International Research Journal of Biological Sciences _____ ISSN 2278-3202
Vol. **3(9),** 65-78, September **(2014)** *Int. Res. J. Biological Sci.*

Studies on Diversity and Abundance of Phytoplankton in Glacial fed mountainous Goriganga River of Kumaun Himalaya, Uttarakhand, India

Ashok Kumar
Department of Zoology, Kumaun University Soban Singh Jeena Campus Almora -263601, INDIA

Available online at: www.isca.in, www.isca.me
Received 1st April 2014, revised 14th June 2014, accepted 5th July 2014

Abstract

The paper presents the results that was conducted to analyze the phytoplankton diversity, abundance, monthly and seasonal variations including similarity and dissimilarity index in glacial fed mountainous Goriganga River of Kumaun Himalaya, Uttarakhand" (India) from July-2006 to June-2008. Samples for monitoring phytoplankton diversity and abundance were collected monthly from three sampling spots (spot-1, Jauljibi-600msl; spot-2, Baram-900msl and spot-3, Madkot-1300msl) with in a river stretch of 44 km in the Goriganga river. For the last two years studies on qualitative and quantitative estimation of phytoplankton revealed that some total 46 genera of phytoplankton were encountered during the course of study. Diatoms (Bacillariophyceae) accounted for the major share of phytoplankton diversity, represented by 27 genera (56.69%); green algae (Chlorophyceae) were appeared to be the second dominating group in terms of phytoplankton diversity, represented by 15 genera (32.60%) while the qualitative analysis of blue-green algae (Cyanophyceae) constituted only 04 genera (8.69%). During the course of study, phytoplankton showed the distributional pattern as: Bacillariophyceae (56.69%) > Chlorophyceae (32.60%) > Cyanophyceae (8.69%). The maximum phytoplankton population was recorded in winter season whereas minimum phytoplankton population was recorded in monsoon season. In the present study maximum similarity (s = 0.47 and s = 0.57) was observed among the taxa of bacillariophceae and cyanophyceae during 2006-07 and 2007-08 respectively while minimum similarity (s = 0.25 and s = 0.38) was recorded among the taxa of cyanophyceae and chlorophyceae during 2006-07 and 2007-08 respectively.

Keywords: Diversity, abundance, phytoplankton, glacial fed, goriganga River, Kumaun Himalaya.

Introduction

The Himalayan ecosystem is one of the most important and most threatened of the life support systems on earth. In the shadow of Himalaya live more than 150 million people, some of them are the poorest in the world. The rivers which arise in the Himalayas and flows down in to Gangetic plains, support agriculture and sustain these people. Uttarakhand- the land of celestial beauty, blessed with magnificent glaciers, majestic snow-clad mountains, gigantic and ecstatic peaks, valleys of flowers, skiing slopes and dense forests. Uttarakhand became the 27th North-western central Himalayan state of the republic India on 9th November 2000, previously known as Uttaranchal is well known for its fresh water bodies (lotic and lentic) and always attracted the attention of fishery biologists because of its diversified flora and fauna and ecological parameters with characteristics features. Among many large rivers, the Goriganga River is lying in Munsiyari tehsil of the Pithoragarh district, highly remote part of Uttarakhand state in north India, falls between the latitudes 29˚ 45′ to 36˚ 36′ N and longitudes 79˚ 59′ to 80˚ 45′. The Goriganga river originates from a dual source in a glacier near south of Untadhura ridge feeding the eastern branch and another glacier near Milam (3600 msl) just north east of Nanda Devi, feeding the western branch. Historically Uttarakhand is believed to be the land where the Vedas and Shastras were composed and the great epic, the Mahabharata was written.

It is a well established fact that more than 75% of freshwater fishes which are largely utilized by human beings as food feed on plankton at one or the other stage of their life cycle[1]. The ecological study of plankton is therefore clearly related to the improvement of pisciculture. Phytoplankton are the primary producers of water bodies, these are the main source of food directly or indirectly for various animal groups[2]. Phytoplanktons not only serve as food for aquatic animals, but also play an important role in maintaining the biological balance and quality of water[3]. Phytoplankton play the role of basic component of the aquatic ecosystem and up to much extent, responsible for the primary production in the river, but the productivity potential of any lotic system is influenced by a complex interplay of its physical and chemical attributes. Several investigations have been made on ecology of Plankton[2-8]. A number of workers also reported various species of plankton in Kumaun and Garhwal Himalaya[9-12] , but there is hardly any study on the diversity and abundance of phytoplankton in Goriganga river of Kumaun Himalaya. Thus the The present venture is an attempt to study the diversity and abundance of phytoplankton in Goriganga river and it is essentially needed for the proper management/improvement of indigenous fisheries in the river.

Material and Methods

The samples of phytoplankton were collected monthly and seasonally in the Goriganga river from three selected spots, spot-1, Jauljibi-600msl; spot-2, Baram-900msl and spot-3, Madkot-1300msl figure-1, which are extended in a river stretch of 44 km in the Goriganga river by filtering 50 ltr. of the sub-surface water through planktonic net made up of bolting silk cloth no. 20 (mesh size 0.06 mm). The filtrate thus obtained were brought to the laboratories of Zoology Department, Almora and centrifuged at a moderately high speed, preserved in 5 % formalin and logule's solution separately for further study i,e for qualitative and quantitative analysis. Identification was done following[13-15] .

Counting was done by drop count method using Haemocytometer/Sedgwick rafter counting cell and quantity was estimated in terms of units/l by the standard formula as suggested by Adoni[16].

$$\text{Organisms/l} = A \times \frac{1 \times n}{L \times V}$$

Where A = No. of organisms per drop, L = Volume of original sample, N = Total volume of concentrated sample, V = Volume of one drop in ml.

Index of Similarity and Dissimilarity: Similarity and dissimilarity index is used to record the similarity and dissimilarity among different taxa in different samples Odum[17]. Similarity and dissimilarity index can be determined by the following formulae: $S = \frac{2C}{A+B}$

Where S = similarity index, A = taxa in A sample, B = taxa in B sample, C = taxa common in both the samples.

Dissimilarity index = 1 – S.

Where S = similarity index.

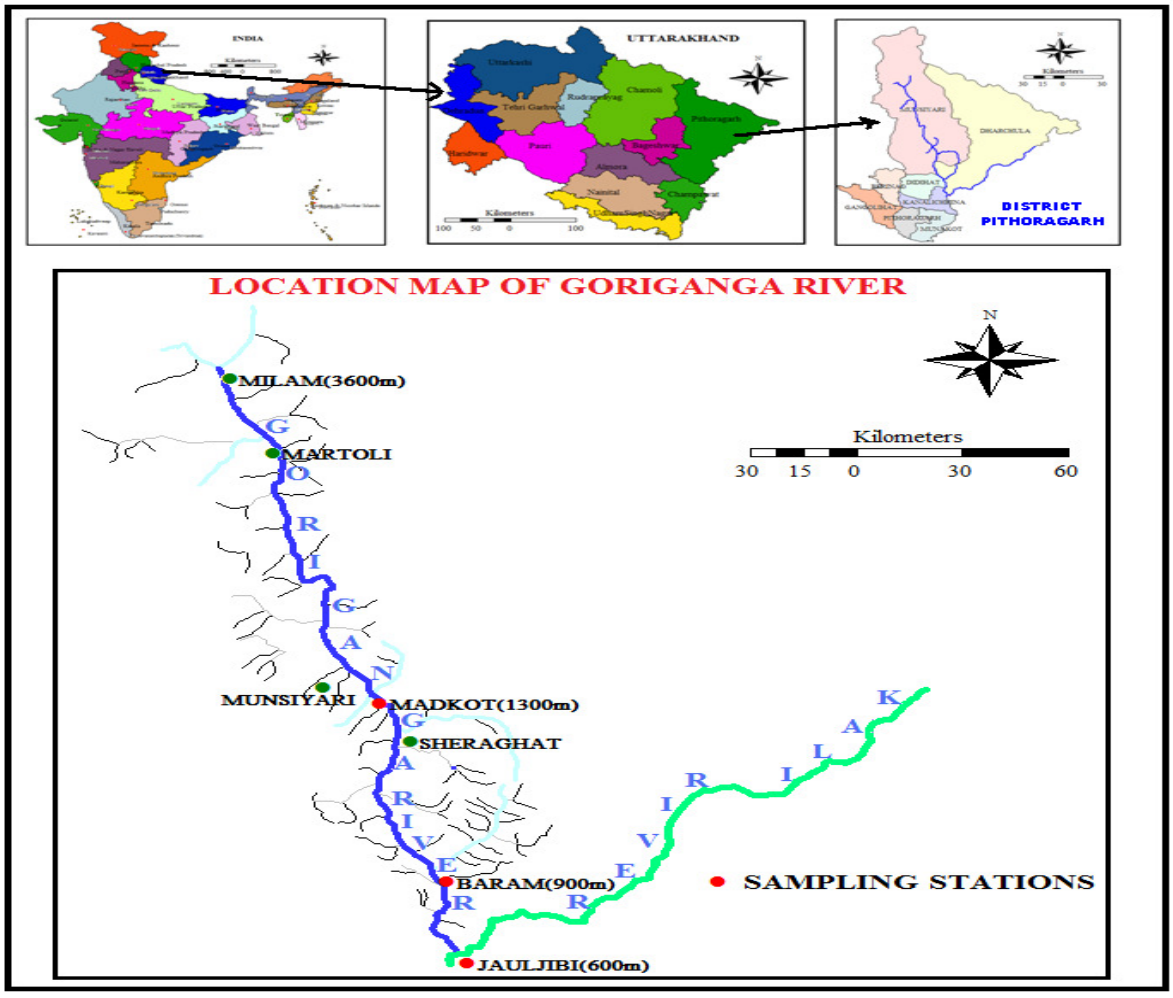

Figure-1
Location Map Showing The Three Sampling Stations, Jauljibi (600 MSL), Baram (900 MSL) and Madkot (1300 MSL) in the Gorigana River of Kumaun Himalaya

Results and Discussion

Qualitative Estimation of Phytoplankton: A total of 46 genera of phytoplankton were encountered during the course of study. The occurrence of various phytoplankton species at the three selected sampling stations has been given in the table-1. Diatoms (Bacillariophyceae) accounted for the major share of phytoplankton diversity, represented by 27 genera (56.69%) (*Achnanthes, Amphipleura, Amphora, Bacillaria, Biddulphia, Brebissonia, Caloneis, Cocconeis, Cymatoplerua, Cymbella, Denticula, Diatoma, Diatomella, Epithelmia, Eunotia, Fragilaria, Frustulia, Gomphoneis, Melosira, Meridion, Navicula, Nedium, Nitzschia, Pinnularia, Rhicosphenia, Synedra and Tabellaria*), green algae (Chlorophyceae) were appeared to be the second dominating group in terms of phytoplankton diversity, represented by 15 genera (32.60%) (*Chlorella, Cladophora, Closterium, Debarya, Hormidium, Mesotaenium, Microspora, Pediastrum, Rhizoclonium, Spirogyra, Stigeoclonium, Tetradesmus, Ulothrix, Uronema, Zygnema*) while the qualitative analysis of blue-green algae (Cyanophyceae) constituted only 04 genera (8.69%) (*Anabena, Anacystis, Microcystis, Oscillotori)* table-1. During the course of study phytoplankton showed distribution pattern as: Bacillariophyceae (56.69%) > Chlorophyceae(32.60%) > Cyanophyceae (8.69%). During first year (2006-07) there were 43 genrea at all the spots. Maximum 39 genera (90.69%) were observed at spot-1 followed by 32 genera (74.41%) at spot-2 and minimum 31 genera (67.39%) were recorded at spot-3 table-1. Among 43 genera recorded at all spots during first year (2006-07), maximum 24 genera (55.81%) belong to class bacillariophyceae, 15 genrea (34.88%) to chlorophyceae and 04 genera (9.30%) to cyanophyceae. During second year (2007-08), a total of 44 genera were noticed at all the spots. Maximum 39 genera (88.63%) were again recorded at spot-1 followed by 34 genera (77.27%) at spot-2 and minimum 30 genera (68.18%) were again recorded at spot-3. Among 44 recorded genrera during second year (2007-08), maximum 27 genera (61.36%) belong to bacillariophyceae, 14 genera (31.81%) to chlorophyceae while minimum 03 genera (6.81%) to cyanophyceae. During first year a total 24 genera of diatoms were recorded belonging to 10 families of class bacillariophyceae (Coscinodisceae, Biddulphiniaceae, Fragilariaceae, Achnanthaceae, Naviculaceae, Gomphonemaceae, Cymbellaceae, Epithelmiaceae, Nitzschiaceae and Surirellaceae). Maximum 08 genera (33.33%) were recorded in family Naviculaceae followed by 04 genera (16.66%) in Fragilariaceae; 02 genera (8.33%) in Achnanthaceae, Cymbellaceae, Epithelmiaceae and Nitzschiaceae each while minimum one genera (4.16%) was recorded in Coscinodisceae, Biddulphiaceae, Gomphonemaceae and Surirellaceae families each. During second year total recorded 27 genera of diatoms belong to 11 families of class bacillariophyceae (Coscinodisceae, Biddulphiniaceae, Fragilariaceae, Achnanthaceae, Eunotiaceae, Naviculaceae, Gomphonemaceae, Cymbellaceae, Epithelmiaceae, Nitzschiaceae and Surirellaceae). Maximum 08 genera (29.62%) were again represented by family Naviculaceae followed by 05 genera (18.51%) by Fragilariaceae; 03 genera (11.11%) by Achnanthaceae; 02 genera (7.40%) by Cymbellaceae, Epithelmiaceae and Nitzschiaceae each, whereas minimum 01 genera (3.70%) was represented by families Coscinodisceae, Biddulphiaceae, Eunotiaceae, Gomphonemaceae and Surirellaceae each. It was observed that phytoplanktons are fluctuating month wise and season wise in the present study tables-2,3,4,7 and 8 and figures-2,3,4 and 5. Most of the diatoms were present round the year while some ten genera of bacillariophyceae (*Achnanthes, Amphora, Bacillaria, Denticula, Diatoma, Navicula, Nitzschia, Pinnularia, Synedra and Tabellaria),* two genera of chlorophyceae *(Hormidium and Microspora) and one genera of cyanophyceae (Oscillatoria)* were fairly common to all selected stations table-1. Some six genera (*Navicula, Nitzschia, Fragilaria, Synedra, Melosira* and *Cymbella*) of diatoms and four genera of green algae (*Chlorella, Closterium, Spirigyra* and *Zygnema*) were recorded as pollution indicators according to Palmer-1969 in the study but their population was very low table-1. It was observed that diversity of phytoplankton increase from upstream to downstream. It was also observed that the diversity of phytoplankton varied spot wise, monthly, seasonally, yearly and altitudinally in the water tables-2,3,4,7 and 8 and figures-4 and 5.

Monthly qualitative composition of phytoplankton diversity at three spots (Jauljibi, Baram and Madkot) in the Goriganga river during 2006-07 and 2007-08 has been depicted in the tables-2,3 and 4. During first year (2006-07), the maximum (30) genera of phytoplankton were recorded in the month of November followed by October, January, March and April (29), December and February (27), May (19), September (16), June (13) and the minimum (08) genera were recorded in the month of July and August at spot-1 Jauljibi; table-2; at spot-2 (Baram), the maximum (27) genera of phytoplankton were recorded in the month of December followed by November and January (25), April (24), October, February and March (23), May (19), June (16), September (13), July (07) and the minimum (06) genera were recorded in the month of August table-3, whereas at spot-3 Madkot, the maximum (29) genera were recorded in the month of November followed by December (27), October and January (24), February (19), March (18), September and May (17), April and June (15), July (08) and the minimum (06) genera were recorded in the month of August table-4. During second year, (2007-08), the maximum (29) genera were recorded in the month of February followed by November, December and January (27), October (26), April and May (24), March (22), September (20), June (15), August (10) and minimum (04) genera were recorded in the month of July at spot-1 Jauljibi; table-2; at spot-2 (Baram), the maximum (30) genera were recorded in the month of January followed by October and January (29), February (26), December (25), March (24), April (23), September (22), May (18), June (09), August (05) and minimum (03) genera were recorded in the month of July Table-3, whereas the maximum (25) genera were recorded in the month of January followed by November (23), February and

March (22), October (21), September, December and May (20), April (18), June (13), August (09) and minimum (03) genera were recorded in the month of July at spot-3 Madkot, Table-4 in the present study.

Table-1
Qualitative composition of phytoplankton in Goriganga river during 2006-07 and 2007-08

	Genera	**July 2006-June 2007**			**July 2007-June 2008**		
S.No	**Bacillariophyceae**	**Jauljibi (Spot-1)**	**Baram (Spot-2)**	**Madkot (Spot-3)**	**Jauljibi (Spot-1)**	**Baram (Spot-2)**	**Madkot (Spot-3)**
01	Achnanthes	+	+	+	+	+	+
02	Amphipleura	-	+	+	+	+	+
03	Amphora	+	+	+	+	+	+
04	Bacillaria	+	+	+	+	+	+
05	Biddulphia	+	-	-	+	-	-
06	Brebissonia	+	+	-	+	+	-
07	Caloneis	+	-	-	+	+	-
08	Cocconeis	-	-	-	+	+	+
09	Cymatoplerua	+	+	+	-	-	+
10	Cymbella	+	+	+	+	+	-
11	Denticula	+	+	+	+	+	+
12	Diatoma	+	+	+	+	+	+
13	Diatomella	-	+	+	+	+	+
14	Epithelmia	+	-	+	+	+	+
15	Eunotia	-	-	-	-	+	+
16	Fragilaria	+	+	+	+	+	-
17	Frustulia	+	+	-	-	+	+
18	Gomphoneis	+	-	+	+	+	-
19	Melosira	+	+	-	+	-	-
20	Meridion	-	-	-	+	+	+
21	Navicula	+	+	+	+	+	+
22	Nedium	+	+	+	+	-	-
23	Nitzschia	+	+	+	+	+	+
24	Pinnularia	+	+	+	+	+	+
25	Rhicosphenia	+	-	-	+	-	-
26	Synedra	+	+	+	+	+	+
27	Tabellaria	+	+	+	+	+	+
	Genera	**July 2006-June 2007**			**July 2007-June 2008**		
S. NO	**Chlorophyceae**	**Jauljibi (Spot-1)**	**Baram (Spot-2)**	**Madkot (Spot-3)**	**Jauljibi (Spot-1)**	**Baram (Spot-2)**	**Madkot (Spot-3)**
01	Chlorella	+	+	+	+	+	-
02	Cladophora	+	-	+	+	+	+
03	.Closterium	+	+	+	+	-	+
04	Debarya	-	+	-	+	+	+
05	Hormidium	+	+	+	+	+	+
06	Mesotaenium	+	+	+	+	-	+
07	Microspora	+	+	+	+	+	+
08	Pediastrum	+	+	+	+	-	+
09	Rhizoclonium	+	-	-	-	+	+
10	Spirogyra	+	-	-	+	+	-
11	Stigeoclonium	+	-	+	-	-	-
12	Tetradesmus	+	+	+	-	+	+
13	Ulothrix	+	-	+	+	+	-
14	Uronema	+	+	+	+	-	+
15	Zygnema	+	+	-	+	+	-
	Cyanophyceae						

01	Anabena	+	-	+	+	+	+
02	Anacystis	-	+	-	-	-	-
03	Microcystis	+	+	-	+	-	-
04	Oscillotoria	+	+	+	+	+	+
	Total	39	32	31	39	34	30
	%	84.78%	69.56%	67.39%	84.78%	73.91%	65.21%
	(+ = Present and - = Absent.)						

Quantitative Estimation of Phytoplankton: In the present study a sharp distinction in numerical population of phytoplankton were clearly observed at different sampling stations in Goriganga river tables-5 and 6 and figures-2 and 3. During first year (2006-07) the phytoplankton population at spot-1 was observed to be rising from summer season (36.35%) and reached the maximum during winter season (55.95%) and at spot-2, the maximum phytoplankton population was recorded in winter season (49.78%) and same trend of maximum (54.84%) phytoplankton density was observed at spot-3 during winter season in the present study table-8 and figure-4. While the minimum density of phytoplankton (7.68%, 9.63% and 9.73%) was recorded at spot-1, spot-2 and spot-3 respectively during monsoon season in the Goriganga river during first year (2006-07) table-8 and figure-4. The study of second year (2007-08), showed the same seasonal rhythm of phytoplankton population table-8 and figure-5). During second year phytoplankton population increase from summer season (37.07%, 33.54% and 37.68%) and reached the maximum during winter season (54.69%, 59.65% and 54.20%) at spot-1, spot-2 and spot-3 respectively in the present study table-8 and figure-5. whereas the lowest phytoplankton population during second year (2007-08) was observed similar to the first year in monsoon season (8.22%, 6.73% and 8.10%) at spot-1, spot-2 and spot-3 respectively, in the present study table-8 and figure-5. It showed that the phytoplankton maxima in winter season may be due to low temperature and low velocity of water, moderate in summer season and minima in monsoon season due to high temperature and velocity of water. It has been observed that total annual percentage of phytoplankton population dominated by Bacillariophyceae (80.05%, 79.23%, and 79.01%) and (80.53%, 82.99% and 79.52%) at spot-1, spot-2 and spot-3, during first year (2006-07) and second year (2007-08), respecitvely in the study tables-5 and 6.

It was also observed that January samples during both the years revealed a maximum phytoplankton population abundance (830 units/l at spot-1, 652 units/l at spot-2 and 612 units/l at spot-3) during first year and similar trend was observed during second year (756 units/l at spot-1, 642 units/l at spot-2 and 692 units/l at spot-3) when the velocity of water was low tables-5 and 6 3 and figures-2 and 3. The density of diatoms which form the bulk of the phytoplankton population during first year was 80.05% at spot-1, 79.23% at spot-2 and 79.01% at spot-3. While it was (80.53% at spot-1, 82.99% at spot-2 and 79.52% at spot-3) during second year (2007-08), followed by chlorophyceae (16.71% at spot-1, 17.98% at spot-2 and 17.99% at spot-3) during first year (2006-07) and it was 15.95% at spot-1, 13.74% at spot-2 and 17.25% at spot-3 during second year (2007-08) but cyanophyceae appeared to be low in quantity (3.22% at spot-1, 2.78% at spot-2 and 2.99% at spot-3) during first year and (3.51% spot-1, 3.26% spot-2 and 3.22% spot-3) during second year tables-5 and 6. Some genera like, *Achnanthes, Amphora, Bacillaria, Denticula, Diatoma, Navicula, Nitzschia, Pinnularia, Synedra, Tabellaria, Hormidium, Microspora, Oscillatoria* were commonly present at all the sites table-1. The population of bacillariophyceae is dominated over chlorophyceae and cyanophyceae in the Goriganga river. The quality and quantity of phytoplankton always varied spot wise (altitudinally), month wise, season wise and year wise in the water of Goriganga river in the present study tables-1,2,3,4, 5,6,7 and 8 and figures-2,3,4 and 5. The altitudinal variations and low percentage of chlorophyceae with a high annual percentage of cyanophyceae indicated pollution zone at Jauljibi in the Goriganga river.

For the first time the Similarity and Dissimilarity index among different groups of phytoplankton (bacillariophceae, chlorophyceae and cyanophyceae) dwelling at three spots in glacial fed mountainous Goriganga river has been attempted and presented in table-9. Similarity index recorded ranged from, s = 0.25 to s = 0.47 during 2006-07 and from s = 0.38 to s = 0.57 during 2007-08, table-9. Maximum similarity (s = 0.47 and s = 0.57) was observed among the taxa of bacillariophceae and cyanophyceae during 2006-07 and 2007-08 respectively, table-9 and figures-6, 7, while minimum (s = 0.25 and s = 0.38) was recorded among the taxa of cyanophyceae and chlorophyceae during 2006-07 and 2007-08 respectively in the study, table-9, figures-6 and 7.

Discussion: Members of bacillariophyceae and chlorophyceae were the main contributors to the phytoplankton population in Goriganga river. Among phytoplankton, diatoms dominate other groups in the present study; similar observations were also made by Pathani and Mahar[18] in river Suyal, Kumaun Himalaya. But the present study goes against the observations made by Nath et.al.[19] in Narmada river, Madhya Pradesh in which they reported that among phytoplankton, the dominant group was chlorophyceae followed by bacillariophyceae. In the present study phytoplankton followed the distribution pattern as, Bacillariophyceae > Chlorophyceae > Cyanophyceae. Some total 46 taxa of phytoplankton belonging to bacillariophyceae (27), Chlorophyceae (15) and Cyanophyceae (04) at different collecting spots with variations in months and seasons of the year have been recorded in the water. The richness of phytoplankton is low in the Goriganga river in comparison to

the other lotic water bodies of Kumaun Himalaya recoded by earlier workers[20-22]. The highest population density of phytoplankton was recorded in winter season and the lowest in monsoon season at all the spots in the present study. Similar findings were also noticed by Sharma[23] in Bhagirathi river. It was also observed that abundance of diatoms was attributed to less current velocities, little turbidity and low temperature. High velocity and turbidity were responsible for fall in diatoms population as also reported by Nautiyal[24]. Similarly current velocities according to Chandler[25] have confirmed the importance of parameter in determining the density of diatoms in the riverine systems. Diatoms account for 70-79% of phytoplankton population in the present study and coincide with the observations made by Negi[26] and Nautiyal[27] in river Ganga and its tributaries. The dominance of diatoms over blue-green algae in the Goriganga river at all the spots clearly Corroborated with the findings of Mahar[28] and Upadhyay[29]. Recently, Pathani et.al.[30] have studied the population of diatoms and recorded 69 taxa from different lotic water bodies of Kumaun Himalaya. Chlorophyceae (green algae) were observed to be the second dominating group of phytoplankton in the present study. The green algae constituted 15 genera (*Chlorella, Cladophora, Closterium, Debarya, Hormidium, Mesotaenium, Microspora, Pediastrum, Rhizoclonium, Spirogyra, Stigeoclonium, Tetradesmus, Ulothrix, Uronema and Zygnema)* and have showed monthly, seasonally and yearly fluctuations in numerical abundance at different spots in the present study. Like diatoms, highest population of green algae (chlorophyceae) were also recorded in winter season and minimum in monsoon season. Low population of green algae (chlorophyceae) during rainy season may be due to silt, flood, and very high velocity of water. It was observed that during winter, there was an increase in the concentration of dissolved nutrients which could have supported the dense population of algae and corroborates with the findings made by Ellsworth[31].

Cyanophyceae were represented by only four genera (*Anabena, Anacystis, Micystis and Oscillotoria*) in the present study. Maximum (04) genera were recorded at spot-2, (03) genera at spot-1 and minimum (02) genera were recorded at spot-3 during the study of both years. The distribution and abundance of Cyanophyceae was low in the Goriganga river through out the study period as compared to other two groups of phytoplankton. Blue-green algae are of considerable biological importance because of their enormous production in most of the polluted waters. Thus, low population of cyanophyceae in Goriganga is an indication that water is not much polluted till now and accessed to be safe at present from this ever increasing hazard.

During winter season in Goriganga river, when the water temperature and velocity was low, water was with little turbidity and water level was comparatively low, the replacement of nutrients declined, and there was an increase in phytoplanktonic population. The fast flowing nature of Goriganga river might be the reason for the poor representation of phytoplankton distribution and abundance, especially during rainy season, when the river was heavily flooded and dispersed the phytoplankton as a whole. It was also observed that increased velocities flush and remove attached algae by abrasion from surfaces and may also break off long strand of filamentous algae. Elevated velocities can also be very destructive for stream plankton[32]. The minimum plankton density during monsoon season was remarkably due to frequent disturbances (frequent floods) in the present study and coincides with the observations recorded by Sharma and Bhanot[33] in Dhauliganga and Biggs and Gerbeaux[34].

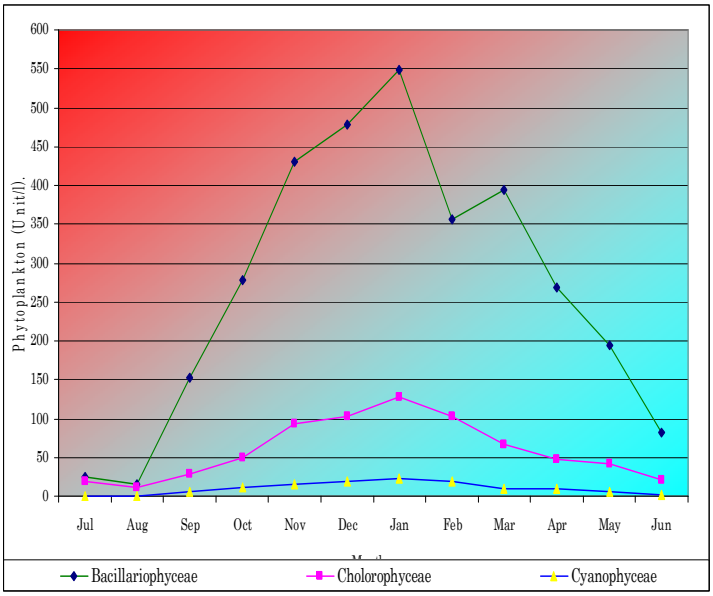

Figure-2
Monthly distribution of phytoplankton in the Goriganga river during 2006-07

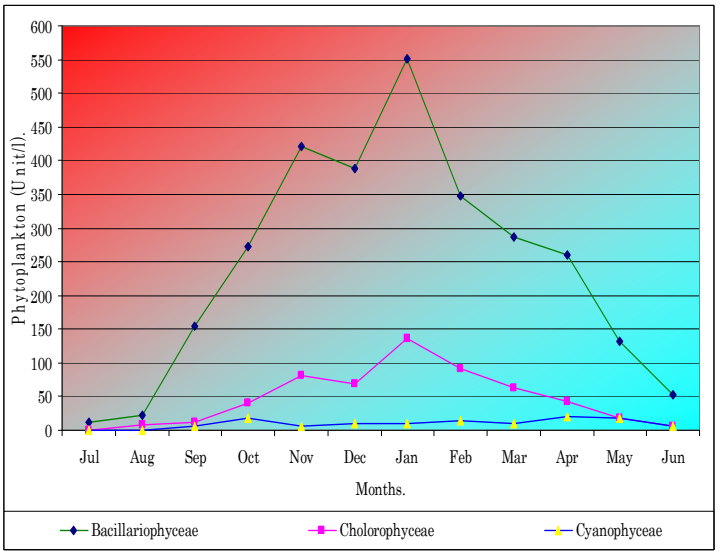

Figure-3
Monthly distribution of phytoplankton in the Goriganga river during 2007-08

Table-2
Monthly Qualitative composition of phytoplankton at spot-1 (Jauljibi) in the Goriganga river during 2006-07 and 2007-08

Genera	Monthly qualitative composition of phytoplankton at spot-1 (Jauljibi) in the Groriganga river during 2006-07 and 2007-08																							
	July		Aug		Sept		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
Bacillariophyceae	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Achnanthes	-	-	-	-	-	-	+	-	+	+	+	-	-	+	+	+	-	-	-	-	-	-	-	-
Amphipleura	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-	-	+	-	-	-	-
Amphora	-	-	-	-	-	+	+	-	-	+	+	-	+	+	+	-	+	+	+	+	-	-	-	-
Bacillaria	-	-	-	-	-	-	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-	+	-	-
Biddulphia	-	-	-	-	-	+	+	-	+	+	-	+	-	+	-	+	+	+	+	+	+	+	-	-
Brebissonia	-	-	-	-	-	+	+	+	+	+	-	-	+	-	-	+	-	+	-	-	-	-	-	-
Caloneis	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	-	-	-
Cocconeis	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	+	-	-	-	+	-	+	-	-
Cymatoplerua	-	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-
Cymbella	-	-	-	-	+	+	+		+	-	+	+	+	-	+		+	-	+	+	+	-	-	-
Denticula	-	-	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
Diatoma	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Diatomella	-	-	-	-	-	+	-	+	-	-	-	+	-	+	-	+	-	-	-	-	-	+	-	+
Epithelmia		-	-	-	-	-	+	+	+	-	+	+	+	-	+	+	+	-	+	-	-	+	+	+
Eunotia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Fragilaria	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
Frustulia	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-
Gomphoneis	+	+	-	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
Melosira	-	-	-	-	-	+	+	+	+	+	+	+	+	-	+	-	-	-	+	+	-	+	+	+
Meridion	-	+	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-	+
Navicula	-	-	+	+	+	+	+	+	+	-	-	-	+	-	-	+	+	+	-	+	-	+	+	-
Nedium	+	-	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	-	+	+	-	+	+	+
Nitzschia	-	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-	-	-
Pinnularia	+	-	+	+	+	+	+	+	+	-	-	+	+	+	+	-	+	+	+	-	+	+	+	+
Rhicosphenia	-	-	-	-	-	+	+	+	+	-	+	+	+	+	-	-	+	-	+	-	-	+	-	-
Synedra	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+	-	+	-
Tabellaria	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
Chlorophyceae																								
Chlorella	-	-	-	-	-	-	-	-	-	-	-	+	-	+	+	+	+	+	+	+	+	+	-	+
Cladophora	-	-	-	-	-	-	+	-	+	-	+	-	-	+	-	+	-	+	+	+	-	+	-	-
Closterium	-	-	-	-	+	-	-	+	+	-	+	+	+	+	-	+	+	+	+	-	+	+	+	-
Debarya	-	-	-	+	-	-	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-
Hormidium	-	-	-	-	-	-	-	-	+	+	-	+	-	-	+	+	+	+	+	-	+	+	-	+
Mesotaenium	-	-	-	-	-	+	-	+	+	+	-	-	-	+	-	-	+	-	-	-	-	-	+	-
Microspora	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-	+	-	+	+	+	+	-	-	+
Pediastrum	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	+	+	-	+	+	-	-	-	-
Rhizoclonium	-	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Spirogyra	+	-	+	+	+	+	-	+	-	+	-	-	-	+	+	+	-	-	+	+	-	+	-	-
Stigeoclonium	+	-	-	-	-	-	+	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-
Tetradesmus	-	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-	-	-
Ulothrix	+	-	-	-	-	+	+	+	-	+	+	-	-	-	-	+	-	-	+	+	-	+	+	-
Uronema	-	-	-	-	-	-	-	+	-	+	+	+	-	+	+	-	-	-	-	-	-	+	-	-
Zygnema	+	-	-	+	+	-	-	-	+	+	+	-	+	-	+	+	-	+	+	-	+	-	-	-
Cyanophyceae																								
Anabena	-	-	-	-	-	-	-	+	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+
Anacystis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microcystis	-	-	-	-	+	+	+	+	-	+	+	-	+	-	+	+	-	-	+	+	+	+	-	-
Oscillotoria	-	-	-	-	+	-	-	-	+	-	+	+	+	+	-	-	+	+	+	+	+	+	+	+
Total	08	04	08	10	16	20	29	26	30	27	27	27	29	27	27	29	29	22	29	24	19	24	13	15

{I = during first year- 2006-07; II = during second year-2007-08; + = present and - = absent)

Table-3

Monthly qualitative composition of phytoplankton at spot-2 (Baram) in the Groriganga river during 2006-07 and 2007-08

Genera	Monthly qualitative composition of phytoplankton at spot-2 (Baram) in the Groriganga river during 2006-07 and 2007-08																							
	July		Aug		Sept		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
Bacillariophyceae	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Achnanthes	-	-	-	-	-	+	-	+	+	+	-	-	+	-	+	-	+	-	+	-	-	-	-	-
Amphipleura	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	-	-	+	+	+	-	-	-	-
Amphora	-	-	-	-	+	+	-	+	+	+	+	+	+	+	+	-	+	+	+	+	-	+	+	-
Bacillaria	-	-	-	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+
Biddulphia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brebissonia	-	-	-	-	-	+	+	+	+	+	-	+	+	+	-	+	+	+	+	+	-	+	-	-
Caloneis	-	-	-	-	-	+	-	+	-	+	-	-	-	+	-	+	-	+	-	+	-	-	-	-
Cocconeis	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Cymatoplerua	-	-	-	-	-	-	+	-	+	-	+	-	+	-	-	-	+	-	+	-	+	-	-	-
Cymbella	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	-	-
Denticula	-	+	+	-	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
Diatoma	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-
Diatomella	-	-	-	-	-	+	-	+	-	+	+	-	-	+	+	+	+	-	+	+	-	-	-	-
Epithelmia	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-
Eunotia	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Fragilaria	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	+	-	+	+	+	-
Frustulia	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-	-	-
Gomphoneis	-	-	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Melosira	-	-	-	-	-	-	+	-	+	-	+	-	+	-		-	+	-	-	-	-	-	+	-
Meridion	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Navicula	+	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+
Nedium	-	-	-	-	+	-	+	-	+	-	+	-	-	-	+	-	-	-	-	-	+	-	+	-
Nitzschia	-	-	-	-	+	-	+	+	+	+	+	+	+	+	-	+	-	-	+	-	+	+	+	-
Pinnularia	-	-	-	-	+	-	+	+	+	+	+	+	+	+	-	+	+	+	-	+	+	-	+	+
Rhicosphenia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Synedra	-	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Tabellaria	+	+	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Chlorophyceae																								
Chlorella	+	-	+	-	+	-	-	-	+	-	+	-	+	+	+	+	+	-	+	+	+	+	+	-
Cladophora	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-	-
.Closterium	-	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Debarya	-	-	-	-	-	-	-	-	-	+	+	-	+	+	-	-	+	+	+	+	+	-	+	-
Hormidium	+	-	+	-	-	-	+	+	+	+	-	+	+	+	+	-	-	+	+	-	+	-	-	-
Mesotaenium	-	-	-	-	-	-	-	-	+	-	-	-	+	-	-	-	-	-	+	-	+	-	-	-
Microspora	-	-	-	-	-	+	+	+	-	+	+	+	-	+	+	+	+	-	-	-	-	-	-	-
Pediastrum	-	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-	-	-	-	-	-
Rhizoclonium	-	-	-	-	-	-	-	+	-	-	-	-	-	+	-	+	-	+	-	-	-	-	-	-
Spirogyra	-	-	-	-	-	+	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-
Stigeoclonium	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Tetradesmus	-	-	-	-	+	-	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-	-	+	-
Ulothrix	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	+	-	+	-	-	-	-	-	-
Uronema	-	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	-	-	-	-	-	-
Zygnema	+	-	+	-	+	-	-	-	+	+	+	+	+	+	-	-	-	+	-	+	+	+	+	-
Cyanophyceae																								
Anabena	-	-	-	-	-	+	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	-
Anacystis	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-
Microcystis	-	-	-	-	-	-	-	-	-	-	+	-	-	-	+	-	+	-	+	-	-	-	-	-
Oscillotoria	-	-	-	-	-	-	+	+	+	+	+	-	+	+	-	+	-	+	+	+	+	+	+	-
Total	07	03	06	05	13	22	23	29	25	29	27	25	25	30	23	26	23	24	24	23	19	18	16	09

{I = during first year- 2006-07; II = during second year-2007-08; + = present and - = absent)

Table4

Monthly Qualitative composition of phytoplankton at spot-3 (Madkot) in the Goriganga river during 2006-07 and 2007-08

Genera	Monthly qualitative composition of phytoplankton at spot-3 (Madkot) in the Groriganga river during 2006-07 and 2007-08.																							
	July		Aug		Sept		Oct		Nov		Dec		Jan		Feb		Mar		Apr		May		Jun	
Bacillariophyceae	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II	I	II
Achnanthes	-	-	-	-	-	+	+	-	+	+	+	-	+	-	-	-	-	-	-	-	-	-	-	-
Amphipleura	-	-	-	-	-	-	+	+	+	+	+	-	+	+	-	+	+	+	-	-	-	-	-	-
Amphora	-	-	-	+	-	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+	+	+
Bacillaria	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	+	+	-	+
Biddulphia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Brebissonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Caloneis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cocconeis	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+
Cymatoplerua	-	-	-	-	-	+	+	-	+	+	+	+	+	-	+	+	+	+	-	+	-	+	-	-
Cymbella	-	-	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	+	-	+	-
Denticula	+	+	+	+	+	+	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+	+	+	-
Diatoma	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Diatomella	-	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	+	+	-	-
Epithelmia	-	-	-	-	-	+	+	+	+	+	+	+	-	+	-	+	-	+	+	+	+	+	+	+
Eunotia	-	-	-	-	-	-	-	+	-	+	-	+	-	+	-	-	-	+	-	+	-	+	-	+
Fragilaria	-	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	-	-	+	-	+	-	+	-
Frustulia	-	-	-	-	-	+	-	+	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	-
Gomphoneis	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	-	-	+	-
Melosira	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Meridion	-	-	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	+	-	+	-	+	-	-
Navicula	+	+	-	+	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	-	+	+	+	-
Nedium	+	-	-	-	+	-	+	-	+	-	+	-	-	-	-	-	+	-	+	-	+	-	+	-
Nitzschia	-	-	-	+	+	+	+	+	+	-	+	+	+	+	+	+	+	-	-	-	+	+	-	-
Pinnularia	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	-	+	-	+	+	-	+	+
Rhicosphenia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Synedra	-	-	-	-	+	+	+	+	+	+	+	-	+	+	-	+	-	-	-	-	+	+	-	-
Tabellaria	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+
Chlorophyceae																								
Chlorella	-	-	-	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-	+	-
Cladophora	+	-	+	+	+	-	-	-	+	+	+	-	-	+	+	+	-	+	+	+	+	+	-	+
Closterium	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	-	-
Debarya	-	-	-	+	-	-	-	+	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-
Hormidium	-	-	-	-	+	+	+	+	+	-	+	+	+	+	-	+	+	+	-	-	-	+	-	+
Mesotaenium	-	-	-	-	+	-	-	-	-	-	-	+	+	+	-	-	-	-	-	-	-	-	-	-
Microspora	-	-	-	+	-	-	-	-	+	+	+	+	+	+	+	-	-	+	+	-	-	-	-	+
Pediastrum	-	-	-	-	-	-	-	-	+	+	-	-	-	+	-	-	-	+	-	-	-	-	-	-
Rhizoclonium	-	-	-	-	-	-	-	-	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Spirogyra	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Stigeoclonium	+	-	-	-	-	-	+	-	+	-	+	-	-	-	-	-	+	-	-	-	-	-	+	-
Tetradesmus	-	-	-	-	-	+	-	+	-	-	+	-	-	+	+	+	-	-	-	-	-	-	-	-
Ulothrix	+	-	+	-	+	-	+	-	+	-	-	-	-	-	+	-	+	-	-	-	-	-	+	-
Uronema	-	-	-	-	-	-	-	+	+	+	-	+	+	+	-	-	-	+	-	+	-	-	-	-
Zygnema	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Cyanophyceae																								
Anabena	-	-	-	-	+	+	+	+	+	+	+	+	+	-	+	-	-	-	-	+	-	+	-	+
Anacystis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Microcystis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Oscillotoria	-	-	-	-	-	-	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+
Total	08	03	06	09	17	20	24	21	29	23	27	20	24	25	19	22	18	22	15	18	17	20	15	13

{I = during first year- 2006-07; II = during second year-2007-08; + = present and - = absent)

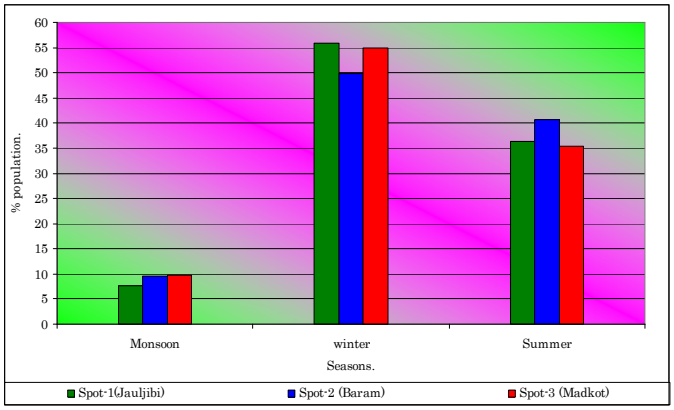

Figure-4
Seasonal variations in phytoplankton percentage at three spots in the Goriganga river during 2006-07

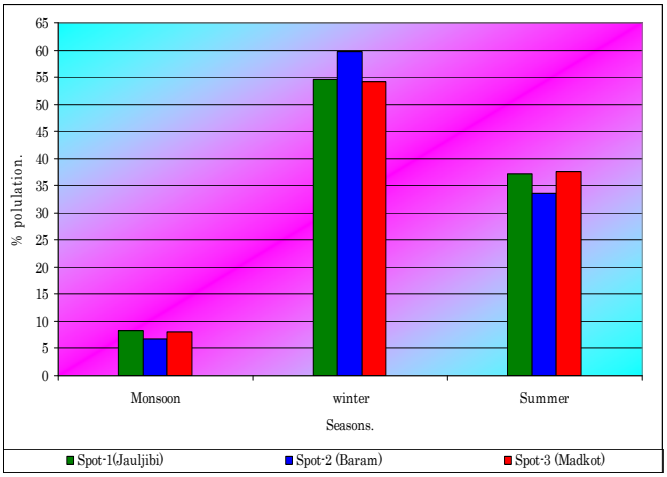

Figure-5
Seasonal variations in phytoplankton percentage at three spots in the Goriganga river during 2007-08

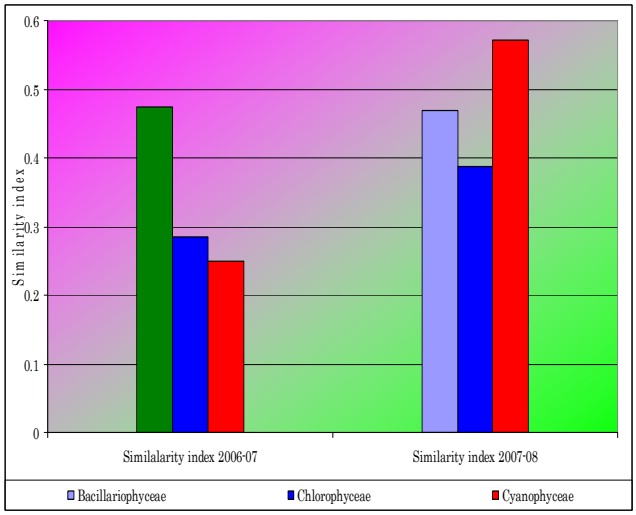

Figure-6
Similarity index among different groups of phytoplankton (bacillariophyceae, chlorophyceae and cyanophyceae) in the Goriganga river during 2006-07 and 2007-08

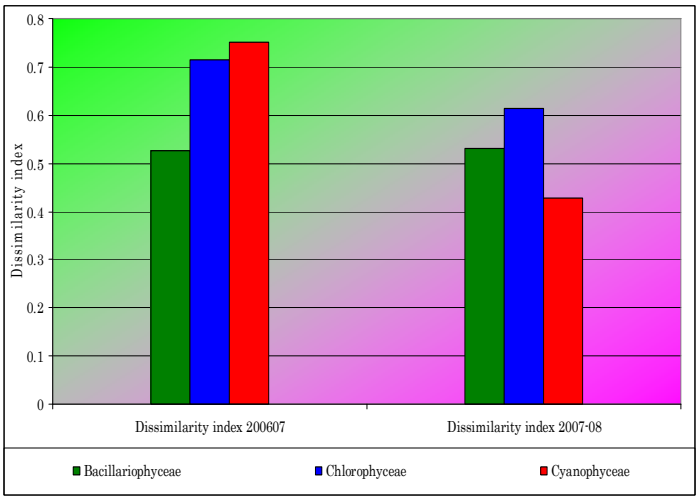

Figure-7
Dissimilarity index among different groups of phytoplankton (bacillariophyceae, chlorophyceae and cyanophyceae) in the Goriganga river during 2006-07 and 2007-08

Conclusion

Studies were conducted on diversity and abundance of phytoplankton in glacial fed mountainous Goriganga River of Kumaun Himalaya, Uttay\rakhand India from July-2006 to June-2008. Some total 46 genera of phytoplankton were identified during the study period. Diatoms (Bacillariophyceae) accounted for the major share of phytoplankton diversity, represented by 27 genera (56.69%), green algae (Chlorophyceae) were appeared to be the second dominating group in terms of phytoplankton diversity, represented by 15 genera (32.60%) while the qualitative analysis of blue-green algae (Cyanophyceae) constituted only 04 genera (8.69%). During the course of study, phytoplankton showed the distributional pattern as: Bacillariophyceae (56.69%) > Chlorophyceae (32.60%) > Cyanophyceae (8.69%). Some six genera of diatoms (*Navicula, Nitzschia, Fragilaria, Synedra, Melosira* and *Cymbella*) and four genera of green algae (*Chlorella, Closterium, Spirigyra* and *Zygnema*) were recorded as pollution indicators but their population was very low. Thus low population of cyanophyceae in Goriganga is an indication that water is not much polluted till now and accessed to be safe at present from this ever increasing hazard. It was observed that diversity of phytoplankton increase from upstream to downstream. In other words we can say that diversity of phytoplankton increases with the decrease in latitude. Seasonally, maximum phytoplankton diversity and density was recorded during winter season and minimum during monsoon season. In the present study maximum similarity (s = 0.47 and s = 0.57) was observed among the taxa of bacillariophceae and cyanophyceae during 2006-07 and 2007-08 respectively while minimum similarity (s = 0.25 and s = 0.38) was recorded among the taxa of cyanophyceae and chlorophyceae during 2006-07 and 2007-08 respectively.

Table-5
Monthly Quantitative abundance of phytoplankton at three spots in the Goriganga river from July 2006 to June 2007

Month	Bacillariopphyceae			Chlololophyceae			Cyanophyceae		
	Spot-1 (Jauljibi)	Spot-2 (Baram)	Spot-3 (Madkot)	Spot-1 (Jauljibi)	Spot-2 (Baram)	Spot-3 (Madkot)	Spot-1 (Jauljibi)	Spot-2 (Baram)	Spot-3 (Madko)
July	24	20	28	20	22	18	-	-	-
August	16	12	18	12	8	16	-	-	-
September	128	176	156	10	42	36	8	6	4
October	308	252	276	48	36	64	12	8	14
November	488	408	396	78	60	140	14	14	18
December	524	404	504	86	94	124	22	20	16
January	640	512	492	164	122	98	26	18	22
February	388	376	304	106	132	68	18	16	24
March	360	416	408	70	66	64	12	10	8
April	272	284	248	54	48	40	14	12	4
May	216	172	196	46	52	28	10	4	6
June	84	68	92	26	22	14	3	1	2
Total.	3448	3100	3118	720	704	710	139	109	118
Annual %	80.05%	79.23%	79.01%	16.71%	17.98%	17.99%	3.22%	2.78%	2.99%

Table-6
Monthly Quantitative abundance of phytoplankton at three spots in the river Goriganga from July 2007 to June 2008

Month	Bacillariopphyceae			Chlololophyceae			Cyanophyceae		
	Spot-1 (Jauljibi)	Spot-2 (Baram)	Spot-3 (Madkot)	Spot-1 (Jauljibi)	Spot-2 (Baram)	Spot-3 (Madkot)	Spot-1 (Jauljibi)	Spot-2 (Baram)	Spot-3 (Madkot)
July	16	8	12	-	-	-	-	-	-
August	28	18	22	10	-	14	-	-	-
September	168	118	178	18	10	10	6	-	4
October	288	260	268	36	22	66	18	16	18
November	452	388	424	86	46	112	8	6	6
December	424	312	428	100	42	64	12	10	8
January	596	512	548	146	122	138	14	18	6
February	376	242	428	104	72	98	18	12	14
March	438	202	218	48	68	74	14	6	12
April	224	248	308	52	12	62	28	10	22
May	136	88	174	24	10	18	16	18	22
June	64	44	52	12	-	8	6	-	12
Total.	3210	2440	3060	636	404	664	140	96	124
Annual %	80.53%	82.99%	79.52%	15.95%	13.74%	17.25%	3.51%	3.26%	3.22%

Table-7
Seasonal phytoplankton percentage of bacillariophyceae, chlorophyceae and cyanophyceae at three spots in the Goriganga river during 2006-07 and 2007-08

Year	Seasons	Phytoplankton	% Population		
			Spot-1	Spot-2	Spot-3
2006-07	Monsoon	Bacillariophyceae	7.30	8.90	9.42
		Chlorophyceae	9.44	13.35	11.83
		Cyanophyceae	7.91	6.42	5.08
	Winter	Bacillariophyceae	56.84	50.83	53.49
		Chlorophyceae	52.22	44.31	60.00
		Cyanophyceae	52.23	55.04	59.32
	Summer	Bacillariophyceae	35.84	40.25	37.07
		Chlorophyceae	38.33	42.32	28.16
		Cyanophyceae	38.84	38.53	35.59
2007-08	Monsoon	Bacillariophyceae	8.59	7.70	8.62
		Chlorophyceae	6.28	2.47	4.81
		Cyanophyceae	8.57	6.26	12.90
	Winter	Bacillariophyceae	54.82	60.32	54.50
		Chlorophyceae	57.86	54.42	57.22
		Cyanophyceae	37.14	45.83	30.64
	Summer	Bacillariophyceae	36.57	31.96	36.86
		Chlorophyceae	35.84	40.09	37.95
		Cyanophyceae	54.28	47.91	56.45

Table-8
Seasonal phytoplankton percentage(combined all classes) at three spots in Goriganga river during 2006-07 and 2007-08

Phytoplankton / Years	Seasons	Spots		
		Spot-1 (Jauljibi) % Population	Spot-2 (Baram) % Population	Spot-3 (Madkot) % Population
2006-07	Winter	55.95	49.78	54.84
	Summer	36.35	40.58	35.42
	Monsoon	7.68	9.63	9.73
2007-08	Winter	54.69	59.65	54.20
	Summer	37.07	33.54	37.68
	Monsoon	8.22	6.73	8.10

Table-9
Similarity and dissimilarity index of phytoplankton in Goriganga river during 2006-07 and 2007-08.

Phytoplankton	Similarity index		Dissimilarity Index	
	2006-07	2007-08	2006-07	2007-08
Bacillariophyceae	0.47456	0.46875	0.52543	0.5312
Chlorophyceae	0.28571	0.3870	0.71428	0.613
Cyanophyceae	0.25	0.5714	0.75	0.4286

Acknowledgement

The author is grateful to the Head, Department of Zoology, Kumaun University, Soiban Singh Jeena Campus Almora for providing necessary laboratory facilities. Thanks are also due to Prof. S.S.Pathani, the then Principal Investigator UCOST Research Project Dehradun for his constant help, guidance and providing financial assistance to carry out this research venture very successfully.

References

1. Jafri S.I.H., Mahar M.A. and Leghari, Diversity of Fish and Plankton in Manchhar lake (Dist. Dadu) Sindh, Pakistan. *Proc.Semi.Aq.Biodiv.Pakistan.,* 63-70 **(1999)**

2. Rao V.S., An Ecological study of three ponds of Hyderabad, India III. The phytoplankton volvocales, chroococcals and desmids. *Hydrobiologia,* **47(2),** 319-337 **(1975)**

3. Banarjee G and Narsimha R.K., Physio-chemical factors influenced plankton biodiversity and fish abundance-a case study of Nagaram tank of Warangal, A.P., *Int.J.life Sci.Biotech. and pharma Res.,* **2(2),** 248-260 **(2013)**

4. Spase S., Rotifers in Littoral Zone of lake shkdra/skadar(Albania-Montenegro) as a toolof determining water quality., *Int.Res.J.Biol.Sci.,* **3(3),** 71-77 **(2014)**

5. Kulkarni D.A. and Surwase S.S., Studies on occurance, richness and composition of zooplankton in Seena River water at, Mohl dist-Solapur,MS india., *Int.Res.J.Biol.Sci*., **2(2),** 29-33 **(2013)**

6. Purkayastha P and Gupta S., Estimating Ecosystem healthof shallow water pondin lower longmara, barrak valley, Assam, India using ASPT, SPI and BWMP score., *Int.Res.J.Biol.Sci.,* **(8),** 5-8 **(2013)**

7. Sivalingam P., Swamy M. and Ravinder R.T., Zooplankton diversity with reference to physic-chemical parameters of kajjarla lake, a dilabad Dist.AP, India., *Int.Res.J.Biol.Sci.,* **2(11),** 24-28 **(2013)**

8. Nautiyal P., Studies on the riverine ecology of torrential waters in the Indian uplands of the Garhwal region. I. Seasonal variations in percentage occurrence of planktonic algae. *Uttar Padesh J. Zool.,* **5(1),** 14-19 **(1985)**

9. Badola S.P. and Singh H.R., Hydrobiology of river Alaknanda of the Garhwal *Himalaya, Indian J. Ecol.,* **8**, 269-276 **(1981)**

10. Bhatt S.D., Pande R.K., Pathak J.K. and Rawat D.S., Relationship between hydrosol, water chemistry and biota with special reference to fish production and development rhythms in the Sarju- Ramganga (E) water basin of Kumaun Himalaya, *FTR, CSIR, Govt. of India, New Delhi,* 32 **(1990)**

11. Pathani S.S., Fsih survey in relation to management of fishery resources in Kumaun Uttatanchal, *Final Progress Report, UCOST, Dehradun* **(2008)**

12. Pathani S.S. and Mahar S., Study on population of plankton in the river Suyal of Uttaranchal, India, *Flora and Fauna,* **12(2),** 93-99 **(2006)**

13. Ward H.B. and Whipple G.C., Fresh water biology. *In W.T. Edmondson (Ed.),* 2nd Wiley, New York, 1248 **(1959)**

14. Kant S. and Gupta P., Algal flora of Ladakh. *Scientific Publishers (India), Jodhpur India,* 326 **(1998)**

15. A.P.H.A., Standard methods for examination of water and waste waters, American public health Association, New York, 1193 **(1976)**

16. Adoni A.D., Work book of limnology. *Pratibha Publishers, Sagar India,* 209 **(1985)**

17. Odum E.P., Fundamentals of Ecology, Natraj Publishers Dehradun. 574 **(1971)**

18. Pathani S.S. and Mahar S., Study on population of plankton in the river Suyal of Uttaranchal, India, *Flora and Fauna,* **12(2)**, 93-99 **(2006)**

19. Nath D., Shrivastava N.P. and Mondal S., Water pollution at river Narmada in Madhya Pradesh, *J. Inland Fish. Soc. India,* **40(2),** 74-77 **(2008)**

20. Bhatt S.D., Bisht Y. and Negi U., Ecology of limnofauna in the river Kosi of the Kumaun Himalaya (Uttar Pradesh), *Proc. Natn. Sci. Acad., **B*** **50(4),** 395-405 **(1984)**

21. Pathani S.S., In: Impact of changing aquatic environment on the snow trout Kumaun Himalaya, FTR Ministry of Environment and Forest New Delhi, 53 **(1995)**

22. Pathani S.S. and Kumar Ashok, Diversity and seasonal abundance of aquatic biota in a snow fed river river, Goriganga of Kumaun Himalaya (India), *Third National Seminar on Status of Bio-diversity Among the Mountainous States of India, GKU-Hardwar, Abstrract No-064:* 46 **(2008)**

23. Sharma R.C., Seasonal abundance of phytoplankton in the Bhagirathi river, Garhwal Himalaya, *Indian J. Ecol.* **12(1),** 157-160 **(1985)**

24. Nautiyal P., Studies on the riverine ecology of torrential waters in the Indian uplands of the Garhwal region, III, Floristic and faunal survey, *Trop. Ecol.,* **27**, 157-165 **(1986)**

25. Chandler D.S., Limnological studies of Western Lake, Erie, I: Plankton and certain physico-chemical data of Bass Island region from September 1938 to November 1939, *Ohio. J. Sci.,* **40**, 291-336 **(1940)**

26. Negi M., Phytobenthos of the hill stream Alaknanda of Garhwal Himalaya, In: Advances in limnology, *(Eds.) Singh, H.R. Narendra Publishing House, Delhi,* 139-144 **(1993)**

27. Nautiyal P., Ecology of Ganga river system in the uplands of Garhwal. In: Himalaya: Environment Resources and Development, *(Ed.) Shah, N. K. Bhatt, S. D. and Pandey, R.K. Shree Almora Book Depot. Almora,* 69-73 **(1990)**

28. Mahar S., Ecology of the suyal river of the Kumaun Himalaya. *Ph.D. Thesis, K.U. Nainital* **(2002)**

29. Upadhyay K.K., Productivity and energy flow in the Ramganga (W) river system in Kumaun Himalaya, *Ph.D. Thesis Kumaun University Nainital* **(2002)**

30. Pathani S.S., Kanwal B.P.S., Kumar Ashok, Tewari Manisha and Nailwal P.C., A study on the population of diatoms in the lotic water bodies of Kumaun Himalaya, (India), *Flora and Fauna,* **14(1),** 101-106 **(2008)**

31. Ellsworth M.M., *Journal of Fresh water Ecology, 2* **(1983)**

32. Peterson C.G. and Grimm N.B., Temporal variation in enrichment effects during periphyton succession in a nitrogen-limited desert stream ecosystem, *J. North. Am. Soc.* **11**, 20-36 **(1992)**

33. Sharma R.C. and Bhanot G., Monitoring of periphyhtonic diversity of Dhauliganga in Nanda Devi Biosphere Reserve, Uttaranchal, *Himalayan Biosphere Reseves,* **5 (1&2)** *69-82* **(2003)**

34. Biggs B.J.F. and Gerbeaux, Patterns in benthic algae of streams; In: Algal Ecology Fresh water Benthic Ecosystem. (eds. R. J. Stevenson, M. L. Bothwell and R. L. Lowe*), Academic Press, New York.* 1-779 **(1993)**