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IMPACT OF TEHRI DAM CONSTRUCTION ON PHYTOPLANKTONIC POPULATION IN BHILANGANA RIVER OF THE GARHWAL HIMALAYA, UTTARAKHAND (INDIA)

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ABSTRACT: Water impoundment imposes fundamental changes on natural landscapes by transforming rivers into reservoirs. The dramatic shift in physical conditions accompanying the loss of flow creates novel changes in species composition and community structure due to ecosystem fragmentation. In the present study, we observed the impact of habitat alteration due to Tehri dam construction on phytoplanktonic profile of river Bhilangana during May, 2009 to April, 2011. For the data collection and analysis of samples, five different sites were selected on lotic and lentic segments of Bhilangana River. Two on lotic segment viz: inflow (S-1), outflow (S-5) and three in lentic, segment viz: S-2, S-3 and S-4. The total Phytoplanktonic population observes increased in lentic sites (S-2, S-3 and S-4) as compared to inflow site (S-1) and outflow sites (S-5). The density (Unit/L) of Bacillariophyceae family has been significantly decreased in lentic sites as compared to inflow (S-1) and outflow site (S-5), while the density of Chlorophyceae has been increased in lentic sites (S-2, S-3 and S-4) as compared to inflow (S-1) and outflow sites (S-5). The density of *Oedogonium, Pediastrum, Selenastrum, Spirogyra, Volvox, Anabaena* and *Coelosphaerium* have also been increased in lentic sites. Some Phytoplanktonic taxa viz: *Cyclotella, Cymbella, Diatoma, Fragilaria, Frustulia, Navicula, Synedra, Tabellaria, Ankistrodesmus, Closterium, Ulothrix, Zygnema* and *Oscillatoria* were commonly reported from all the sites.

Key words: Lentic site, lotic site, Inflow site, Outflow site, Bhilangana river Impoundment and Community composition.

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INTRODUCTION

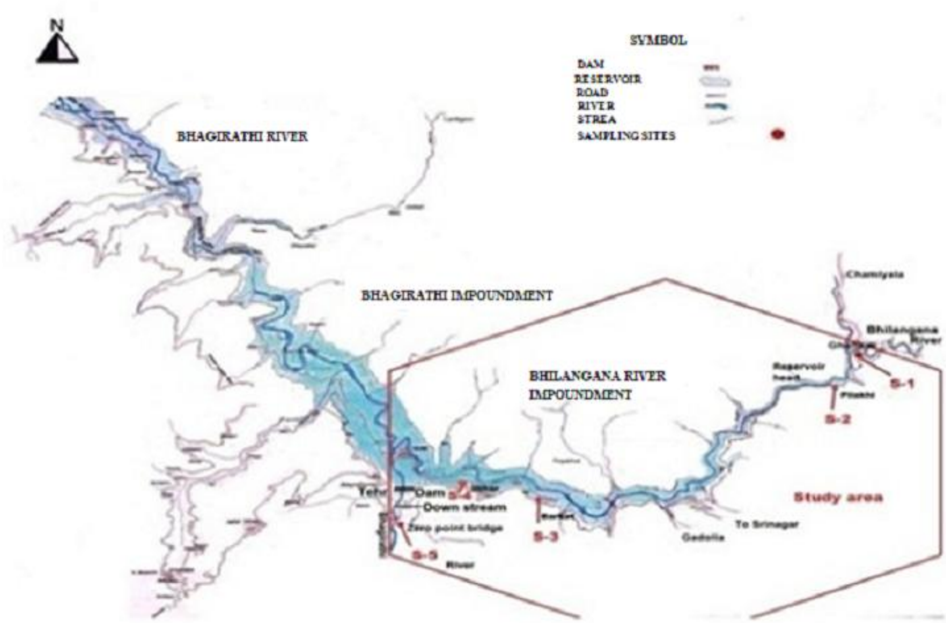
Phytoplankton forms the vital source of energy as primary producers and serves as a direct source of food to the other aquatic plants and animals. They are the source of oxygen in aquatic systems. The quantitative and qualitative studies of phytoplankton may provide good indices of water quality and capacity of water to sustain heterotrophic communities. But the freshwater biodiversity is threatening worldwide due to river impoundment and modification of natural hydrologic regimes [1]. Impoundment affects species composition and community structure due to ecosystem fragmentation, extirpation of native species dependent on lotic conditions, and modification of patterns of energy flow and trophic structure [2, 3, & 4].

In addition, hydrologic modification facilitates invasions by non-native species [5 & 6], which are in turn implicated as primary threats to native biodiversity in freshwaters [7 & 8]. Alterations to species composition or community structure, such as those that follow river impoundment, may disrupt the ability of the ecosystem to provide goods and services [9 & 10].

The first most obvious effect of presence of a dam and impoundment in the course of a free flowing river is; it creates a discontinuity in the natural structure and function of a stream, leading to changes in physical, chemical, and biological conditions both upstream and downstream of the dam [11 & 12]. Understanding the impacts of river impoundment on this important ecosystem service may facilitate conservation initiatives in developing countries in tropical latitudes, where development of large impoundments continues to threaten rich biological diversity [13 & 7].
Phytoplankton is highly sensitive to nutrient level, temperature range, light intensity and duration, pollution level and predation. They have been used as indicators of water quality. Some species flourish in highly eutrophic waters while others are very sensitive to organic and/or chemical wastes. Therefore a major interest in phytoplankton investigation is to understand the impact of habitat alteration and environmental factors that influence their diversity. In the present study an attempt has been made to understand the Impact of Tehri Dam Construction on Phytoplanktonic Population in Bhilangana River of the Garhwal Himalaya, Uttarakhand (India)

STUDY AREA AND METHODOLOGY

River Bhilangana is a snow fed river originating from Khatling glacier (3634m asl). Earlier, when Tehri dam reservoir had not constructed, the river Bhilangana joins the river Bhagirathi on its left bank at Ganesh Prayag (Tehri) after travelling 80kms from its source. But now a 25kms stretch from Ghansali (870 m asl) to Tehri (750m asl) of this river is changed into lentic habitat due to construction of Tehri dam with a total surface area of 42 square kilometres . Based on the topographical feature and different habitat in Bhilangana river, five sampling sites have been selected viz: – S-1 at inflow (lotic habitat), S-2 at the head of reservoir (intermediate zone), S-3 middle of reservoir (lentic habitat), S-4 near the dam site (lentic habitat) and S-5 at outflow (lotic habitat) by covering 35 km. The monthly samples for phytoplankton were collected by filtering 50 liter of water in the plankton net made up of bolting silk cloth of standard grade (No. 25) from each sampling sites and were immediately preserved in 4% formalin during the two consecutive year May, 2009 to April, 2011. Sedgwick –Rafter cell method and Pathological microscope manufactured by Zetner (India) was used for qualitative and quantitative analysis.



Map of the study area showing Bhilangana River Impoundment and location of sampling sites.

Planktons were quantified according to Welch [14] on a unit / liter basis by using formulae

$$\text{Plankton (unit/l)} = \frac{(a \times 1000)\ C}{L}$$

Where,

a = average number of plankton in one small counting chamber of Sedgwick rafter counting cell

C = milimeter of plankton concentrate

L = volume of original water filtered in litre.

Qualitative analyses of planktons were done according to Needham and Needham [15] and Ward and Whipple [16].

RESULTS AND DISCUSSION

In the present study, Comparative analysis of phytoplankton from lentic and lotic sites have been revealed that the density of phytoplanktonic population have been increased in altered lentic zone (Table-1). This is due to adequate conditions for their growth in lentic site such as Less turbidity, higher transparency, low water currents, elevated nitrate and phosphate concentration (Table-3). In contrast to our study, Ayoade *et. al.*, [17,18] has also reported higher phytoplanktonic population and faunal diversity in lentic sites of Bhagirathi water owing to reduced water current and low turbidity. Similar observations have been reported by Sugunan [19]; Singh *et al.* [20]; Okogwu and Ugwumba [21]; Reynolds, [22]; Salmaso & Braioni, [23].

The density (unit/Litre) of family Bacileriophycece has been significantly decreased in the altered lentic site(S-2,S-3, S-4) due to river impoundment in contrast to unaltered lotic site (S-1) On the contrary, Chlorophyceae density has been increased in the altered lentic sites (S-2, S-3 and S-4) contrast to unaltered lotic sites. As per these observations, Bacillariophyceae has less adopted in altered habitat of river as its raising temperature and low water current, while Chlophyceae has well adopted in stagnant and transparent water and raised temperature (Fig-1). Sugunan [19] also observed less population of Bacillariophyceae in lotic zone compared to lentic zone in Nagarjuna sager reservoir.

Present study also reveals that Bacillariophyceae constituted the most dominant group of phytoplanktonic population and represented by 17 taxa (Table-2 & Fig-2).Singh *et. al*., Sugunan and Aggarwal *et. al.* [24, 19 and 25] have also reported that the Bacillariophyceae is dominant group over Chlorophyceae in lotic water. Quantitatively, diatoms dominated the Bacillariophyceae counts in both the riverine and impounded sites throughout the study period. The commonest species were *Diatoma* spp., *Cymbella* spp., *Cyclotella* spp., *Synedra* spp. and *Tabellaria* spp. The annual percent contributions of Bacillariophyceae amongst phytoplankton in terms of population density reveal that it contributed maximum (units/l) from all the sampling sites (Table-1 & Fig-1). The dominance of Bacillariophyceae amongst phytoplankton substantiates the findings of Zutshi *et. al.* [26] who recorded maximum number of diatom species from the high altitude lakes of the Himalayan region.

Intra relation profiles among various physico-chemical and phytoplankton have also been computed. Phytoplankton showed highly significant negative correlation with water temperature and phosphate ($P < 0.01$) at all the sampling sites. A significant negative correlation between phytoplankton and nitrate was observed at 5% significance level in upstream and downstream sites. At impounded sites, this relationship was non significant. However significant positive correlation with transparency at upstream ($r = 0.794736$) and downstream ($r = 0.777619$) sites was noticed while non significant relationship observed at impounded sites. Very high positive significant correlation ($P < 0.01$) was calculated between phytoplankton and CO_2 from all the study sites (Table-3).

Table-1: Quantitative analysis of Phytoplankton (units^{-l}) from the five sampling sites during May 2009-April 2011.

Months	S-1(USR)	S-2(R)	S-3(R)	S-4(R)	S-5(DSR)
May-09	6366.58±57.41	6960.24±102.51	6060.53±70.94	6160.20±55.95	6353.25±53.89
Jun-09	3314.17±94.32	6684±88.00	5985.66±54.59	6043.54±89.62	3353.50±55.33
Jul-09	2482.32±175.43	3687.06±33.87	1534.75±42.36	1572.23±52.04	2623.32±55.05
Aug-09	2922.03±103.57	2311.78±38.32	1165.50±40.44	1248.88±29.35	2956.37±59.80
Sep-09	1191.95±11.08	1577.42±12.88	1483.48±42.46	1188.36±23.04	1133.62±50.73
Oct-09	2229.03±55.01	2266.37±33.44	1621.63±22.55	1948.72±32.62	2209.37±32.00
Nov-09	2912.07±101.96	3681.70±38.17	2977.65±23.03	2988.42±10.94	2855.40±45.51
Dec-09	5088.05±106.61	5806.82±15.39	5379.77±47.25	5421.09±18.86	5029.38±57.69
Jan-10	8086.73±50.69	8494.67±42.25	8785.99±36.51	9273.46±22.98	7995.73±39.77
Feb-10	8234.28±79.85	8311.40±54.87	9013.03±50.81	9094.02±86.44	8291.62±38.12
Mar-10	8128.78±99.90	8491.58±41.40	8269.41±50.12	7231.43±46.05	8209.45±26.47
Apr-10	7280.30±99.35	7424.75±33.02	6666.21±51.42	7428.14±39.60	7425.30±33.61
Mean	**4853.03±2639.41**	**5474.89±2624.19**	**4911.97±2895.857**	**4966.54±3048.15**	**4869.69±2654.19**
May-10	6402.20±36.35	7013.47±71.17	6153.62±68.54	6231.20±75.76	5405.28±48.14
Jun-10	3416.45±38.41	6749.99±49.98	6022.77±69.99	6093.09±89.84	3249.10±31.20
Jul-10	2553.31±55.04	3697.69±46.58	1515.97±75.23	1560.12±72.31	2407.17±80.80
Aug-10	2911.69±48.59	2305.64±58.66	1162.86±60.90	1329.48±61.34	2140.25±30.38
Sep-10	1260.37±26.29	1537.54±36.37	1402.34±53.55	1222.50±75.12	1212.75±15.67
Oct-10	2273.85±29.71	2196.67±45.10	1698.07±52.91	1907.11±100.76	1537.23±27.49
Nov-10	2884.84±47.58	3703.85±48.34	3085.24±55.63	2898.03±97.06	2600.12±22.83
Dec-10	5038.54±27.77	5857.14±39.77	5495.32±45.20	5410.33±101.59	4226.45±35.95
Jan-11	7982.43±63.50	8896.05±29.13	8852.67±59.37	9228.20±94.20	6521.13±29.84
Feb-11	8282.20±62.24	8354.65±57.11	9119.80±78.55	9232.92±61.24	6552.10±53.18
Mar-11	8197.28±61.96	8517.46±55.30	8429.42±79.05	7371.00±41.88	6613.47±70.43
Apr-11	7355.00±57.67	7450.71±51.07	6724.56±89.40	7454.38±56.69	5251.37±43.19
Average	**4879.85±2628.11**	**5523.41±2694.41**	**4971.89±2937.37**	**4994.86±3073.03**	**3976.37**±2036.89

(Note: USR=Upstream reservoir, R=Reservoir, DSR=Downstream Reservoir)

Table-2: Distribution profile of various Phytoplankton taxa recorded from five sampling sites during May 2009-April 2011.

S.No	Family	Name of taxa	Lotic water		Lentic water		
			S1(USR)	S5(DSR)	S2(R)	S3(R)	S4(R)
1.	Bacillariophyceae	*Asterionella*	++	++	+++	+++	+++
		Cocconeis	+	+	+	+	+
		Cyclotella	+++	+++	+++	+++	+++
		Cymbella	+++	+++	+++	+++	+++
		Diatoma	++	++	+++	+++	+++
		Eunotia	+	+	+	+	+
		Fragilaria	+++	+++	++	++	++
		Frustulia	+++	+++	+++	+++	+++
		Gyrosigma	++	++	+++	+++	+++
		Gomphonema	++	+++	+	+	+
		Melosira	+	+	++	++	++
		Meridion	+++	++	++	++	++
		Navicula	++	++	+++	+++	+++
		Nitzschia	++	++	+++	+++	+++
		Stauroneis	+++	+++	+++	++	+
		Synedra	+++	+++	+++	+++	+++
		Tabellaria	+++	+++	+++	+++	+++
2.	Chlorophyceae	*Ankistrodesmus*	+++	++	+++	+++	+++
		Closterium	+++	+++	+++	+++	+++
		Oedogonium	+	+	+++	+++	++
		Pediastrum	+	+	++	+++	+++
		Selenastrum	+++	++	+++	+++	+++
		Spirogyra	++	++	+++	+++	+++
		Ulothrix	+++	+++	++	+	++
		Volvox	++	+	+++	+++	+++
		Zygnema	+++	+++	+++	+++	+++
3.	Myxophyceae	*Anabaena*	+	+	+++	+++	+++
		Coelosphaerium	+	+	++	++	++
		Oscillatoria	+++	+++	+++	+++	+++
		Rivularia	++	++	+++	+++	+++

(Note: +++ = Dominant, ++ = Subdominant, + = Rare)

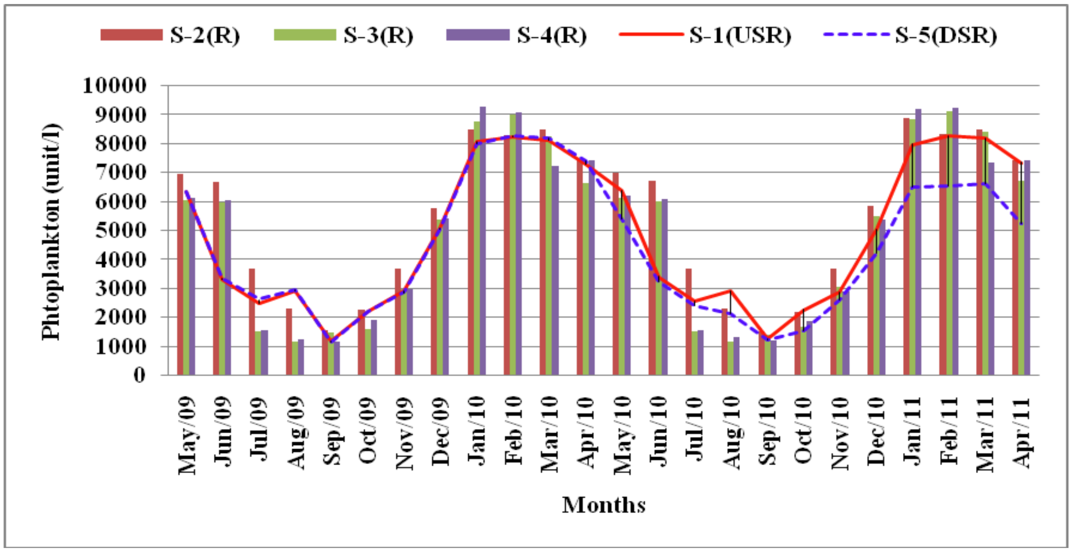


Fig. 1: Comparative illustration of Phytoplankton (unit $^{-l}$) numbers from five sampling sites in Bhilanga River and its impoundment.

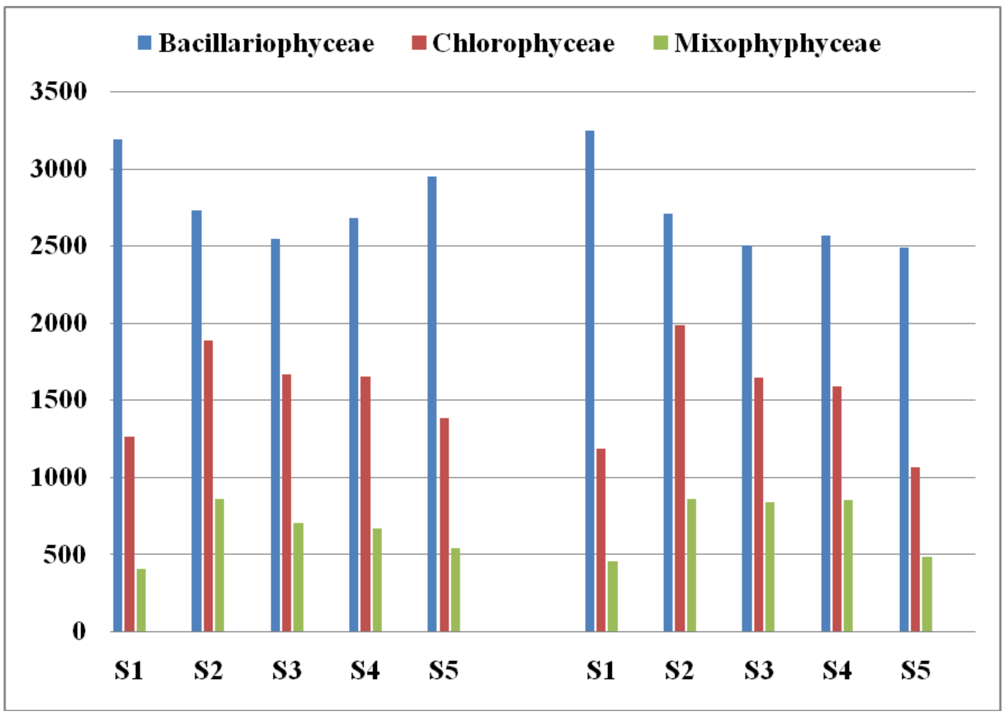


Fig-2: Annual average composition of phytoplankton groups at five sampling sites during may 2009 to April 2011.

Table-3: The Correlation coefficient (r) of between phytoplankton abundance and physico-chemical parameters at five sampling sites located in river Bhilangana and its impoundment.

Parameters	Correlation coefficient (r)				
	Upstream site	Impoundment sites			Downstream sites
	S-1(USR)	S-2(R)	S-3(R)	S-4(R)	S-5(DSR)
Water temp. v/s Phytoplankton	-0.6189**	-0.45742*	-0.58077**	-0.57393**	-0.76534**
Transparency v/s Phytoplankton	0.794736**	0.058634	0.116451	*0.03335*	0.777619**
Free CO_2 v/s Phytoplankton	0.643112**	0.615492**	0.632751**	0.633301**	0.655089**
Nitrate v/s Phytoplankton	-0.45063*	0.132466	-0.06504	-0.03102	-0.42416*
Phosphate v/s Phytoplankton	-0.70006**	-0.6008**	-0.61471**	-0.66296**	-0.6571**

[Note: USR=Upstream reservoir, R=Reservoir, DSR=Downstream Reservoir, * - Values significant at 5% ($P < 0.05$), **- Values significant at 1% ($P < 0.01$)]

CONCLUSION

The overall study reveals that total density of phytoplankton in the altered lentic site has been increased due to adequate living conditions. Bacileriophyce has been significantly decreased in the altered lentic sites due to their less adoptability in raised temperature and low water current while chlorophyceae density has been increased in altered lentic sites is due to their high adaptability in stagnant, transparent water with combination of raised temperature. Bacillariophyceae still most dominant group both the riverine and impounded sites.

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