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Status of phytoplankton diversity in relation to water quality of Bhagirathi riverine system in Garhwal Himalaya

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Abstract
The Bhagirathi is one of the most important and largest river of the Garhwal hills. The phytoplanktonic community in Bhagirathi was represented mainly by Bacillariophyceae (86%), Chlorophyceae (10%) and Myxophyceae (4%). The most common blue-green algae were *Fragilaria* species followed by *Diatoms* species frequent in the mountainous stretch and its degree of occurrence decrease in the lower region. The *Ulothrix* species of Chlorophyceae algae were moderately frequent at the upper part of Bhagirathi but less frequent in the lower region. *Phormidium* species was less frequent at upper region but moderately frequent at downstream of Bhagirathi. The highest resemblance between phytoplanktonic communities of two Zones, upstream and downstream of Tehri reservoir was observed. Zone 1 showed 60% resemblance with these two zones. The diatoms density shows an inverse relationship with turbidity, despite the fact that high turbidity indicates the possibility of high silicate level in the water, which is essential for diatoms growth. The present study revealed that the combined impact of DO, TDS, the velocity of water, turbidity and water temperature influenced the diversity of phytoplankton population dwelling Bhagirathi river.

Keywords: phytoplankton, water quality, bhagirathi river, Tehri

1. Introduction
The main stream of the river Ganga, the Bhagirathi originates from the ice cave of Gaumukh (33^0 55'N, $79^0$07E) at the snout of Gangotri glacier in the Garhwal portion of Western Himalaya, at an elevation of about 4100 meters. The Alaknanda, the sister streams of Bhagirathi rises beyond Mana pass, 8 km from Badrinath (33^0 44'29''N, $79^0$29'41''E, and 3123 m above msl) joins at Devpryag. It is below this confluence, the united stream is known as Ganga river. After a runoff some 267 Km, it emerges into Indo-Gangetic plains at Haridwar (elevation 288m), where it swells into the mighty system, 750 m wide (approx.). Riverine water quality affects through the abundance, species composition, stability, productivity and physiological condition of the indigenous population of aquatic organisms. As a result, the nature and health of the aquatic communities is an expression of the quality of water. Water must be of the good quality not only for its consumption but also for its aesthetic value. Several workers have conducted their study on water quality of river Ganga in different forms of characteristics in Himalayan and plain regions, Badola, 1975 [4]; Tilak and Baloni, 1983 [19]; Sharma, 1984 [13]; Singh *et al*., 1987 [17] ; Lakra *et al*.,1987 [8]; Dobriyal 1991 [6]; Khanna and Badola, 1991 [7]; Singh *et al*., 1993 [18]; Agarwal *et al*., 2005 [1]; Agarwal *et al*.,2011 [2]; Bisht *et al*., 2009 [5]; Malik, 2011 [10]. The present study deals with the water quality of Bhagirathi River in respect of Physico-chemical parameters and phytoplanktonic diversity.

2. Materials and Methods
2.1 Study area
The study area was confined to the long stretch of the riverine system of Bhagirathi in Garhwal Himalaya. In Present study, four sampling zones have been selected for analysis the physic-chemical parameters and phytoplankton determination. Sampling zone Z1 (Upper Bhagirathi river Basin) was selected from Bandra koti ($30^0$30'16.99 N longitude, $78^0$23'04.08 E latitude) to Jhinwali ($30^0$27'01.96 N longitude, $78^0$25'51.41 E latitude), Sampling zone Z2 (Pre impoundment of Tehri reservoir) is from Jhinwali to Tehri ($30^0$24'29.03 N longitude, $78^0$27'30.08 E latitude), Sampling zone Z3 (Post impoundment of Tehri reservoir) from Tehri to Koteshwar ($30^0$15'12.90 N longitude, $78^0$31'27.11 E latitude), Sampling zone Z4 (Lower Bhagirathi river Basin) from Koteshwar to Devprayag ($30^0$14'63.15 N longitude, $78^0$59'82.51 E latitude).

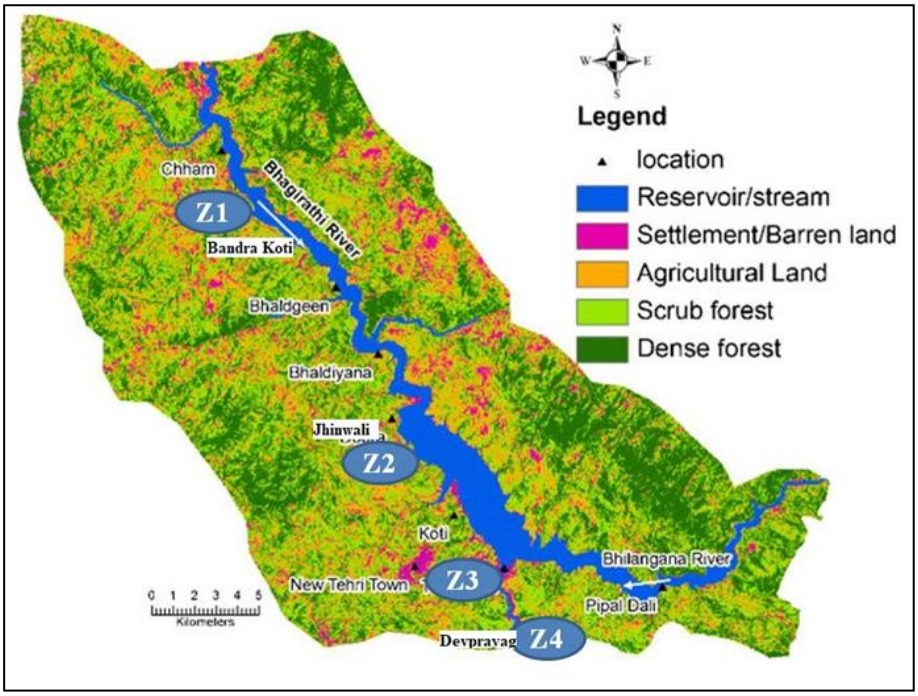


Fig 1: LULC Map of Selected sampling zones on Bhagirathi River

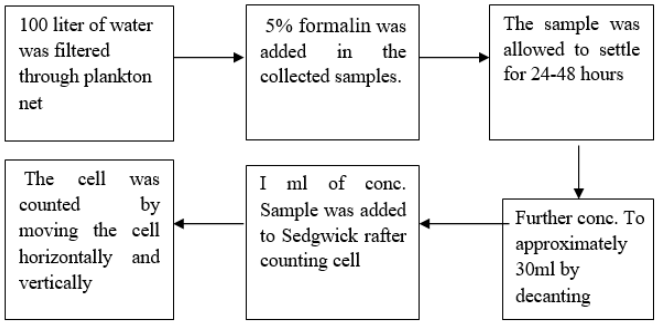
2.2 Physiographic variables

The percentage cover of the different sized substrate within each Surber quadrate was estimated visually and the substrate was classified with the help of Wentworth scale (Boulders (>256mm), Cobbles (64-256mm), Pebbles (16-64mm), Gravels (2-16mm), and Sand (<2mm).

2.3 Water quality parameters

For physico-chemical parameters, monthly water sample was collected in all sampling zones and analyzed following standard methods (APHA, 2012) [3] and (Trivedy *et al*. 1987) [20]. The temperature of air and water was recorded with the help of a digital thermometer (-50…+250^{0}C). Hydrogen ion concentration (pH) of the water was determined by the pH digital meter (Hanna), while the turbidity was measured by the turbidity meter (model- 5Dim). Phosphate was determined with the help of Systronic spectrophotometer. Chloride, alkalinity, and hardness were calculated by titration methods.

2.4 Procedure for Plankton Measurement



2.5 Calculation

$$No.of\ plankton\ /\ ml = \frac{No.of\ organism\ counted}{No.of\ replicates\ taken}$$

$$(Plankton/l)\ = \frac{(a\ \times 1000)c}{L}$$

Where,
n= no. of plankton/ liter of water
a= Average number of plankton in one small counting chamber of S-R cell
c= ml of plankton concentrate
I=volume of original water filtered in liter

2.6 Identification

From the concentrated sample, the slides for the plankton were prepared. Then these slides were placed under a microscope, and the phytoplankton's and zooplankton were observed in 100 X in the binocular microscope. The images of the phytoplankton were captured by using a digital camera. Later on, the phytoplankton were identified by using the book Needham and Needham, (1962) [12].

2.7 Diversity Indices

For the data of species, diversity indices were calculated using the Shannon-Wiener Index (1949) [15].

$$(H)=\sum_{i=1}\left(\frac{n_i}{N}\right)\text{Log }2\left(\frac{n_i}{N}\right)$$

Where,
H'= Shannon Diversity Index,
n_i= Total no of individuals of the species
N= Total no of individuals of all species

3. Results

Table 1: Physiographic variables of Bhagirathi River at selected sampling zones.

Physiographic variables	Zone 1	Zone 2	Zone 3	Zone 4
Embankment	Good riparian vegetation	Devoid of riparian vegetation	Devoid of riparian vegetation	Good riparian vegetation
Boulders (>256mm)	31%	67%	52%	40%
Cobbles (64-256mm)	35%	15%	13%	31%
Pebbles (16-64mm)	25%	8.0%	8.0%	6.0%
Gravels (2-16mm)	8%	3.0%	2.0%	7.0%
Sand (<2mm)	1.0%	2.0%	2.0%	4.0%

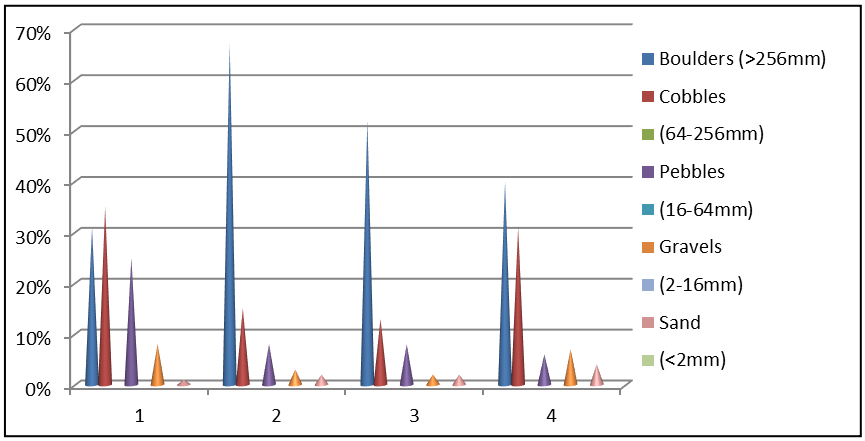


Fig 2: Physiographic variables of selected sampling zones.

Table 2: Mean monthly variation of aquatic habitat ecological parameters of Bhagirathi river recorded during August 2016 to August 2017.

Parameters	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Mean + S.D
Air temperature (^{0}C)	28.3	21.5	17.5	16.2	13.8	17.4	19.5	21.5	24.4	27.0	29.8	30.2	22.25±5.61
Light intensity (Lux)	13581	13007	12981	12586	10661	11581	175631	17923	18536	18991	15671	14283	27952.66±46586.50
Water velocity (m/sec.)	2.0	2.3	2.2	1.8	1.0	1.2	1.1	0.9	1.6	2.2	3.1	3.9	1.94±0.89
Relative Humidity (%)	64	57	49	35	25	30	37	46	55	62	70	75	50.41±16.16
UV Light(µW/cm^2)	350	209	189	150	100	130	195	250	357	360	368	391	254.08±105.52

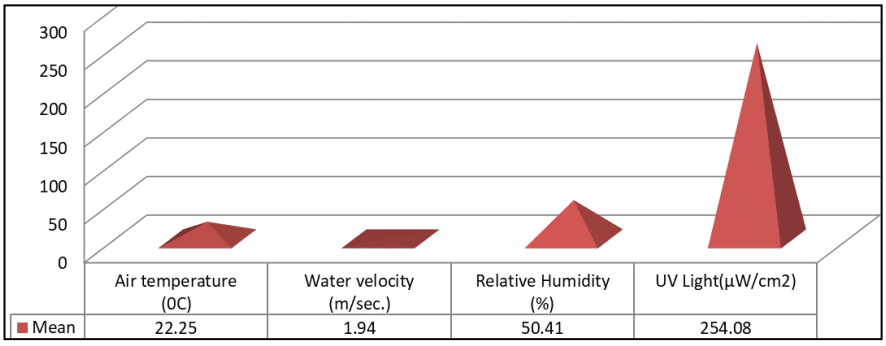


Fig 3: Mean monthly variation of aquatic habitat ecological parameters of Bhagirathi river.

Table 3: Mean monthly variation of aquatic habitat ecological parameters of Bhagirathi river recorded during August 2016 to August 2017.

Parameters	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	August	Mean + S.D.
Water Temperature(^{0}C)	17.2	14.3	11.5	10.7	9.2	10.8	14.6	15.0	15.2	17.0	19.1	21.3	14.65±3.65
pH	7.5	7.6	7.6	7.7	7.9	7.4	7.5	7.7	7.6	7.4	7.3	7.2	7.53±0.19
Conductivity (µS/cm)	138.1	125.7	120.3	117.4	111.5	136.2	145.2	148.1	149.9	150.4	199.5	194.2	144.70±27.7
Turbidity (NTU)	11.00	18.01	16.05	15.55	10.99	11.02	20.23	32.5	30.65	218.20	550.01	710.05	137.02±239.80
TDS(mg/L)	87.34	82.04	75.61	76.13	70.81	89.12	93.21	93.19	95.51	98.52	125.31	125.01	92.65±17.45
DO(mg/L)	10.01	10.00	10.02	10.08	11.76	12.00	11.50	10.52	10.21	10.00	9.60	9.20	10.40±0.80
Alkalinity (mg/L)	40.00	49.01	50.02	51.00	49.03	50.04	59.03	55.01	48.02	45.01	48.03	39.00	48.60±5.55
Hardness (mg/L)	47.05	58.01	70.01	90.04	70.02	60.01	60.05	58.04	50.00	36.9	34.05	30.01	55.34±17.12
Chloride (mg/L)	5.00	5.30	5.69	5.85	5.15	5.55	5.96	5.40	5.90	4.20	4.10	4.00	5.17±0.71
Phosphate (mg/L)	0.01	0.00	0.05	0.17	0.35	0.01	0.02	0.03	0.00	1.01	0.66	0.40	0.22±0.32

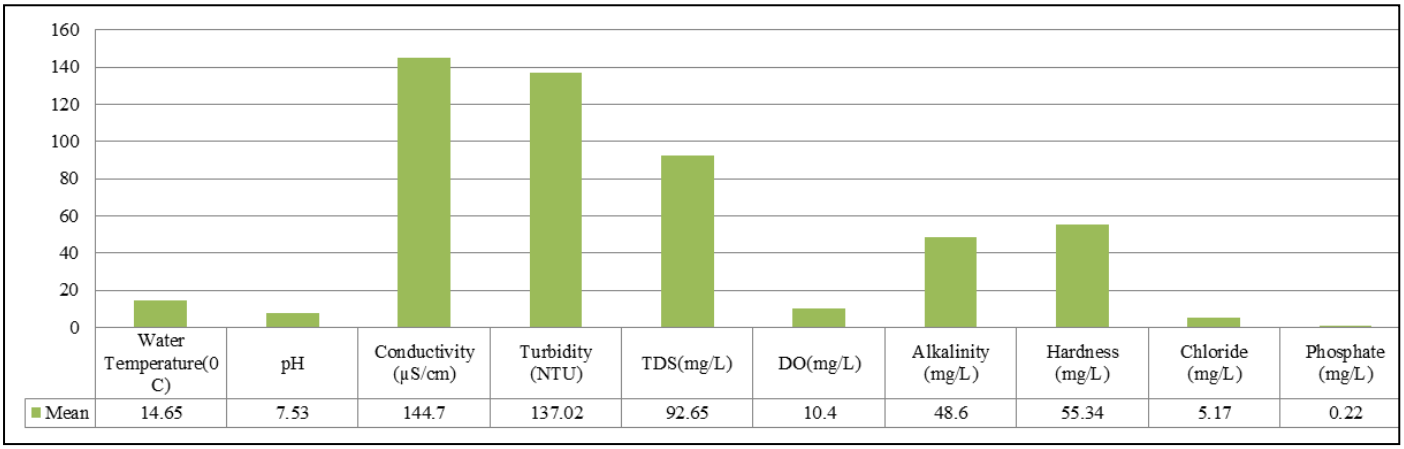


Fig 4: Mean monthly variation of aquatic habitat ecological parameters of Bhagirathi river.

Table 4: Mean monthly variation of phytoplankton density (ind.m^2) dwelling Bhagirathi river during August 2016 to August 2017.

Name	Sep	Oct	Nov	Dec	Jan	Feb	March	April	May	June	July	Aug	Mean+ S.D.
Bacillariophycaeae													
Achananthes sp.	5	11	13	20	15	16	18	15	8	2	3	2	10.66±6.47
Amphora ovalis	11	7	0	5	15	16	10	20	3	2	6	0	7.91±6.55
Cytotella sp.	2	0	3	3	10	8	5	0	4	2	0	0	3.08±3.26
Cymbella sp.	80	95	115	170	139	220	190	140	130	99	74	20	122.66±54.75
Cocconeis sp.	6	9	6	20	39	32	12	8	10	6	0	3	12.58±11.87
Coloneis sp	3	0	0	0	4	0	4	0	6	0	0	4	1.75±2.26
Ceretoneis sp.	10	7	21	25	8	21	12	10	9	0	0	0	10.25±8.44
Denticula sp.	7	8	10	21	31	38	37	10	15	4	12	4	16.41±12.41
Diatoma sp.	40	32	45	83	120	139	110	135	122	20	55	31	77.66±45.19
Fragilaris inflate	120	96	152	108	185	240	190	150	160	90	80	20	132.58±59.06
Gyrosigma sp.	0	0	3	10	15	9	0	0	7	0	0	3	3.91±5.12
Hantzschia sp.	1	3	0	7	10	15	0	3	10	4	5	0	4.83±4.80
Navicula radiosa	90	101	110	180	190	195	210	170	70	60	30	15	118.41±68.24
Nitzchia sp.	70	89	100	150	180	100	85	50	74	81	91	29	91.58±40.40
Opephora sp.	4	0	0	4	8	7	3	0	3	0	1	0	2.50±2.84
Pinnularia sp.	8	3	7	1	25	17	27	10	8	10	5	0	10.08±8.71
Syendra ulna	12	13	12	55	70	80	85	10	1	7	3	0	29.00±33.13
Tabellaria fenestris	70	25	75	110	170	150	80	45	70	35	40	30	75.00±46.90
Tetracyclus sp.	3	0	0	3	7	15	3	0	5	3	0	0	3.25±4.35
Total	542	499	672	975	1241	1318	1081	776	715	425	405	161	734.16±357.60
Chlorophyceae													
Closterium sp.	1	0	5	15	10	3	7	0	8	10	0	0	4.91±5.07
Cosmarium sp.	5	6	15	20	25	31	10	3	15	0	8	0	11.50±9.92
Cledophora sp.	1	15	25	22	33	45	20	13	9	13	3	5	170±12.91
Desmidium sp.	1	0	0	13	13	9	8	10	8	9	5	0	6.33±4.97
Hydrodictyon sp.	5	0	0	3	5	0	10	13	9	0	0	0	3.75±4.67
Microspora	13	3	12	8	17	27	21	15	11	0	3	0	10.83±8.48
Oedogonium sp.	1	9	0	5	10	1	9	10	3	2	0	0	4.16±4.19
Stigeoclanium sp.	5	0	8	3	6	22	10	15	16	7	8	0	8.33±6.5
Ulothrix zonata	5	22	28	22	37	25	21	25	30	13	6	0	19.50±11.19
Zygnema sp.	2	0	0	5	3	10	7	16	3	4	0	1	4.25±4.78
Total	39	55	93	116	159	173	123	120	112	58	33	6	90.58±52.18
Myxophyceae													
Anabaena sp.	1	0	4	7	5	7	3	2	1	3	1	3	3.08±2.31
Coccochloris sp.	3	0	0	3	2	0	5	3	2	3	0	0	1.75±1.71
Oscillatoria sp.	5	3	12	10	7	20	10	7	6	0	0	2	6.83±5.68
Phorimidium sp.	3	15	25	13	35	30	7	22	10	7	1	7	14.58±11.00
Total	12	18	41	33	49	57	25	34	19	13	2	12	26.25±16.72

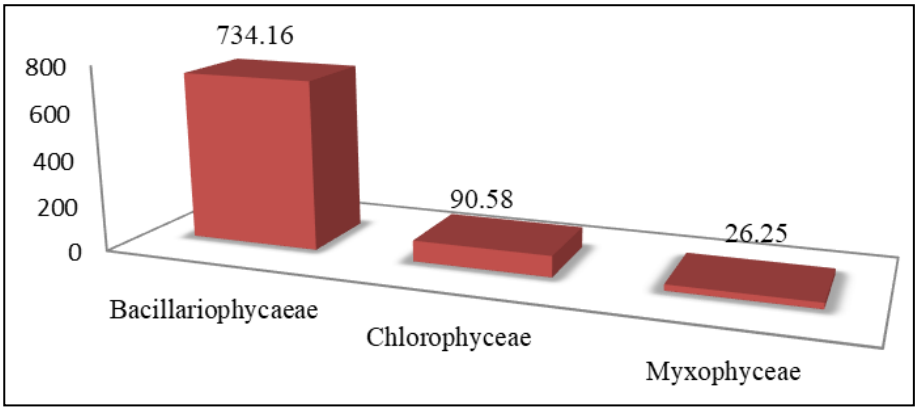


Fig 5: Mean monthly variation of Phytoplanktonic density (ind.m^2) dwelling Bhagirathi river during August 2016 to August 2017.

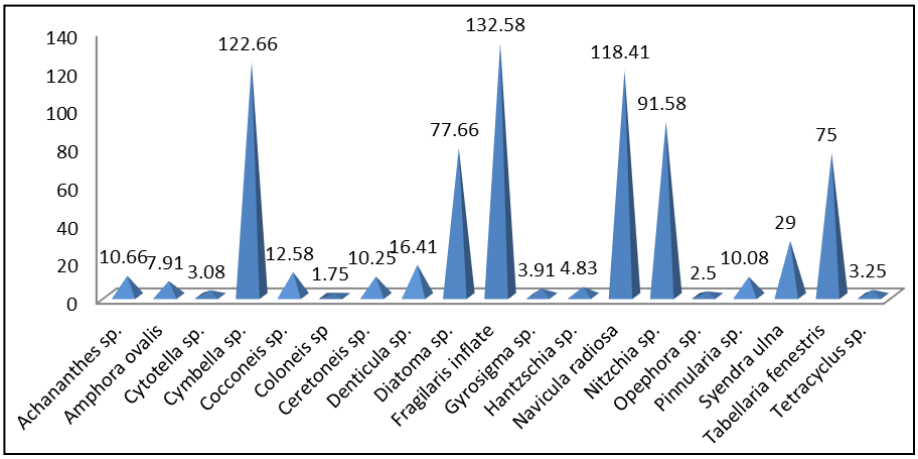


Fig 6: Mean monthly variation of Bacillariophyceae density (ind.m^2) dwelling Bhagirathi river during August 2016 to August 2017.

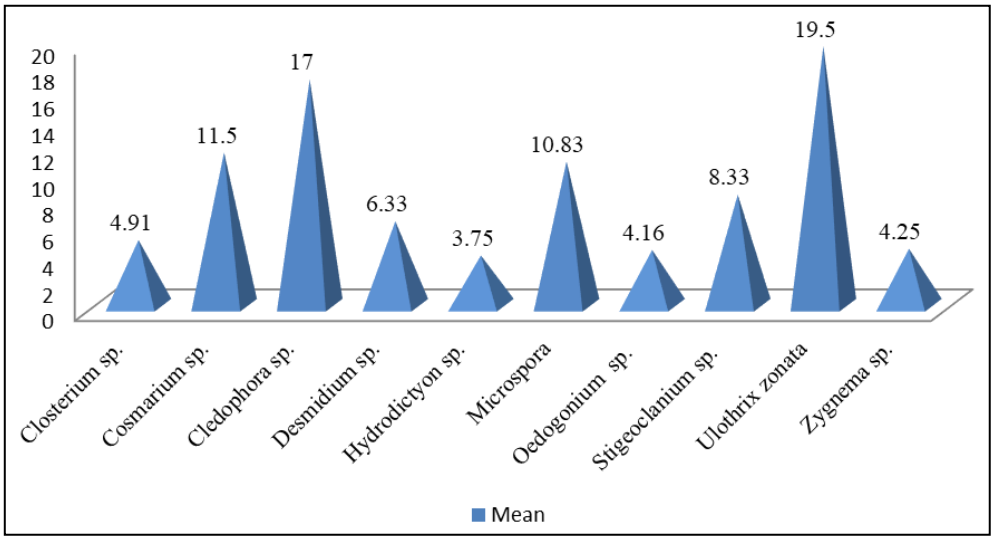


Fig 7: Mean monthly variation of Chlorophyceae density (ind.m^2) dwelling Bhagirathi river during August 2016 to August 2017.

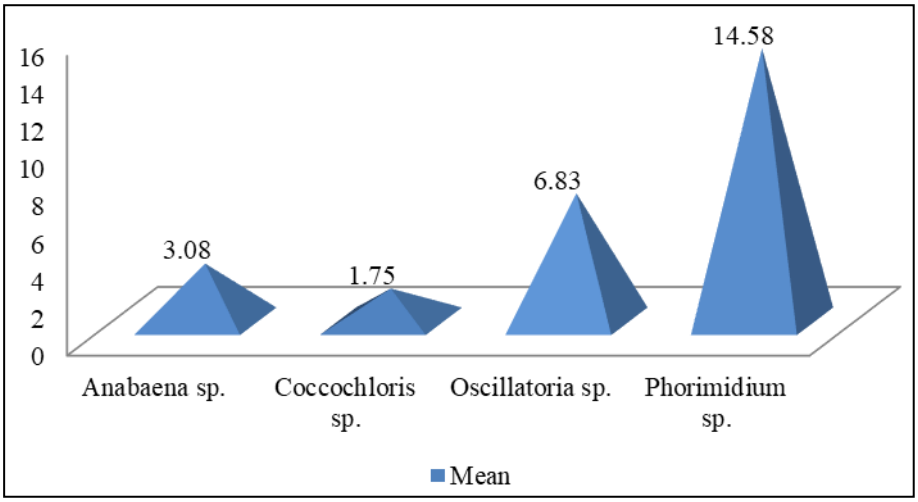


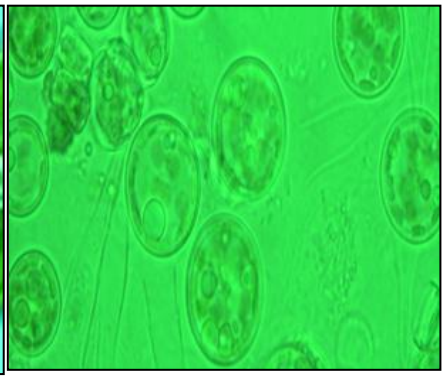
Fig 8: Mean monthly variation of Myxophyceae density (ind.m^2) dwelling Bhagirathi river during August 2016 to August 2017.

Table 5: Monthly mean variations in Shannon-Weiner diversity index of phytoplankton in Bhagirathi River.

Months	Shannon-Wiener diversity index
September	2.514
October	2.423
November	2.538
December	2.689
January	2.789
February	2.760
March	2.650
April	2.570
May	2.655
June	2.452
July	2.288
August	2.327
Mean+ S.D.	2.555±0.161

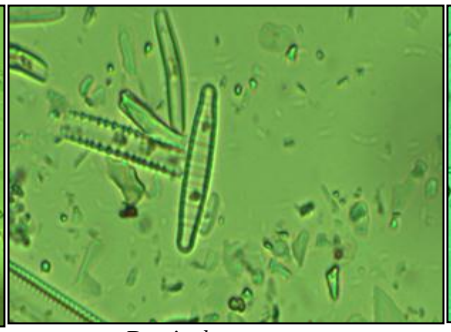
Achananthes sp.

Amphora sp.

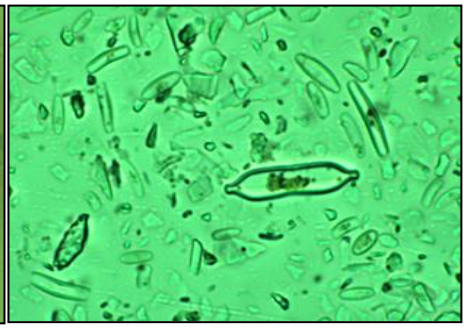


Cytotella sp.

Cymbella sp.



Denticula sp.



Diatoma sp.

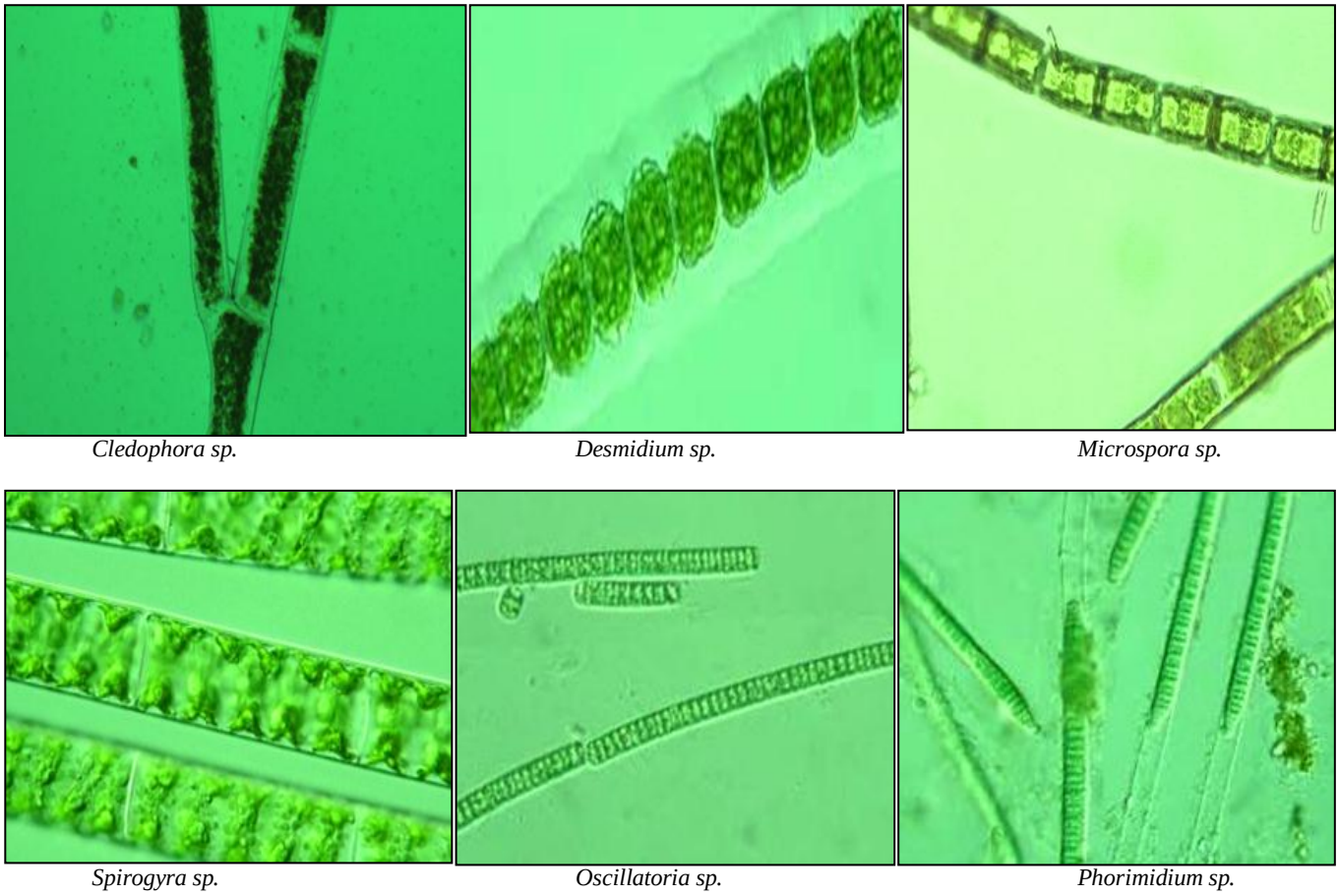


Fig 9: Different species of phytoplankton found in Bhagirathi river.

4. Discussion

4.1 Physiographic profile of sampling zones

Physiographic profile of Bhagirathi River at all the four inspecting zone has been presented in table 1. The zone Z1 was secured with good riparian vegetation and the bottom substrate covered with 31% boulders, 35% cobbles, 25% pebbles and 1% sand. A similar observation has been made by Sharma *et al*, (2008) [14] while working on the Preimpoundment study of Tehri reservoir. The sampling zone Z4 was likewise secured with good riparian vegetation and the bottom substrate covered with 40% boulders, 31% cobbles, 6.0% pebbles and 4% sand. But the sampling zones Z2 and Z3 devoid of riparian vegetation and fluctuating with bottom substrate, 67% boulders, 15% cobbles, 3% pebbles and 2% sand in zone Z2 while 52% boulders, 13% cobbles, 8% pebbles and 2% sand in zone Z3.

4.2 Physico-Chemical profile of Bhagirathi River

Monthly variation in physico-chemical profile of Bhagirathi river has been presented in Table 2 and 3. The air temperature was observed o be most extreme (30.2^0C) in August and least (13.8^0C) in January. A similar pattern was found with water temperature. The maximum water temperature (21.3^0C) was recorded in August and minimum (9.2^0C) in January. Water velocity was recorded to be maximum (3.9 m/sec.) in August and Minimum (0.9 m/sec.) in April. The water was exceedingly turbid (710.05 NTU) during August, while it was clear (10.99 NTU) in January. Overall turbidity was highest during monsoon months (July- August) due to highest precipitation in the catchment basin. Dissolved oxygen was recorded maximum (12.00 mg/l) in February and minimum (9.20 mg/l) in August. The concentration of phosphate was recorded to be highest (1.01 mg/l) in June and completely absent in month of February. Similarly, observation has been made by Singh and Kumar (2000) [16] while working on the ichthyofauna and ecology of hillstream of Garhwal Himalaya.

4.3 Diversity and Density of Phytoplankton's

33 genera were found over the span of the present study. Phytoplankton communities were represented by Bacillariophyceae (19 genera), Chlorophyceae (10 genera) and Myxophyceae (4 genera). Monthly mean variation in the density of phytoplankton has been presented in table 4. The density of phytoplankton was maximum (1548 ind.m^2) in February and minimum (179 ind.m^2) in August. Shannon Weiner index of phytoplankton abiding Bhagirathi river was recorded to be maximum (2.789) in January and minimum (2.288) in July (table 5). Dam and reservoirs are regarded as one of the most critical ecological factors contributing to changes in river ecosystem (Malik and Tyagi, 2014) [11]. The annual percentage composition revealed that the Bacillariophyceae contributed maximum (86%) to the total phytoplankton followed by Chlorophyceae (10%) and Myxophyceae (4%). Similarly, observation has been made by Malik and Bharti (2012) [9] while working on the status of plankton diversity and biological productivity of

Sahastradhara stream at Uttarakhand, India.

5. Conclusion

Based on the present study, it may be concluded that the Bhagirathi river hosts a number of plankton species. During the study, 33 genera Bacillariophyceae (19 genera), Chlorophyceae (10 genera) and Myxophyceae (4 genera) were recorded. The family Bacillariophyceae constituted the highest species number in all the season followed by the family Chlorophyceae whereas family Myxophyceae constituted lowest species number. It was also observed that anthropogenic activity altering the fine tune of the river ecosystem and established as a major cause of aquatic habitat alteration and thus many of the species were rare. It may also conclude that combined impact of DO, TDS, the velocity of water, turbidity and water temperature influenced the diversity of phytoplankton population. The present research data will be contributed significantly to assess the status of plankton diversity in relation to water quality dwelling Bhagirathi river.

6. Acknowledgement

The author is highly thankful to Prof. D.S. Malik for their guidance and constant supervision as well as for providing necessary information regarding the research.

7. Reference

1. Agarwal NK, Khanna DR, Thapliyal BL, Rawat US. Resources assessment and Potential of Hill Fisheries in Garhwal Himalaya Region of Uttranchal. Aquaculture Biodiversity, Present Scenario, Daya Publishing House, New Delhi, 2005, 81-97.
2. Agarwal NK, Singh G, Singh H. Present status of Ichthyofaunal diversity of Garhwal Himalayan river Bhilangana and its tributaries with reference to changing environment. Environment Conservation Journal. 2011; 12(3): 101-108.
3. APHA. Standard Methods for the Examination of Water and Waste Water. 22nd Edition, American Public Health Association, American Water Works Association, Water Environment Federation, 2012.
4. Badola SP. Fish fauna of Garhwal hills, part II Pauri Garhwal-U.P. Ind. J Zoot. 1975; XVI(1):57-70.
5. Bisht B, Badoni AK, Bahuguna SN. Seasonal Distribution and Relative Abundance of Fish Fauna of a Small Hill Stream Dangchaura Takoli Gad, along with River Alaknanda. Our nature. 2009; 7:182-186.
6. Dobriyal AK. An appraisal of the fishery resources of riverine ecosystem of Garhwal Central Himalaya. In. SD. Bhatt and RK. Pande eds., Ecology of the Mountain Water, Ashish Publishing House, New Delhi, 1991, 306-312.
7. Khanna DR, Badola SP. Fish fauna of the river Ganga at Haridwar. Aquatic Environment, Ashish Publishing House, 8/81 Punjab Bagh New Delhi, 1991, 90-93.
8. Lakra WS, Agarwal NK, Singh HR. Present status of Snow trout in Garhwal Himalaya. U.P.J. Zoology, 1987; 7(1):85-88.
9. Malik DS, Bharti Umesh. Status of plankton diversity and biological productivity of Sahastradhara stream at Uttarakhand, India J Appl. Nat. Sci. 2012; 4(1):96-103.
10. Malik DS. Population dynamics and conservation management of Himalayan mahseer (Tor species) in riverine aquatic ecosystem in Garhwal region of Uttarakhand (India). Journal of Applied and Natural Science. 2011; 3(1):9-101.
11. Malik DS, Tyagi D. A preliminary assessment of biodiversity and ecological services of Ramganga reservoir at Kalagarh Uttarakhand. Journal of Sustainable Environmental Research. 2014; 3(2):195-201.
12. Needham JG, Needham PR. A guide to freshwater biology. Holden Day Ins., San Francisco USA. 1962, 108.
13. Sharma RC. Icthyofauna of the snowfed river Bhagirathi of Garhwal Himalaya. Uttar Pradesh J Zool. 1984; 4(2):208-212.
14. Sharma RC, Bahuguna M, Chauhan P. Periphytonic diversity in Bhagirathi: preimpoundment study of Tehri dam reservoir. J Environ Sci. Eng. 2008; 50(4):255-62.
15. Shannon CE, Weaver W. The mathematical theory of communication. University of Illinois Pres, Urbana, 1949.
16. Singh HR, Kumar N. Some aspects of ecology of hillstreams. Stream morphology, zonation, characteristics, and adaptive features of ichthyofauna in Garhwal Himalaya In. JS Datta Munshi eds., Modern Trends In Fish Biology Research, Narendra Publishing House, New Delhi, 2000, 1-18.
17. Singh HR, Badola SP, and Dobriyal AK. Geographical distribution list of Icthyofauna of Garhwal Himalaya with some new records. J. Bombay Nat. Hist. Soc. 1987; 84(1): 126-132.
18. Singh N, Bahuguna SN, and Bhatt KC. The profile of river ecosystem, food and feeding habits of hill stream fishes and consequences of recent environmental degradation in Garhwal Himalaya. ACTA Ichthyologica et. Piscatorial. 1993; XXIII.
19. Tilak R, Baloni SP. On the food and feeding habits of hill stream fishes of Tehri-Garhwal, Uttar Pradesh 4th All India Seminar Icthyol; Dehradun. 1983; 68(Abstract).
20. Trivedy RK, Goel PK, Trisal CL. Practical methods in Ecology and Environmental Science, 1987.