis. Manju P. Gusain and O.P. Gusain conceptualized the study and helped with data analysis and preparation of the manuscript.

Conflict of interest: We declare no conflict of interest.

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