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# Water Quality in Relation to Phytoplankton Diversity of Gautam Kund, Dehradun (Uttarakhand), India

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## ABSTRACT

This study deals with the study of water quality of Gautam Kund in relation to its phytoplankton diversity from December 2018 to April 2019 at two sites. A Total of 76 genera were identified belonging to 8 classes, 20 orders and 40 families during the present study period. Class Chlorophyceae contributes maximum to phytoplankton population. Total density of phytoplankton was ranged in between 207.0 to 1615.67 Unit l<sup>-1</sup>. Three different ecological indices were applied to phytoplankton data show that water of Gautam Kund ranges from moderately polluted to clean water. Principal component analysis was applied to explore relationship between physico-chemical parameters and phytoplankton diversity.

**Key words:** *Physico-chemical, PCA, Phytoplankton, Water quality, Ecological indices.*

## Introduction

Physico-chemical characteristics of water play a vital role to detect the quality of water when compared with the standard values (Begum *et al.*, 2005). The physico-chemical parameters and its biotic property determine standard water quality.

Distribution of phytoplankton communities in a water system is a result of physical, chemical, and biological conditions (Cloern and Jassby, 2010). The qualitative and quantitative analyses of phytoplankton of an ecosystem provide distribution and diversity status of that system (Hany *et al.*, 2017). They are the basic fundamental manufacturer in an aquatic ecosystem, the major food production for other higher life forms. The physical and the chemical influence indicate the different species content and the seasonal variations of phytoplankton and benthic lives (Cetin and Sen, 2004). Planktons are termed as

‘ecosystem engineers’ because it helps in changing the obtainable raw materials in the aquatic body (Reynolds, 2006). The availability and diversity of planktons rely on the physico chemical properties of the water. In order to evaluate proper monitoring and stability of the water quality, one must know the different physico-chemical and biological characteristics of water.

According to Ingole *et al.* (2010) and Gayathri *et al.* (2011) study done on phytoplankton diversity and density helps in assessing the water quality as they act as biological indicators. There is concern over the inland freshwater resources as these are being affected drastically by human actions. Hence, Limnological studies and research studies are of great importance today. With this concern, now there are numbers of studies on limnology of India’s fresh water viz, Sebastian and Thomas (2016); Nwonumara *et al.*, (2016), Joshua (2018), etc.

## Materials and Methods

The present research work is done in 'Doon Valley' which is situated between outer and lesser Himalaya. Geographically lies between 29° 50'-30° 30' N Latitude and 77° 35'- 78° 20' E Longitude. The present study was conducted in Chandrabani locality in Dehradun city which is closed to southern forests of Dehradun situated at an altitude of 621m asl. The total length is 5.89 m at Site S1 and 8.6m at Site S2, whereas width is 5.25 m and 6.2 m respectively. Monthly various physicochemical and biological parameters was undertaken during December 2018 to April 2019.

### Physico-chemical Analysis

Physicochemical parameters were studied following standard methods outlined in Welch (1952), Trivedy and Goel (1984) and APHA (2005). Phytoplankton samples were collected by filtering 100 litre of water through phytoplankton net and preserved in 4% formalin. Further analysis was done in laboratory. Phytoplankton were identified up to the lowest recognizable taxonomic unit mostly genus following keys by Needham and Needham (1962), Ward and Whipple (1959), Sarode and Kamat (1984), Phytoplankton were enumerated using Sedgwick-Rafter Cell Counter and number of plankton per ml of water was calculated according to Welch (1952).

### Diversity Indices

The monthly data collected on the phytoplankton density was subjected to further analysis by applying different ecological indices, i.e., Shannon-Weiner species diversity index (Shannon and Wiener, 1963), Species richness index (Margalef, 1957), evenness index (Pielou, 1969). Principal component analysis (PCA) was applied to explore relationships between physio-chemical parameters variables and phytoplankton diversity during the study period using PAST version 2.17c (Hammer *et al.*, 2001).

## Results and Discussion

### Physico-chemical Analysis

Average air temperature of Gautam Kund was minimum 11 °C in February and maximum 33 °C in April. The average water temperature ranged from 15 °C in December to 31 °C in April. Similar range of water temperature had been recorded by

Umerfaruq and Solanki (2015) in Biki Lake, Ahmedabad, Gujarat.

The dissolved oxygen ranged 9.00 mg/l in December to 12.90 mg/l in February. Dissolved oxygen is of great significance to aquatic organisms. The free CO<sub>2</sub> fluctuates from 2.20 mg/l (December, January, February, April) to 3.30 mg/l (March). Alkalinity ranges from 12.50 mg/l (February, March) to 17.50 mg/l (January).

The pH of the water varied between 7.00 and 7.25 during December and February, respectively. The average TDS varied from 0.31±0.00 (January, February, and March) to 0.34±0.00 (December), whereas the average salinity ranges from 4.95±0.07 (February) to 20.15±0.49 (December).

### Phytoplankton Diversity

A total of 76 genera were collected and identified from Gautam Kund during the December 2018 to April 2019 and belongs to 8 classes, 20 orders and 40 families (Table 1). Total density of phytoplankton ranged from 207.0 Unit l<sup>-1</sup> at site S1 during April to 1615.67 Unit l<sup>-1</sup> at S2 during January (Figure 5). Den-

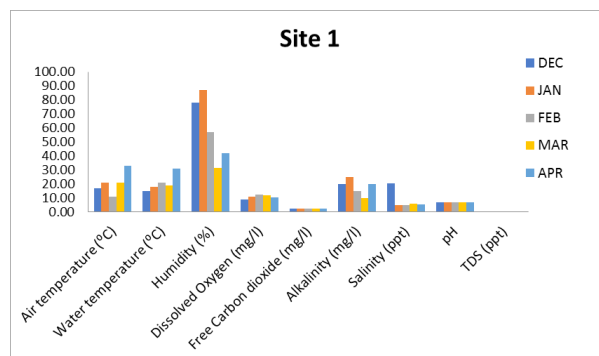


Fig. 1. Monthly fluctuation of physico-chemical parameters in Gautam Kund at Site S1 (December 2018-April 2019).

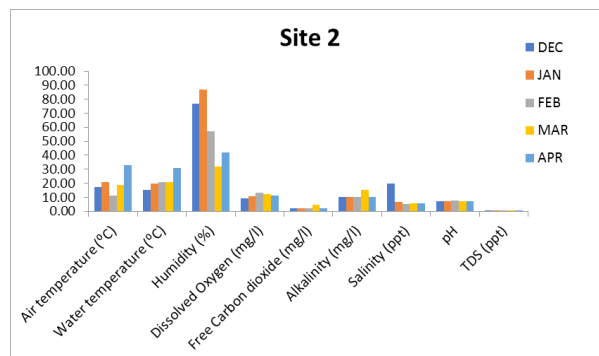


Fig. 2. Monthly fluctuation of physico-chemical parameters in Gautam Kund at Site S2 (December 2018-April 2019).

**Table 1.** Checklist of phytoplankton of Gautam Kund during December 2018-April 2019.

Class	Order	Family	Genus		
Chlorophyceae	Chlorococcales	Oocystaceae	<i>Kirchmedriella</i>		
			<i>Ankistrodesmus</i>		
			<i>Dictyosphaerium</i>		
					<i>Oocystis</i>
				Coelastraceae	<i>Trochischia</i>
				Delastraceae	<i>Coelastrum</i>
				Scenedesmaceae	<i>Scenedesmus</i>
		Zygomatales	Desmidiaceae	<i>Pleurotaenium</i>	
				<i>Desmidium</i>	
	<i>Cosmarium</i>				
	<i>Triplocerua</i>				
	<i>Staurastrum</i>				
	<i>Docidium</i>				
				Mesotaeniaceae	<i>Gonatozygon</i>
					<i>Genicularia</i>
					<i>Netrium</i>
					<i>Mesotaenium</i>
				Zygnemataceae	<i>Mougeotia</i>
					<i>Spirogyra</i>
			Oocystaceae	<i>Closterium</i>	
	Tetrasporales	Pleurochloridaceae	<i>Trachychlorom</i>		
		Coccomyxaceae	<i>Elakatothrix</i>		
	Ulotrichales	Tetrasporaceae	<i>Tetraspora</i>		
Ulotrichaceae		<i>Ulothrix</i>			
		<i>Hormidium</i>			
Volvocales	Microsporaceae	<i>Microspora</i>			
	Cladophyceae	<i>Rhizoclonium</i>			
	Spondylomoraceae	<i>Pascherieella</i>			
		<i>Dermatophyton</i>			
Cyanophyceae	Ulvales		<i>Monostroma</i>		
	Oedogoniales	Ulvaceae	<i>Oedogonium</i>		
	Sephonales	Oedogoniaceae	<i>Desmodesmus</i>		
	Chroococcales	Dichotomosiphonaceae	<i>Anacystis</i>		
			<i>Dactyococcopsis</i>		
		Chroococcaceae	<i>Microcystis</i>		
			<i>Polycystis</i>		
			<i>Gomphosphaeria</i>		
			<i>Anabaena</i>		
	Hormogonales	Nostoceae	<i>Nostoc</i>		
<i>Oscillatoria</i>					
Oscillatoriaceae		<i>Phormidium</i>			
		<i>Schizothrix</i>			
		<i>Dolichospermum</i>			
Euglenophyceae	Euglenales		<i>Phaeospaera</i>		
Cryptophyceae	Cryptomonadales	Euglenaceae	<i>Trachelomonas</i>		
			<i>Euglena</i>		
	Cryptococcales	Cryptochrysidaceae	<i>Rhodomonas</i>		
	Cryptococcaceae	<i>Tetragonidium</i>			
Dinophyceae	Dinokontae	Phytodiniaceae	<i>Cystodinium</i>		
Bacillariophyceae	Naviculales	Glenodiniaceae	<i>Glenodinium</i>		
	Cymbellaceae	Naviculaceae	<i>Navicula</i>		

**Table 1.** Continued ...

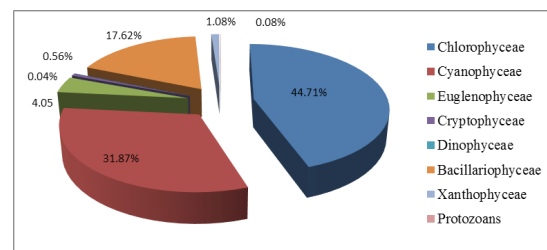
Class	Order	Family	Genus	
Xanthophyceae	Bacillariales	Cymbellaceae	<i>Cymbella</i>	
		Gomphonemetaceae	<i>Gomphonema</i>	
		Achnathoidae	<i>Rhoicosphentia</i>	
		Fragilariaceae	<i>Synedra</i>	
			<i>Fragilaria</i>	
			<i>Tabellaria</i>	
			<i>Planothidium</i>	
			<i>Pseudonitzschia</i>	
			<i>Diatoma</i>	
			Coscinodiscaceae	<i>Cyclotella</i>
			Cymbellaceae	<i>Amphora</i>
			Nitzschiaceae	<i>Nitzschia</i>
			Achnanthidiscaceae	<i>Achnanthes</i>
			Eunotiaceae	<i>Eunotia</i>
Xanthophyceae	Centrales	Epithemiaceae	<i>Epithemia</i>	
		Coscinodiscaceae	<i>Melosira</i>	
		Stephanodiscus	<i>Cosnicodiscus</i>	
		Heterococcales	Pleurochloridaceae	<i>Leuvenia</i>
				<i>Monallantus</i>
				<i>Diachros</i>
Protozoans	Peniculida	Heterotrachaceae	<i>Chlorgibba</i>	
			<i>Tribonema</i>	
			<i>Paramecium</i>	

sity of class chlorophyceae was minimum 95.00 Unit l<sup>-1</sup> at S1 (April) and maximum 800.33 Unit l<sup>-1</sup> at S2 (January). Class chlorophyceae was dominating by the species *Spirogyra*, *Netrium*, *Microspora*, *Tetraspora*, and *Gonatozygon*. Cyanophyceae was minimum 37.00 Unit l<sup>-1</sup> at S1 (April) and maximum 473.00 Unit l<sup>-1</sup> at S2 (January). Bacillariophyceae was minimum 25.33 Unit l<sup>-1</sup> at S1 (December) and maximum 415.67 Unit l<sup>-1</sup> at S2 (December), whereas Xanthophyceae was minimum 0.00 at S1 (December) and maximum 27.00 Unit l<sup>-1</sup> at S2 (January). Among the phytoplankton the class Xanthophyceae was represented by *Leuvenia*, *Monallantus*, *Diachros*, *Chlorgibba*, and *Tribonema*.

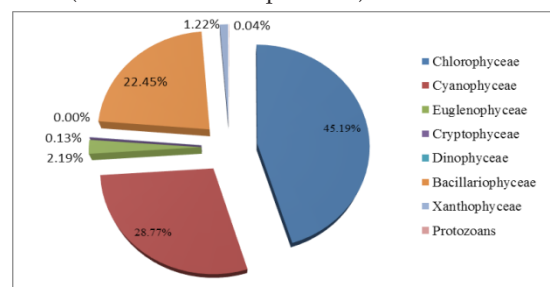
Euglenophyceae was minimum 5.00 Unit l<sup>-1</sup> at S1 (December) and maximum 57.00 Unit l<sup>-1</sup> at S2 (January), while Dinophyceae ranged from nil at S1 (December, February, March, April) S2 (December, January, February, March, April) to 1.00 Unit l<sup>-1</sup> at S1 (January). Density of class Cryptophyceae maximum 13.00 Unit l<sup>-1</sup> at S1 (March). In Gautam Kund protozoans were not observed in S1 during December, March, and April and S2 during December, February, March, April and maximum 2.0 Unit l<sup>-1</sup> at S2 (January) during the present study period.

Phytoplankton density was dominant by the

Chlorophyceae in Gautam Kund. In Gautam Kund at site S1 (Figure 3) Chlorophyceae had largest contribution of 44.71% followed by Cyanophyceae,



**Fig. 3.** Percentage fluctuation of phyto-plankton in Gautam Kund at site S1 during the study period (December 2018-April 2019).

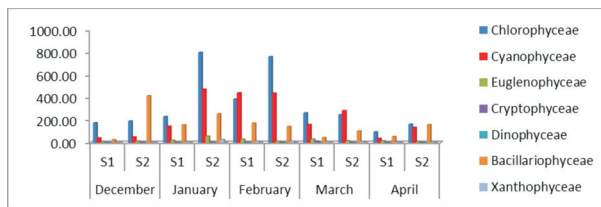


**Fig. 4.** Percentage fluctuation of phyto-plankton in Gautam Kund at site S2 during the study period (December 2018-April 2019).

Bacillariophyceae, Euglenophyceae, Xanthophyceae, then Cryptophyceae, Protozoans, and Dinophyceae. At site S2 (Figure 4) same trend was observed. The highest number of phytoplanktonic genera belonged to class Chlorophyceae (33), followed by Bacillariophyceae (19), Cyanophyceae (12). Anil and Suman (2013) during the study period in Lake Tilyar, Rohtak observed 33 phytoplankton and 22 zooplankton genera. The study revealed that Cyanophyceae and Chlorophyceae were the major contributors among phytoplankton whereas Bacillariophyceae contributed by four taxa only.

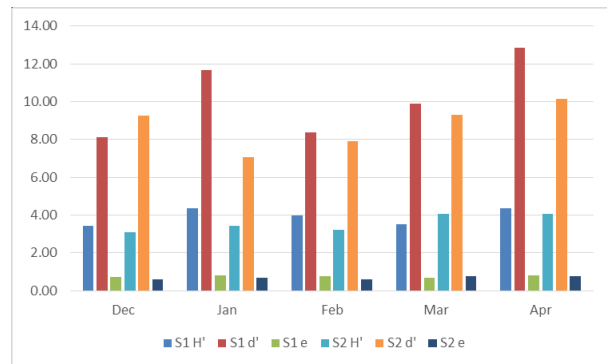
**Ecological Indices**

In Gautam Kund, maximum value of Shannon-Weiner diversity index was 4.37 in January at Site S1, whereas the lowest was 3.09 in December at Site S2. Therefore, from this index the quality of water ranged from moderately polluted to clean water.



**Fig. 5.** Class-wise density fluctuation in Gautam Kund during the study period (December 2018-April 2019).

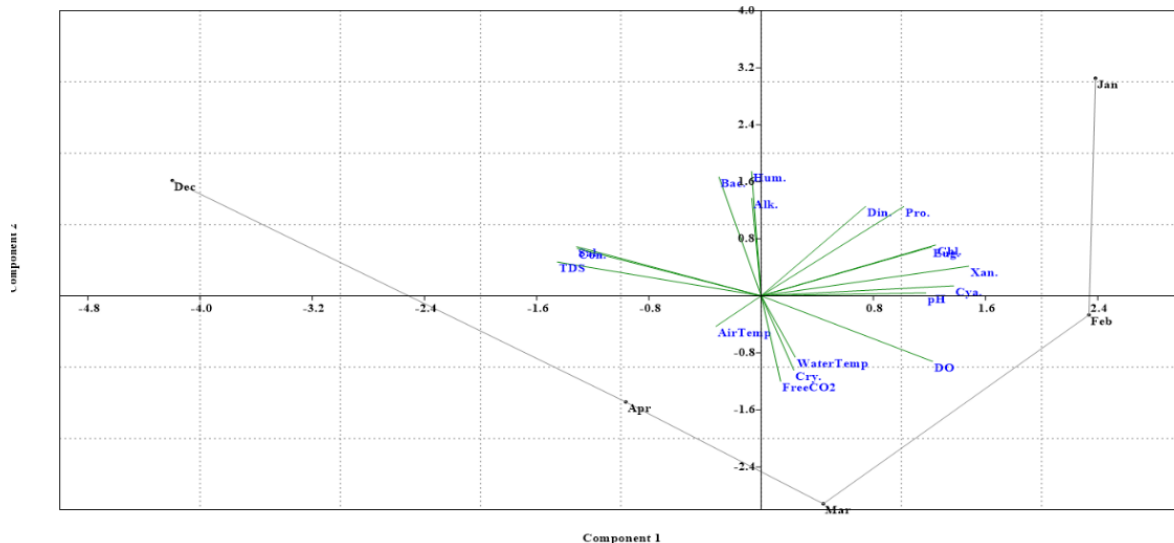
The phytoplankton genus richness ranged between 7.08 (minimum) at site S2 January and 12.87 (maximum) at site S1 (April). The Evenness index (e) ranged from 0.58 to 0.82 in the selected water body which shows that the individuals of the phytoplankton community were not evenly distributed. Based on various ecological indices calculated, water of Gautam Kund can be considered clean (Figure 6).



**Fig. 6.** Monthly fluctuation in diversity index of Gautam Kund at site S1 and S2 during the study period (December 2018-April 2019).

**Principal Component Analysis**

The four axes explained the variance in the data with Eigen values for Axis 1= 7.47 with variance 41.52% followed by for Axis 2 = 5.68 with variance 31.57%, Axis 3= 2.90 with variance 16.11%, and



**Fig. 7.** Ordination diagram of PCA of phytoplankton class and environmental variables in different months. The length of an arrow and its closeness to PCA axes is a measure of its strength. [Din. - Dinophyceae, Pro. - Protozoa, Chl. - Chlorophyceae, Eug. - Euglenophyceae, Xan. - Xanthophyceae, Cya. - Cyanophyceae, Cry. - Cryptophyceae, Bac. - Baccillariophyceae, TDS- Total dissolved solids, DO- Dissolved oxygen. Con. - Conductivity, Sal. - Salinity, Hum. – Humidity, Alk. – Alkalinity, FreeCO2- Free carbon dioxide]

Axis 4= 1.94 with variance 10.78%. The PCA showed distribution of phytoplankton class and environmental variables at different sections of the river were varied seasonally (Figure 7).

The phytoplankton class i.e., Dinophyceae, Chlorophyceae, Euglenophyceae, Xanthophyceae and Cyanophyceae along with pH associated with January on upper right quadrant of biplot. The phytoplankton class Cryptophyceae along with 03 physico-chemical parameters namely dissolved oxygen, water temperature and free carbon dioxide associated with March and February month present in bottom right quadrant. Air temperature associated with April month is plotted in bottom left quadrant of biplot. On upper left quadrant Bacillariophyceae along with water parameters TDS, conductivity, salinity, humidity, and alkalinity associated with December is plotted in upper left quadrant of biplot.

## Conclusion

The Gautam Kund represents a naturally occurring ecosystem that is oligotrophic as per plankton productivity. Chlorophyceae dominates the water of Gautam Kund at both sites S1 and S2 indicating the maximum rate of photosynthesis, which results in the overall productivity of lake. All physico-chemical parameters and phytoplankton diversity indicates the presence of clean water in Gautam Kund.

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