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Status of phytoplankton diversity and biomass in relation to productivity of Ram-Ganga reservoir at Kalagarh (Uttarakhand)

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Abstract
Reservoirs, Lakes and Rivers are most important water resources with multiple human utilization and ecological relevance. Ramganga reservoir (latitude 29º-31'-13" longitude 78º-45'-35") is covering an area 7831 hectares of water surface in the foot hills of Shiwalik Himalayan range in between Garhwal and Kumaun region. The present study was to assess the status of phytoplankton diversity and biomass in order to know the productivity of Ram-Ganga reservoir. A total 31 species were recorded out of which 14 were Chlorophyceae, 9 Bacillariophyceae and 8 Cyanophyceae. Present study revealed maximum percentage wise composition, the highest number of Chlorophyceae (50%) in lower zone, Bacillariophyceae (35%) in the middle zone I and the number of cyanophyceae (20%) in lower zone. Shanon Weiner index (H') values (2.26) were found to be the highest at middle zone II and lowest value (0.69) were found in upper zone.

Keywords: Phytoplankton, productivity, reservoir, Shanon-Weiner index

Introduction
Phytoplankton is a major component of aquatic ecosystems, not only in terms of biological diversity, but also because it contributes to primary productivity that helps to maintains fisheries and other important lake ecosystem attributes. The phytoplankton have contributed significantly to produce the oxygen level to sustain the life cycles of all biotic communities in reservoir ecosystem. The phytoplankton constitutes the bulk of primary producers and are the base of food chains in any water body. Diversity of phytoplankton helps to enhance the productivity and strongly depicts the water quality as well as corresponds to the biotic factors (Moss, 1988; Scheffer, 1998) [11, 15]. Plankton is the more sensitive floating community which is being the first target of water pollution, thus any undesirable change in aquatic ecosystem affects diversity as well as biomass of this community. Phytoplankton are autotrophs and belonging to first trophic level. Plankton communities exhibit an essential role in biomass production and energy transfer in aquatic environments by including organisms of different trophic levels, from the base (phytoplankton) to consumers of high levels (zooplankton) of food web (Almeida *et al.* 2010) [2]. Plankton communities in each environment depend on adaptations to biotic and abiotic characteristics, including the trophic status, which is directly related to the diversity, abundance and distribution of plankton forms in the reservoirs (Galkovskaya and Mityanina 2005) [4].
Phytoplankton is the primary producer which plays an important role in the material circulation and energy flow in the aquatic ecosystem. Its presence often controls the growth, reproduction capacity, and population characteristics of other aquatic organisms (Ariyadej *et al.,* 2008) [3].The success of ecological studies in reservoirs depends on the evaluation of diversity, structure and dynamics of biological communities (Tundisi and Matsumura- Tundisi 2008) [20]. allied to physical and chemical characterization, since the interactions among these variables are directly linked to processes and patterns in freshwater reservoirs (Straskraba and Tundisi 2000) [17]. The abundance and diversity of Phytoplankton are generally used as the biological indicators of still-water quality in lakes and reservoirs. Some phytoplankton species are also often used as good indicators of water quality including pollution described by Rajashree (1993) [14].
The ecology of phytoplankton is primary importance because they play a dynamic role in trapping solar energy and also reflects the average ecological condition. Phytoplankton converts solar radiant energy into biological energy through photosynthesis as primary production.

It plays an important role in conditioning the microclimate, helps in regulating the atmospheric level of O_2 and CO_2, vital gases for life. Apart from primary production, phytoplankton plays an important role as food for herbivorous animals. The dissemination of phytoplankton and their variation at different zones of a water body is known to be influenced by physico-chemical parameters of water. Phytoplankton study provides a relevant and convenient point of focus for research on the mechanism of eutrophication and its adverse impact on an aquatic ecosystem. Algal flora establish a vital link in food chain and its productivity depends on water quality at a given time (Meshram and Dhande, 2000) [8].

The present study focused on productivity of phytoplankton is the most sensitive floating community which is being the first target of water pollution, thus any undesirable change in aquatic ecosystem affects diversity as well as biomass of this community. The main aim of the present study was to assess the status of phytoplankton diversity and biomass in order to know the productivity of Ram-Ganga reservoir.

Materials and Methods

Study Site: Ramganga river originates from the shiwalik range in the outer Himalayas of district Chamoli and after flowing 125 kms through hilly terrain, it emerges into plain at Kalagarh dam site. Ramganga river is a tributary of River Ganga. The Sub- Himalayan region where the dam is situated is known by the name of Shiwalik Ranges. Ramganga dam is situated about 3 km upstream of Kalagarh villages in district Pauri Garhwal of Uttarakhand. The exact location of the Dam site is latitude 29º 31' 13" North and longitude 78º 45' 35" East. Kalagarh dam is the first venture in the Himalaya and has laid the foundation for still greater venture in these mountains. Government authorized its construction in 1961.

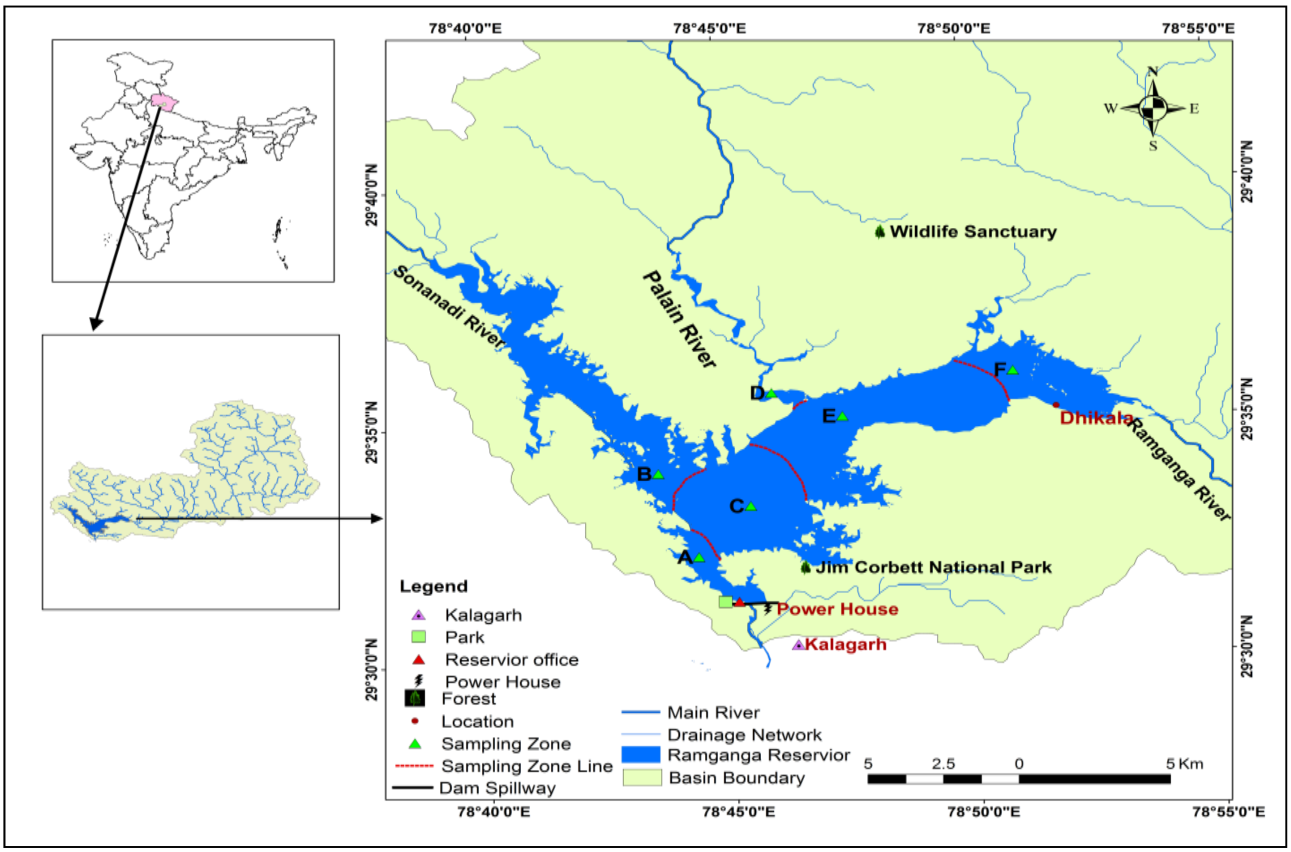


Fig1: Location map of Ram-Ganga reservoir

Methodology

In the present study, phytoplankton sampling was done for one year (August 2015 to July 2016) at four different zones (Upper zone, Middle zone I, Middle zone II, Lower zone) during summer (March, April, May, June) monsoon (July, August, September, October) and winter (November, December, January, February) seasons (Fig.1). Surface plankton's were collected using conical hand plankton net with a specimen tube of 10 ml capacity. The collected samples were filtered through Whatman No. 44 filter paper. The filter paper was carefully washed free of the phytoplankton specimens. The collected plankton sample was preserved in 4% formalin. The phytoplankton were identified as described by Needham and Needham (1962) [12]. Adoni *et al*. (1985) [1]. Michael (1984) [9]. Tonapi (1980) [18]. Trivedy and Goel (1987) [19]. The qualitative and quantitative analysis of Phytoplankton was carried out in the laboratory with the help of Sedgwick- Rafter cell counting chamber. The samples were kept for setting for a period of 48 hrs. Quantitative study of plankton was done by Sedgwick – Rafter Cell method.

Sedgwick–Rafter Cell method

The Sedgwick Rafter Cell is a special kind of slide similar to the Haemocytometer. The cell has a 50 mm x 20 mm x 10 mm rectangular cavity that holds 1 ml sample. The cell is moved in horizontal directions on the stage of an inverted microscope and planktonic species encountered in the field are enumerated. A number of replicate samples are enumerated to calculate plankton/ lit.

Plankton (Units /lit.) = n x c /v
Where,
n = number of plankton in 1 ml.
c = volume of concentrate.
v = volume of sample in lit.
Diversity index Shannon - Weaver (1949) and correlation coefficient were also calculated. Shannon Weaver diversity index (H') was calculated using the following formula:

Shannon - Wiener Index (H) = Σni/N In ni/N
Where, H = Shannon -Weaver index of diversity; ni = total numbers of individuals of species,
N = total number of individual of all species.

Results and Discussion
The morphometric characterstics of Ram-Ganga reservoir are given in Table 1. In the present study seasonal variations in phytoplankton density were observed as maximum in winter season and minimum in monsoon. Comparatively, higher density of phytoplankton was recorded in winter and summer than the monsoon season. The qualitative analysis of phytoplankton belonging to three major groups such as Chlorophyceae, Bacillariophyceae and Cyanophyceae were identified. The different species of phytoplankton which are found in Ram-ganga reservoir shows in Fig 2.
Total 31 species of phytoplankton belonging to three groups were recorded (Table 2). During the study period 14 chlorophyceae species, 9 species were belonging to bacillariophyceae and 8 species were cyanophyceae (Myxophyceae). The chlorophyceae includes Spirogyra, Ulothrix, Chlorella, Closterium, Cladophora, Volvox, Microspora, Rhizoclonium, Gemiinella, Zygenema, Chara, Syndesmus, Oedogonium, Desmidium. The bascillariophyceae comprises Diatoma, Nitzchia, Navicula, Pinnularia, Tabellaria, Cymbella, Caloneis among these former three were noted dominant. The cyanophyceae species represented by Anabena, Nostoc, Spirulina, Oscillatoria, Ravularia, Coccochloris, Phormidium, Crinalium, among these Nostoc and Anabaena were observed as abundant in the plankton sample of Ramganga reservoir.
The quantitative results for total numbers of phytoplankton during the study period are given in Fig.2.The total phytoplankton during the study (2015-16) were fluctuated from 12.75 to 254.00 unit/l. The diversity of phytoplankton was recorded to be maximum for Chlorophyceae (254.00±21.20 Unit/l) at middle zone II followed by Bacillariophyceae (193.75±12.50 Unit/l) and Cyanophyceae (101.25±16.52 Unit/l). At middle I highest for Chlorophyceae (241.75±17.00 Unit/l) followed by Bacillariophyceae (188.00±17.26 Unit/l) and minimum for Cyanophyceae (92.50±13.23 Unit/l) Table 2.While the minimum number of phytoplankton diversity was recorded in lower zone. At this zone the highest number of Cholorophyceae maximum in winter season was recorded (218.75±24.28 Unit/l)followed by Bacillariophyceae (145.50±14.80 Unit/l) and Cyanophyceae (54.40±19.26 Unit/l).The numbers of phytoplankton were lower in the month of July while higher in the month of February. There was a decline in number of phytoplankton in monsoon season while incline in winter season. The study revealed that the total number of phytoplankton were declined in the months of monsoon due to increased water level and decreased transparency. Low light may be another cause for a decrease in the level of phytoplankton during monsoon season. There was incline in the number of phytoplankton during the months of winter season might be due to clear water transparency, intense sunlight and increased light penetration.
In the present study Cholorophyceae population was most abundant followed by Bacillariophyceae and Cyanophyceae. Similar finding were reported by Mishra *et al.* (2010) [10].and observed 30 species of phytoplankton belonging to Cholorophyceae (10 species), Bacillariophyceae (11 species), Cyanophyceae (6 species) and Dinophyceae (3 species) from Dhaura and Baigul reservoirs. The abundance of Chlorophyceae was also reported by in Yeldari reservoir of Nanded District, Maharashtra. Pawar and Phulle (2006) [13]. recorded Chlorophyceae were found to be dominant throughout the study of Pethwadaj dam in taluka Kandhar of Dist. Nanded, Maharashtra. Malik and Bharti (2012) [7]. revealed that Chlorophyceae was dominant in Sahastradhara stream at Uttarakhand. In aquatic ecosystem, calculating phytoplankton biomass are significantly important for determining ecological status. In Ramganga reservoir, the total phytoplankton biomass was observed high in winter, low in summer Table 3. The three classes of phytoplankton were present in different seasons and showed different percentage composition like the highest number of Chlorophyceae (51%) in middle zone II, Bacillariophyceae (35%) in the middle zone I and II both and the number of cyanophyceae (14%) in less percentage in middle zone II Fig 3.
The higher value of Shanon-Weiner index (H'), indicated greater species diversity. The greater species diversity means larger food chain and more cases of inter-specific interactions and greater possibilities for negative feedback control which reduced oscillations and hence increases the stability of the community (Ludwick and Reynold, 1998) [6]. In the present study, this index of diversity (H') shows a value below to 3 for all stations during the study period mention in Table 4. This indicates a low specific structure of these groups indeed, a low diversity characterizes, young settlements of species, While a great diversity indicates mature settlements. The low diversity shows a weak internal structure of population (Le Bris, 1998; Glemarec & Le Bris, 1995) [5].

Table 1: Morphometric characteristics of Ram-Ganga reservoir.

Parameters	Observation
Altitude(m)	366.86
Longitude	78º 45' 31''E
Latitude	29º 31' 10"
Length(m)	715
Width(m)	170
Depth(m)	127.2
Reservoir Area(ha)	7831
Surface Area(km^2)	55
Catchment Area(km^2)	3134
Reservoir basin area(km^2)	78
Volume of water($v\times10^3$m3)	10000

Table 2: Seasonal variation of phytoplankton (Unit/l) in different zones of Ramganga reservoir

Group	Season	Upper Zone	Middle Zone I	Middle Zone II	Lower Zone
Cholorophyceae	Winter	230.75±15.95	241.75±17.00	254±21.02	218.75±24.28
	Summer	173.75±20.56	185±21.12	232.50±37.08	160.25±18.28
	Rainy	118.75±17.50	126.75±14.68	175.75±63.81	109.21±13.76
Bacillariophyceae	Winter	157.50±16.70	188.00±17.26	193.75±12.50	145.50±14.80
	Summer	148.75±13.15	168.50±19.47	179.75±53.13	128.26±44.21
	Rainy	106.25±13.15	117.25±15.71	126.75±18.57	84.75±68.13
Cyanophyceae	Winter	65.50±8.81	92.50±13.23	101.25±16.52	54.40±19.26
	Summer	37.50±18.48	70.00±23.45	81.25±16.52	28.25±13.77
	Rainy	14.25±3.50	21.25±9.95	32.75±11.87	12.75±16.48

Table 3: Distribution of phytoplankton biomass in different season of Ramganga reservoir

Name of Group	Phytoplanktonic Biomass (mg/m^3)											
	Upper Zone			Middle Zone I			Middle Zone II			Lower Zone		
	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
Cholorophyceae	37	31	24	47	41	32	56	45	35	29	22	18
Bacillariophyceae	33	36	11	46	42	17	47	41	22	25	19	12
Cyanophyceae	30	22	11	36	27	18	39	33	23	20	11	7

Table 4: Shanon-Weiner Index (H') of phytoplankton in different zone of Ramganga reservoir

Name of Group	Shanon-Weiner Index (H')											
	Upper Zone			Middle Zone I			Middle Zone II			Lower Zone		
	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy	Winter	Summer	Rainy
Cholorophyceae	2.13	1.9	1.62	2.18	2.11	1.76	2.26	2.19	2.1	2.13	1.4	1.02
Bacillariophyceae	2.01	1.53	1.04	2.15	2.03	1.83	2.18	2.08	1.97	1.09	0.98	0.69
Cyanophyceae	0.71	0.69	0.69	1.00	1.03	0.98	1.00	1.00	1.03	1.04	0.98	0.98

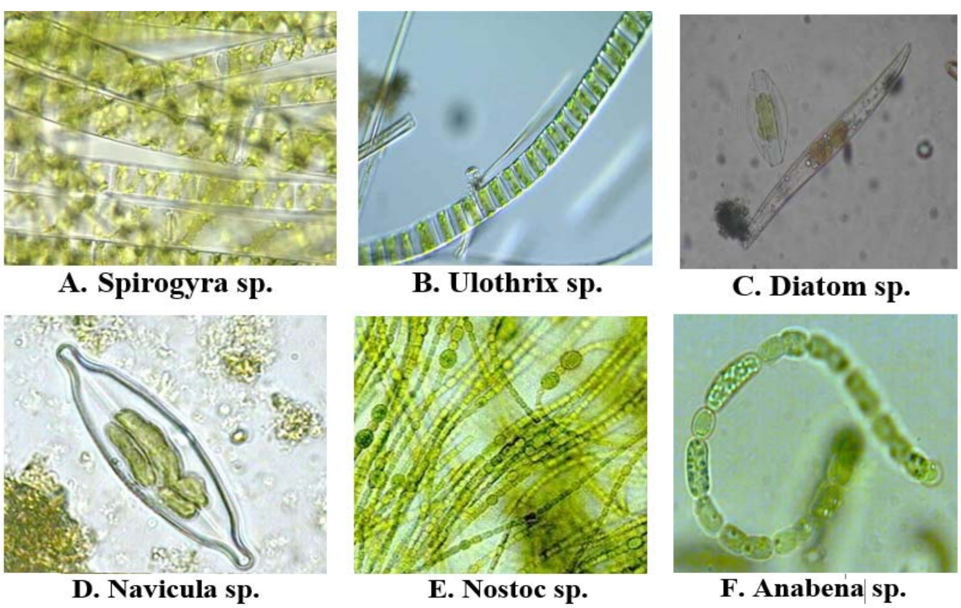
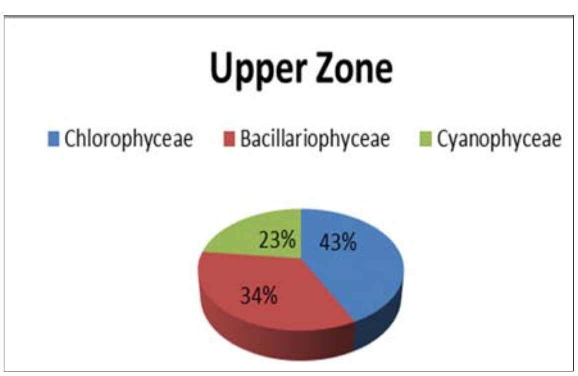
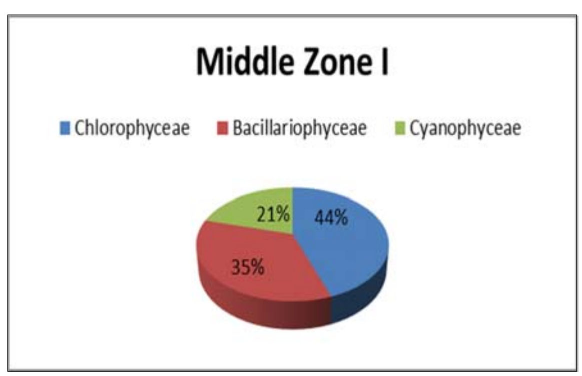


Fig. 2: Different species of phytoplankton found in Ram-Ganga Reservoir





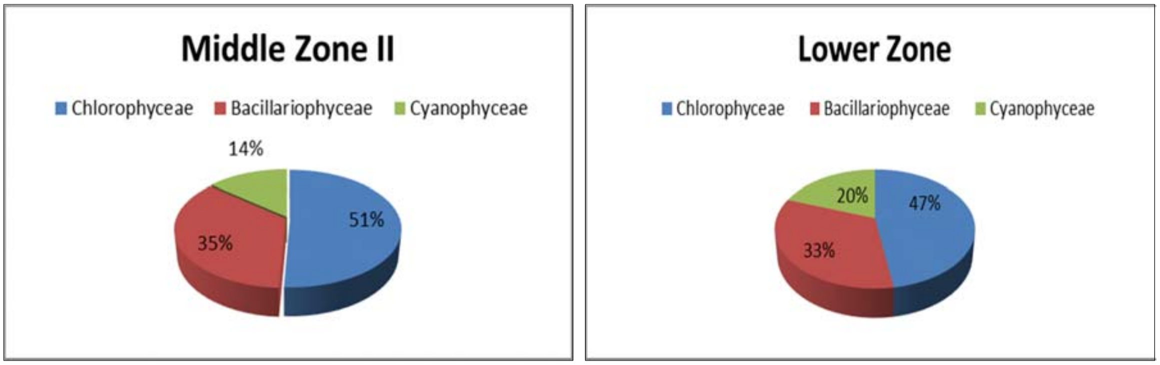


Fig 3: Percentage composition of phytoplankton in different zones of Ram-Ganga Reservoir.

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