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Biodiversity and spatio-temporal variation of periphyton of the River Ganga (Gangotri to Vindhyachal)

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Abstract
This is to study spatial and seasonal distribution pattern of periphytic taxa from Gangotri to Vindhyachal, as periphyton is important food for nibbling fishes like *Rita rita* and *Botia* sp. As diversity of river source create numerous habitat that contribute to structural diversity of spatial pattern in richness, density, taxonomic composition and distribution of periphytic flora. During summer periphytic deposition ranged from 170 ucm^{-2} (Gangotri), to 19180 ucm^{2}, in winter it ranged from 60 ucm^{-2} (Gangotri), to 17340 ucm^{-2} (Kanpur bb), in monsoon from 20 ucm^{-2} (Gangotri), to 17390 ucm^{-2} (Farrukhabad). Centers of higher abundance were Farrukhabad, Kannauj, Kanpur, Allahabad, Tehri and Srinagar. It can be concluded that Ganga at Kanpur and Farrukhabad exhibited continuous higher periphytic abundance (density) in all the seasons. Most of the centres revealed higher diversity during summer, except Kanpur where maximum diversity was noticed in winters. Total 77 periphytic taxa were recorded belonging to various taxonomic groups(Bacillariophyceae-28, Chlorophyceae-21, Myxophyceae-12, Dianophyceae-12, Euglenophyceae-3, Protozoa-8, and Rotifera-3) having various species Bacillariophyceae was dominant at all the centres in monsoon and winter, but in summer season some centers revealed dominance of Chlorophyceae (Srinagar ab and bb) and Myxophyceae (Deoprayag, Narora bb, Farrukhabad and Allahabad). In our studies most abundant periphytic diatoms were *Synedra, Cymbella Cyclotella, Gomphonema, Nitzschia and Navicula.* Among them *Synedra* was omnipresent. From Gangotri to Narora bb *Cymbella* contributed as dominant taxa, but from Kanpur to Vindhyachal it was not observed as dominant taxa, instead of *Cymbella, Nitzschia* was most abundant.

Keywords: ganga, periphyton, abundance, communities, biodiversity, spatio-temporal

1. Introduction
According to US Environmental protection Agency (EPA) periphyton is a complex assemblage of algae, cyanobacteria, macroinvertebrates, their secretions, and detritus attached to submerged surface, are direct users of its surrounding nutrients. It is a fundamental part of food web as the primary food source for all users including fish [5] Periphyton grown on natural stony substrate, show the impact of magnitude of organic pollution, habitat degradation and anthropogenic activities. River provides a system of continuous movement where any suspended particle will be carried out to the sea within a few days. Therefore, periphyton has gained much importance in case of river, being stable in nature, as compared to moving plankton. Hence there is an immense need to organise information on the, diversity of habitat, biotic diversity and structure of major biotic communities in natural or near natural conditions and their distribution in the river Ganga and their tributaries [9]. Periphyton is important food for nibbling fishes like *Rita rita* and *Botia* sp. Hydropower potential is an important asset for the economic development of Uttarakhand, hence multiple dams are planned on the river Ganga and its major tributaries. These dams are assessed as individual development projects which are socially and ecologically acceptable, and when the effects of the numerous individual developments are combined, impact may become larger, additive or even new and therefore significant. Massive urbanisation by irregular expansion without proper planning suddenly generated large volume of organic toxic waste, soil erosion accounting for high pollution load and degradation [3]. All discharge ultimately reaches the major river basin, threatening the habitats and their biodiversity. To understand periphytic community structure, their spatio-temporal variation, and diversity, present work was carried out in the river Ganga

from Gangotri to Vindhyachal as part of project at CIFRI, Allahabad. A study of such a long stretch, at a time, was carried out for the first time.

2. Materials and Methods

From Gangotri to Vindhyachal river length is approximate 1300 km. Samples were collected by scrapping one cm area of periphytic growth on submerged natural substrate like stone or wood/boat on river bank), during monsoon, winter and summer of 2015-16, from various centres of the river Ganga, including (Gangotri, Maneri above and below, Tehri above and below, Srinagar above and below, Alaknanda, Bhagirathi, Deoprayag, Haridwar above and below, Bijnore above and below, Narora above and below, Kanpur above and below, Farrukhabad, Kannauj, Allahabad, and Vindhyachal). Samples were fixed in 4% formalin and analysed by making one ml. volume and recorded as unit/cm2 under microscope [4].

2.1 Study area

From Gangotri to Vindhyachal (near Varanasi) river length is approximate 1300 km. The river Ganga (commonly called as Bhagirathi in the stretch Gangotri to Deoprayag. The entire stretch of river Ganga (main stem) can be viewed into three segments: A. Upper Ganga ≈ 294 km Gaumukh to Haridwar B. Middle Ganga ≈ 1082 km Haridwar to Varanasi C. Lower Ganga ≈ 1134 km Varanasi to Gangasagar. These three segments in their geomorphology and ecology. The river in the upper segment flows on steep and narrow bed, mostly rocks and boulders, carries cold water, is subjected to much less anthropogenic pollution, has highly sensitive and fragile ecosystem and biodiversity, and most importantly considered to have potential for harnessing hydropower. The river has turbulent flow and high velocities in most part of this segment. The habitat is stony intermingled with pebbles and sand. With limited nutrients in the water body. The most important modifications in the river system in this segment have occurred due to construction of dam for hydro- electric projects. The river in the middle segment enters and flows in plains, meandering mostly on bed of fine sand, has wide river bed and flood plain, and most importantly modified through human interventions in terms of huge quantities of water diversion/abstraction and subjected to high degree of pollutant loads from domestic, industrial and agricultural activities. Habitat details are given here-

2.1.1 Gangotri: Represents near natural and pristine conditions, Steep bed with rocks and boulders; Deep Gorges; Slight distributed pollution due to wastes from eating-joints on the Gangotri-shrine; guest houses. Problem of sanitation is most important.

2.1.2 Ab maneri: Modified to impoundment; Reverine environment shifting to lacustrine environment; Slight pollution due to domestic activities; High eutrophication potential.

2.1.3 Bl Maneri: Modified fluctuating flows depending upon power generation, River bed consisting of small stones and pebble; River in combination of riffles and pools. Slight pollution due to domestic activities.

2.1.4 Tehri AB: Modified to impoundment; Reverine environment shifting to lacustrine environment; Slight pollution due to domestic activities; High eutrophication potential; Potential for release of greenhouse gases due to decomposition of submerged biomass in the lake.

2.1.5 Tehri bl: Substantially modified fluctuating flows depending upon power generation at Tehri power plant; River bed consisting of small stones and pebble; River in combination of riffles and pools. Slight pollution due to domestic activities.

2.1.6 Deoprayag: Flow augmented due to confluence of Bhagirathi with Alaknanda; Hydroelectric projects under construction/proposed on Alaknanda and its tributaries may further influence hourly variation in flow.

2.1.7 Haridwar: River bed consisting of large and small pebble with some boulders and sand. Slight pollution due to domestic activities, bathing and other cultural/religious activities; Riverine ecosystem under stress due to frequent fluctuations in flow and water quality (e.g. temperature and turbidity).

2.1.8 Bijnor: Low flow during non-monsoon period. Wide flood plain and sandy bed with some pebbles; Moderate pollution due to domestic and agricultural activities. Subsequently flow modified through discharge of Ramganga waters through feeder canal;

2.1.9 Narora: Extremely low flows during non-monsoon period; Only occasional releases of water during non-monsoon period; Sandy bed; Significant degradation of river water quality.

2.1.10 Kannauj, Bithoor, Kanpur: Low flows during non-monsoon period; Only occasional increase in flows during non- monsoon period; Wide flood plain; Sandy bed; Extensive degradation of river water quality due to domestic and industrial wastes, dumping of solid wastes, animal wallowing, throwing of un-burnt dead bodies.

2.1.11 Allahabad & Vindhyachal: Only occasional increase in flows during non- monsoon period; Agricultural activities in river bed, predominantly Cucurbitaceous crops. Use of excessive pesticides, significant degradation of river water quality. Several important major and mega religious/cultural conglomeration held on the riverside. Discharge of domestic and some industrial wastes, dumping of solid wastes, animal wallowing, throwing of un-burnt dead bodies; Gradual but very slow recovery of the river system. Slight increase in flow due to joining of a major tributary Yamuna.

3. Results

3.1 Observations: Spatio- Temporal variation

Periphytic abundance of the river Ganga is presented in (Fig1). Total 77 periphytic taxa were recorded belonging to various taxonomic groups (Bacillariophyceae-28, Chlorophyceae21, Myxophyceae-12,Dianophyceae 12, Euglenophyceae 3, Protozoa 8, and Rotifera 3) having various species(Table-4).

3.2 Summer

In our present study of Gangotri to Vindhyachal, periphytic depositon ranged from 170 ucm^{-2} (Gangotri), to 19180 ucm^{-2} (Farrukhabad). Centers of higher periphytic population were

Tehri ab (16590 ucm^{-2}) Alaknanda (14780 ucm^{-2}), Kanpur above barrage (15870 ucm^{-2}), Kanpur Below barrage (10630 ucm^{-2}), Narora ab 9890 ucm^{-2}, and Kannauj 11620 ucm^{-2}. At some centers low deposition was observed like, Bl Maneri 200 ucm^{-2}), Chilyasisaur 410 ucm^{-2}, Bijnore bb 580 ucm^{-2}, Narora bb 720 ucm^{-2} (Table-1). During summer Bacillariophyceae ranged from 33.3% (Narora bb) to 100% Bl Maneri, Chlorophyceae, from 0.5% Haridwar bb.) to 48.6% (Srinagar bb,47.8% Srinagar ab.), Myxophyceae from 5.8% (bl Tehri) to 59.4%(Deoprayag). Euglenophyceae was present at few centers and ranged from 0.8% (Ab Tehri) to 29% (bl Tehri). Dianophyceae was observed at Srinagar, Kanpur and Kannauj only. Protozoans were maximum at Allahabad (15.7%) followed by Haridwar (2.3%) and Vindhyachal (1.7%). Rotifers were at Narora bb (4.1%) and Vindhyachal (4.8%) only. Qualitavely *Cymbella, Navicula, Nitzschia, Cyclotella, Synedra and Gomphonema* combinations were found as dominant periphytic taxa, during summer season, of the river Ganga. Number of taxa (Richness) varied between 4 (Gangotri), to 28 (Kanpur bb). Other diversity rich centers (Tehri ab 25, Bijnore ab 19, Haridwar bb 27, Alaknanda 25, Narora ab 27, Vindhyachal 21, Allahabad 23, Kanpur ab 23, Srinagar ab 20).

3.3 Winter

During winter season periphytic deposition ranged from 60 ucm^{-2} (Gangotri), to 17340 ucm^{2} (Kanpur bb). Centers of higher periphytic population were Kanpur bb 12740 ucm^{-2}, Srinagar ab (9600 ucm^{-2}) Srinagar bb (9760 ucm^{-2}) and Haridwar (5130 ucm^{-2}). At some centers low deposition was observed like, ab Maneri 70 ucm^{-2}, Bl Maneri 600 ucm^{-2}), Chilyasisaur 110 ucm^{-2}, Bijnore bb 760 ucm^{-2}, Narora bb 760 ucm^{-2}, Deoprayag 570 ucm^{-2}, (Table-2). During summer Bacillariophyceae ranged from 55.4% (Kannauj) to 100% Gangotri, Chilyasisaur, ab and Bl Maneri, Chlorophyceae, from 0.3% Kanpur ab) to 7.4% (Vindhyachal), Myxophyceae from 1.8% (Srinagar bb, Haridwar bb) to 37.1% (Bijnore bb). Euglenophyceae was present at few centers and ranged from 0.2% (Ab Tehri) to 37% (Kannauj). Dianophyceae, Protozoans and Rotifers were could not be observed in winters. Qualitavely *Cymbella, Navicula, Nitzschia, Cyclotella, Synedra and Gomphonema* combinations were found as dominant periphytic taxa, during winter season, of the river Ganga. Number of taxa (Richness) varied between 1(Gangotri), to 36 (Kanpur bb), 35 (Kanpur bb). Above barrage area were found as diversity rich centers (Tehri ab 15, Bijnore ab 18, Haridwar ab 20, Bhagirathi 19, Narora ab 16).

3.4 Monsoon

During winter season periphytic deposition ranged from 20 ucm^{-2} (Gangotri) to 17390 ucm^{-2} (Farrukhabad). Centers of higher periphytic population were Kanpur ab 7930, Kanpur bb 7840 ucm^{-2}, Bijnore ab (11230 ucm^{-2}) Kannauj (17390ucm^{-2}) and Deop (8060 ucm^{-2}). At some centers low deposition was observed like, ab Maneri 1420 ucm^{-2}, Bl Maneri 770 ucm^{-2}, Bhagirathi 840ucm^{-2}, Narora bb 420 ucm^{-2}, Alaknanda 380ucm^{-2} (Table-2). During monsoon, Bacillariophyceae ranged from 56.6%(Kanpur ab) to 100% Gangotri, Tehri Bb, Chilyasisaur, (99%) ab Maneri (98%), Chlorophyceae, from 0.6% Chilyasisaur to 39% Kanpur ab Myxophyceae from 1.1% (Haridwar bb) to 48.1% (Srinagar ab). Euglenophyceae was present at few centers Farrukhabad (3) and Allahabad (0.9) Rotifers were present at Farrukhabad only. Qualitavely *Cymbella, Navicula, Nitzschia, Cyclotella, Synedra and Gomphonema* combinations were found as dominant periphytic taxa, during summer season, of the river Ganga. Number of taxa (Richness) varied between 1(Gangotri), to Bijnore (24), 22 (Kanpur bb), Kannauj 22, Vindhyachal 19, Faruukh 18, Ald 17, Srinagar ab 19, Haridwar ab 16. In this season centers of lower stretch were found more diversity rich. *Cymbella, Navicula, Nitzschia, Cyclotella, Synedra and Gomphonema* combinations were found as dominant periphytic taxa, during monsoon also.

3.5 Confluence of Bhagirathi and Alaknanda at Deoprayag:

This can be observed from Table 5 that, Percentage contribution of diatoms are more in Bhagirathi (91.9%), in comparison to Alaknanda (73.1%), while at confluence point in Deoprayag, it was (73.9%). Increase in Myxophyceae at Deoprayag after confluence was also noticed (Fig 4A, 4B, 4C). Reduction in diversity at confluence was noticed. During winter Bhagirathi was rich in diversity/ taxa (Bhg. 19, Alk. 19, confl Deop. 7) while in summer Alaknanda was rich (Alk.25 taxa, Bhg. 16, Cofl. 13).

3.6 Impact of Dam

Impact of dam was more visible in summers as compared to winters and monsoon. In most of the above barrage areas revealed higher density and diversity of periphytic flora, except few exception of Srinagar (Monsoon) and Haridwar (summer). Increase in Chlorophyceae contribution in below barrage area (Fig.5A) and increase in Myxophyceae contribution (Fig5B.) in above barrage area was recorded. However Bacillariophyceae dominated in above and below barrage of the river and Euglenophyceae was not affected by this situation.

4. Discussion

Knowledge of ecology helps predictive abilities for resource management. Through physico-chemical interactions with the surrounding environment and biota, periphyton affects many biological communities [5] and ecosystem features including nutrient concentration. They provide dissolved oxygen through photosynthesis, to sustain much of the aquatic life in its surroundings. Furthermore, because periphyton responds rapidly to change environment, it is indicator of changing conditions [8]. Centers of higher abundance were Farrukhabad, Kannauj, Kanpur, Allahabad, Tehri and Srinagar. This can be concluded that Ganga at Kanpur and Farrukhabad exhibited continuous higher periphytic abundance (density) in all the seasons. Higher values in hill stream was also observed by [6] as in our present study of Tehri jheel. Most of the centers revealed higher diversity during summer, except Kanpur where maximum diversity was noticed in winters. Bacillariophyceae was dominant at all the centres in monsoon and winter, but in summer season some centers revealed dominance of Chlorophyceae (Srinagar ab and bb) and Myxophyceae (Deoprayag, Narora bb, Farrukhabad and Allahabad). Contribution of Myxophyceae (Fig 3.) was maximum in summer, followed by monsoon and winter, indicating deposition of organic / nitrogenous substances through anthropogenic activities at river banks.

Most of the centers of the river Ganga revealed dominance of Bacillariophyceae [1, 2, 12] except Srinagar bb (Chlorophyceae Dominant), Narora bb, in upper stretch, Farrukhabad and Allahabad (Myxop. Dominant). In middle stretch Myxophyceae reached its peak at Farrukhabad. However

Eugleophyceae exhbited their presence from Maneri onwards, reached maximum at below Tehri area (29.1%). Our results indicated that the structure of the periphytic community of the river Ganga is mainly driven by seasons and microhabitat types, as they were more influenced by their environmental gradients like change in water chemistry, nutrient concentration and hydrologic condition [5]. Low periphytic deposition at some centers of upper stretch may be attributed to very fast current like Chilyasisaur.

This can be seen from Table 4 that, up to Narora bb *Cymbella* contributed as dominant taxa, but from Kanpur to Vindhyachal it was not observed as dominant taxa, instead of *Cymbella, Nitzschia* was most abundant. In our studies most abundant periphytic diatoms were *Synedra, Cymbella Cyclotella, Gomphonema, Nitzschia and Navicula.* Among them *Synedra* was omnipresent. Dominance of Nitzschia was at Srinagar, Haridwar and Kanpur. As Nitzschia tolerates pollution and prefer phosphate rich waters [7]. River Ganga is rich in nutrients and sun light, hence only controlling factor is microhabitat and quality of runoff water from surrounding areas, which affect pH and type of flora and fauna. Protozoans were also recorded from Haridwar, to Vindhyachal. Rotifers were noticed at Narora, Allahabad and Vindhyachal centers. Rotifers are primary consumers; need food and shelter for survival and periphytic flora provide both their requirements. Presently diversity rich centers were Tehri, Narora, Kanpur, and Allahabad. Accumulation of nutrients and slow current favoured algal growth, yet stagnation favoured growth of Myxophyceae. Presence of Euglenophyceae, Myxophyceae and Protozoa at Haridwar and Allahabad centers.

River Alaknanda at (Srinagar revealed different pattern of biodiversity, as compositions of the periphytic taxa were entirely different from Bhagirathi. Differences in community structure and diversity at Srinagar centre may be due to, Alaknanda which is a tributary of the river Ganga having different origin and path [10, 11]. So periphytic taxa do not show much impact of dam as they are not the part of flowing water, they grow independently. But they are potential organisms to show anthropogenic impact by retaining surrounding water quality for a longer period, while planktonic organisms flow with the water current. Therefore their abundance and quality are decided by microhabitat which play important role [12] in spatial distribution of periphytic flora/taxa.

Table 1: Periphytic abundance (U/cm^2) and composition (%) in summer

	Gangotri	**ab Maneri2**	**bl Maneri**	**abTeheri**	**bl Teheri**	**Chilasis.**	**Alknanda**	**Bhagirathi**	**deoprayag**	**Sring ab**	**Sring bl**	**Harid. ab**
Bacillariophyceae	82.5	81.3	100	87.3	51.2	45.5	50.6	85.6	35.6	46.5	37	78.9
Chlorophyceae	5.8	6.7	0	4.4	13.9	0	12.8	6.5	4.9	37.8	48.6	1.1
Myxophyceae	11.7	6.7	0	6.9	5.8	36.3	30.8	6.9	59.4	6.8	6.2	20
Euglenophyceae	*0*	5.3	0	0.8	29.1	18.1	5.7	0.8	0	3.1	3.1	0
Dinophyceae	0	0	0	0	0	0	0	0	0	5.8	5.1	0
Protozoa	0	0	0	0	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0	0	0	0
T. Periphyton (u/cm2)	170	590	200	16590	860	410	14780	2300	1010	5160	2670	4550
contn.												
	Harid. bl	Bijn. Ab	Bijn. Bl	Narora ab	Narora bl.	Kanp. Ab	Kanp.bb	Kanj.	farukh.	Ald rs	Vindh.	
Bacillariophyceae	89.6	47.3	77.6	73.4	33.3	80.7	78.64	78.3	17.3	18.4	71.7	
Chlorophyceae	0.5	11.9	0.0	2.32	9.7	7.05	9.3	4.7	2.8	14.6	13.4	
Myxophyceae	7.4	35.1	22.4	23.3	50	10	7.61	10.1	80.0	49.9	8.2	
Euglenophyceae	0	4.1	0.0	0	2.7	1.82	3.6	4.3	0.0	0.0	0	
Dinophyceae	0	0.0	0.0	0	0	0.31	0.56	2.6	0.0	0.0	0	
Protozoa	2.31	1.6	0.0	0.4	0	0	0.18	0.0	0.0	15.7	1.7	
Rotifera	0	0.0	0.0	0.5	4.1	0	0	0.0	0.0	1.3	4.8	
T. Periphyton (u/cm2)	3880	3700	580	9890	720	15870	10630	11620	19180	4450	2900	

Table 2: Periphytic abundance (U/cm2) and composition (%) in winter.

	Gangotri	**ab Maneri2**	**bl Maneri**	**abTeheri**	**bl Teheri**	**Chilasis.**	**Alknanda**	**Bhagirathi**	**deoprayag**	**Sring ab**	**Sring bl**	**Harid.ab**
Bacillariophyceae	100	100	100	99.7	65.2	100	87.3	94.9	87.7	96.8	92	82.8
Chlorophyceae	0	0	0	0	3.7	0	8.3	2.5	0	0	0	1.5
Myxophyceae	0	0	0	0	31	0	4.4	2.52	12.2	1.8	6.14	15.5
Euglenophyceae	0	0	0	0.2	0	0	**0**	0	0	1.25	1.8	0
T. Periphyton (u/cm2)	60	70	600	3780	1610	110	1340	3960	570	9600	9760	5130
Contn.	Harid. bl	Bijn. Ab	Bijn. Bl	Narora ab	Narora bl.	Kanp. Ab	Kanp.bb	Kanj.	farukh.	Ald rs	Vindh.	
Bacillariophyceae	98.2	93.5	62.9	99.3	100	94.8	86	55.2	74.8	85.9	74.2	
Chlorophyceae	0	0.4	0	0.6	0	0.3	9	1.6	2	0	7.4	
Myxophyceae	1.8	1.3	37.1	0	0	3.3	2.3	6	8.3	4.3	18.2	
Euglenophyceae	0	4	0	0	0	1.4	2.2	37	14.6	9.7	0	
T. Periphyton (u/cm2)	1670	2160	270	3130	760	17340	12740	2480	2390	2060	1750	

Table 3: Periphytic abundance (U/cm^2) and composition (%) in monsoon

	Gangotri	ab Maneri2	bl Maneri	abTeheri	bl Teheri	Chilasis.	Alknanda	Bhagirathi	deoprayag	Sring ab	Sring bl	Harid.ab
Bacillariophyceae	100	98.59	96.10	98.38	100.00	99.15	81.58	95.24	98.64	100.00	50.73	97.14
Chlorophyceae	0	1.41	3.90	0.00	0.00	0.63	0.00	0.00	0.00	0.00	1.10	1.76
Myxophyceae	0	0	0	0	0	0	18.42	4.76	1.36	0	48.17	1.10
Euglenophyceae	0	0	0	0	0	0	0	0	0	0	0	0
Rotifera	0	0	0	0	0	0	0	0	0	0	0	0
T. Periphyton (u/cm2)	20	1420	770	4930	3810	4730	380	840	8060	5420	5460	4540
Contn.												

	Harid. bl	Bijn. Ab	Bijn. Bl	Narora ab	Narora bl.	Kanp. Ab	Kanp.bb	Kanj.	farukh.	Ald rs	Vindh.	
Bacillariophyceae	97.42	87.27	89.68	83.27	83.33	56.62	88.90	86.31	79.46	68.36	83.27	
Chlorophyceae	2.58	2.94	3.23	1.73	4.76	39.09	4.72	1.32	0.41	18.87	8.19	
Myxophyceae	0.00	9.80	7.10	15.00	11.90	4.29	4.08	12.36	17.04	12.58	8.54	
Euglenophyceae	0	0	0	0	0	0	0	0	3	0.09	0	
Rotifera	0	0	0	0	0	0	0	0	0.09	0	0	
T. Periphyton (u/cm2)	2330	11230	1550	5200	420	7930	7840	17390	21710	9220	8430	

Table 4: Periphytic taxa of the river Ganga

Bacillariophyceae	***Chlorophyceae***	***Conti...***
Gomphonema	*Cosmarium*	*Oscillatoria*
Nitzschia	*Sorastrum*	*Nostoc*
Cymbella	*Ulothrix*	*Schizothrix*
Meridion	*Microspora*	*Rivularia*
Tabellaria	*Pandorina*	*Spirulina*
Navicula	*Ankistrodesmus*	*Dianophyceae*
Synedra	*Eudorina*	*Peridinium*
Tryblionella	*Scenedesmus*	*Ceratium*
Cyclotella	*Westella*	*Euglenophyceae*
Gyrosigma	*Oedogonium*	*Euglena*
Eunotia	*Pediastrum*	*Lepocynclis*
Surierella	*Geminella*	*phacus*
Denticula	*Actinastrum*	*Protozoa*
Achanthes	*Tribonema*	*Chlamydomonas*
Cocconeis	*Coelastrum*	*Amoeba*
Pinnularia	*Kirchneriella*	*Paramoecium*
Amphora	*Protococcus*	*Physarum*
Melosira	*Spirogyra*	*Didinium*
Stauroneis	*Micrasterias*	*Epistylish*
Epithemia	*Staurastrum*	*Zoozanthium*
Asteroinella	*Myxophyceae*	*Diffusia*
Fragilaria	*Lyngbya*	*Rotifera*
Diatoma	*Phormidium*	*Lecane*
Caloneis	*Nodularia*	*Euchlaneis*
Neidium	*Aphanizomenon*	*Brachionus*
Frustulia	*Microcystis*	
Stephanodiscus	*Merismopedia*	
Rhopalodea	*Anabaena*	

Table 5: No. of taxa and Algal succession at each centre of the R.Ganga

	Gangotri	**Ab Maneri2**	**Bl Maneri**	**Ab Teheri**	**bl Teheri**	**Chilasis.**	**Alknanda**	**Bhagirathi**	**deoprayag**	**Sring ab**	**Sring bl**	
Monsoon season												
No. of taxa	1	11	6	10	6	14	8	8	7	10	19	
Dominant taxa	*Synedra*	*Synedra*	*Cymbella*	*Cyclotella*	*Cyclotella*	*Cymbella*	*Cyclotella*	*Cymbella*	*Cymbella*	*Cymbella*	*Gomphon*	
		Cymbella	*Synedra*	*Synedra*	*Navicula*	*Navicula*	*Cymbella*	*Melosira*	*Gomphon*	*Cyclotella*	*Cymbella*	
		Cyclotella	*Cyclotella*	*Cymbella*	*Synedra*	*Nitzschia*	*Nitzschia*	*Synedra*	*Synedra*	*Synedra*	*Synedra*	
Winter season												
No. of taxa	1	5	7	15	13	6	**10**	19	7	23	16	
Dominant taxa	*Meridion*	*Diatoma*	*Tryblionella*	*Asterinella*	*Cyclot*	*Tryblionella*	*Cymbella*	*Cyclot*	*Cyclot*	*Cymbella*	*Cymbella*	
		Eunotia	*Cyclotella*	*Gompho*	*Melosira*	*Synedra*	*Cyclotella*	*Trybli*	*Diatoma*	*Cyclot*	*Synedra*	
				Cymbella			*Synedra*	*Synedra*	*Cymbella*	*Navicula*	*Diatoma*	
Summer season												
No. of taxa	4	8	4	25	13	6	25	16	13	20	16	
Dominant taxa	*Meridion*	*Gomphonema*	*Navicula*	*Cymbella*	*Synedra*	*Phormidium*	*Cymbella*	*Lyngbya*	*Cymbella*	*Microspora*	*Microspora*	
	Synedra	*cymbella*	*Meridion*	*Navicula*	*Ankistrodesmus*	*Euglena*	*Navicula*	*Phormidium*	*Cyclotella*	*Scenedesmus*	*Achanthes*	
				Nitzschia	*Euglena*		*Oscillatoria*	*Oscillatoria*	*Lyngbya*	*Nitzschia*	*Cymbella*	
Contn.	Harid.ab	Harid. bl	Bijn. Ab	Bijn. Bl	Narora ab	Narora bl.	Kanp. Ab	Kanp.bb	Kannauj	Farrukhabad	Allahabad	Vindhy.
Monsoon season	16	14	24	14	15	8	14	22	22	18	17	19
No. of taxa	*Cymbella*	*Navicula*	*Cymbella*	*Fragilaria*	*Navicula*	*Navicula*	*Navicula*	*Navicula*	*Synedra*	*Nitzschia*	*Nitzschia*	*Cyclotella*
Dominant taxa	*Cyclotella*	*Gomphon*	*Navicula*	*Cymbella*	*Synedra*	*Synedra*	*Synedra*	*Synedra*	*Cyclotella*	*Navicula*	*Navicula*	*Synedra*
	Gomphon	*Cymbella*	*Gomphon*	*Navicula*	*Cymbella*	*Cymbella*	*Nitzschia*	*Cyclotella*	*Gyrosigma*	*Synedra*	*Synedra*	*Nitzschia*
Winter season	20	14	18	6	16	8	35	36	22	24	16	15
No. of taxa												
	Navicula	*Navicula*	*Cyclot*	*Nitzschia*	*Cyclot*	*Cyclot*	*Nitzschia*	*Nitzschia*	*Nitzschia*	*Nitzschia*	*Melosira*	*Nitzschia*
Dominant taxa	*Cymbella*	*Synedra*	*Synedra*	*Cyclot*	*Navicula*	*Synedra*	*Cyclot*	*Cyclot*	*Cyclot*	*Synedra*	*Nitzschia*	*Cyclot*

			Gompho				*Synedra*	*Synedra*	*Synedra*	*Cyclot*	*Synedra*	
Summer season	13	27	19	11	27	15	23	28	16	18	23	21
No. of taxa	*Cymbella*	*Cymbella*	*Cymbella*	*Cymbella*	*Cymbella*	*Rivularia*	*Nitzschia*	*Nitzschia*	*Melosira*	*Phormidium*	*Melosira*	*Nitzschia*
Dominant taxa	*Nitzschia*	*Cyclotella*	*Cyclotella*	*Gomphonema*	*Cyclotella*	*Phormidium*	*Navicula*	*Navicula*	*Cyclotella*	*Navicula*	*Phormidium*	*Synedra*
	Navicula	*Phormidium*	*Cosmarium*			*Meridion*	*Phormidium*	*Cyclotella*		*Paramoecium*		*Cyclotella*

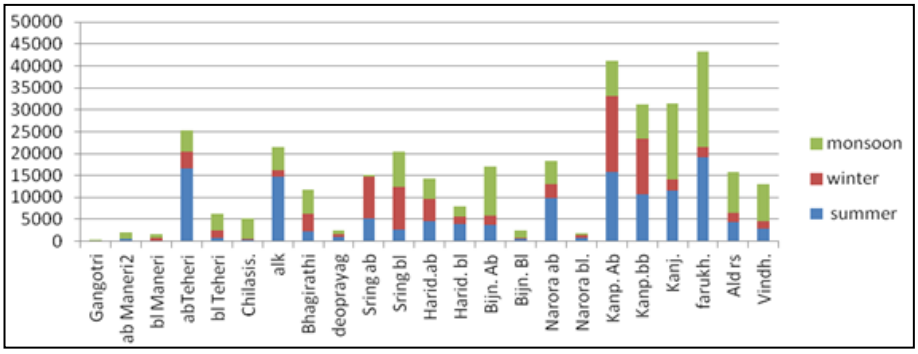

Fig 1: Periphytic abundance (u/cm2) at each centre in monsoon, winter and summer

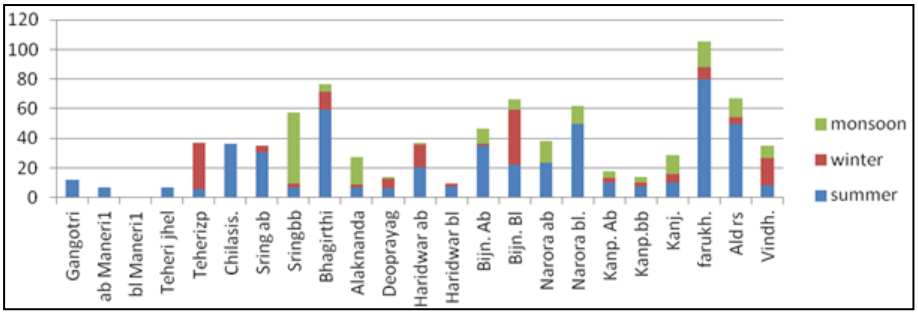

Fig 2: Myxophyceae contribution (%) in periphytic community

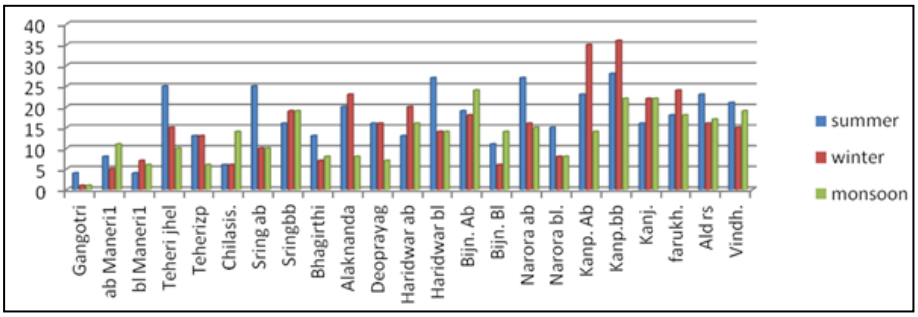

Fig 3: No. of periphytic taxa at each centre in monsoon, winter and summer

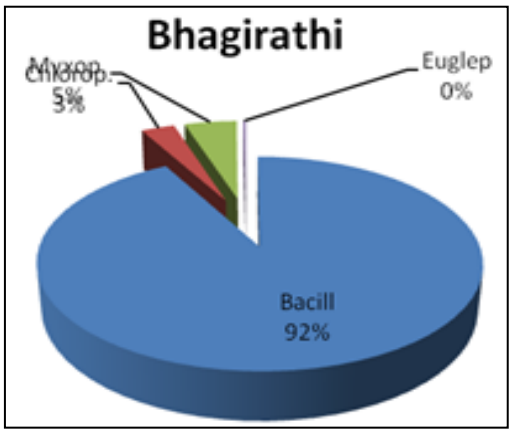

Fig 4A: Algal composition in Alaknanda

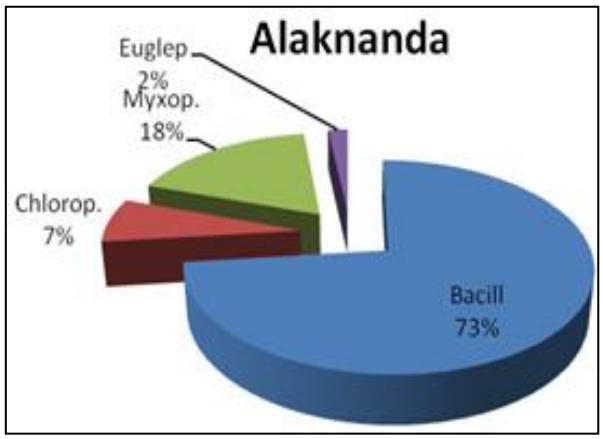

Fig 4B: Algal composition in Bhagirathi

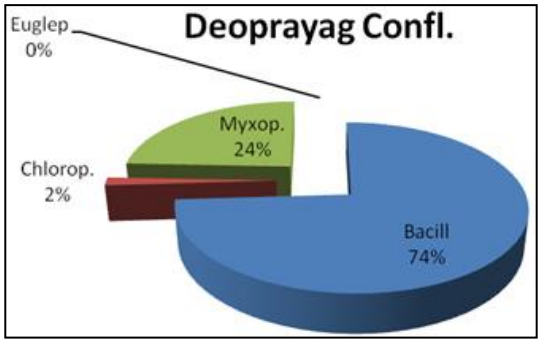

Fig 4C: Algal composition in at Deoprayag

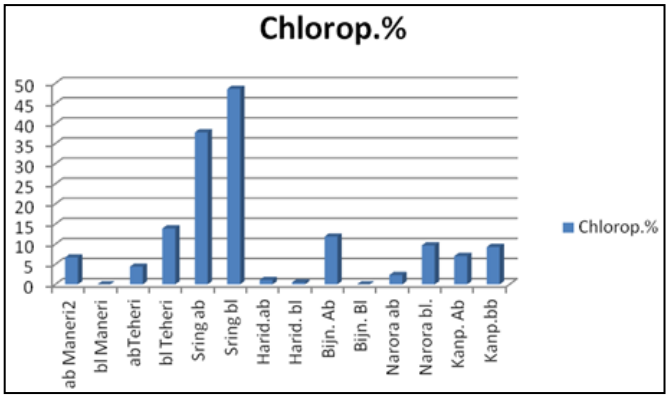

Fig 5A: Impact of dam increase of Chlorophyceae in below barrage area

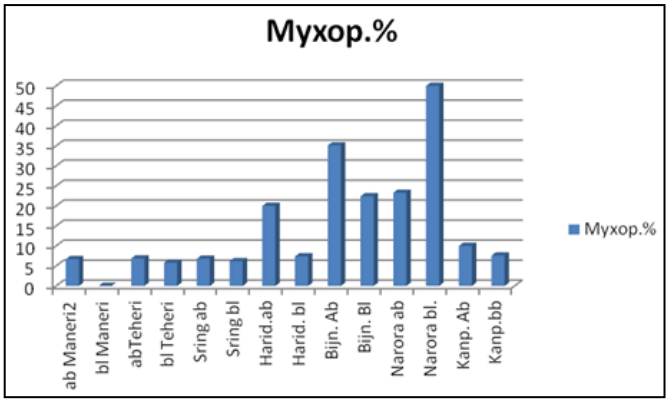

Fig 5B: Impact of dam increase of Myxophyceae in above barrage area.

5. Conclusion

From present study it's very clear about periphytic community structure, their spatio-temporal variation, and diversity at different sampling stations from Gangotri to Vindhyachal which will be helpful for carrying further research on dipper aspects. Hence present study revealed that river Ganga is rich for food for nibbling fishes like *Rita rita* and *Botea sps*.

6. Acknowledgement

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7. References

1. Singh BK, Kalpana S, Panwar RS. Periphytic structure of River Ghagra with special reference to its impact on river Ganga. J Inland Fish. Soc. India. 2002; 35(1):39-41.
2. Singh BK, Kalpana S, Joshi KD, Shrivastava SK. Biotic parameters of the river Yamuna in relation to pollution status. J Inland Fish. Soc. India. 2015; 47(2):51-58.
3. Boston HL Stewart AJ. Evaluating direct toxicity and food chain effects in aquatic systems using natural periphytic communities. Plant for toxicity assessment (Eds.; J. W. Horsuch W. R. Lower, W. Wang and M. A. Levis) ASTM Philadelphia. 1991; 2:126-145.
4. Edmondson WT (Ed). Freshwater Biology.2nd edition Joh Eiley & Sons, inc. New York and London, 1959, 1148.
5. Gaiser E. Periphyton as an indicator of restoration in the Everglades. Ecological indicators. Supplement 1 Amsterdam, Netherland: Elsevier publisher, 2008, 9(6).
6. Gurumayum SD, Daimari P, Choudhury M. Abundance and quality compositon of periphyton communities in hill stream of Arunachal Pradesh. J Envt. Res. 2000; 10:113-116.
7. Jüttner I, Rothfritz H, Ormerod SJ. Diatoms as indicators of river quality in the Nepalese Middle Hills with consideration of the effects of habitat-specific sampling. – Freshwater Biol. 1996; 36:101-112.
8. Laal AK, Sarkar A, Sarkar SK, Shah KL. Species diversity of periphyton as an index of pollution of the River Ganga. J Inland Fish. Soc. India. 1982; 14(1):44-51.
9. Nautiyal P. Food chains of Ganga River ecosystem in the Himalayas. Aquatic ecosystem health and Management. 2010; 13(4):362-373.
10. Nautiyal P, Rachna Nautiyal, Vijay Praksh Semwal, Ashhesh Shivam Misra, Jyoti Verma, Deviprasad Uniyal *et al*. Ecosystem health indicators in the Ganga river Basin(Uttarakhand India); Aquatic ecosystem health and Management. 2013a; 16:362-373.
11. Nautiyal P, Bhatt JP, Kishore B, Rawat BS, Rachna Nautiyal, Badoni K, Singh HR. Altitudina variation in phytobenthos density and its components in the coldwater mountain river Alaknanda-Ganga. Phycos. 2013b; 36:81-88.
12. Kumar R, Hasko Nesemann, Gopal Sharma, Li-Chun Tseng, Prabhakar AK, Roy SP. Community structure of macrobenthic invertibrates in the River Ganga in Bihar, India Aquatic Ecosystem Health and Management. 2013; 16:385-394.
13. Sukumaran PK, Shankuntala Parameswaram S. Production of periphyton in a lentic habitat in Bangalora. J Inland Fish. Soc. India. 1996; 28:28-30.