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Quantitative and qualitative enumeration of phytoplankton community in relation to Physico-Chemical Factors in Tumbadi Lake of Koratagere, Karnataka

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Abstract
The present studies were made on the enumeration of phytoplankton with respect to physico-chemical parameters in Tumbadi Lake of Koratagere in the state of Karnataka. Composite water samples were collected from designated stations at surface level during summer, winter and rainy seasons from January 2020 to December 2020. Total of 49 species of phytoplankton were identified under 31 genera belonging to 5 different taxonomic groups with seasonal maxima during summer. Bacillariophyceae with 36.65% dominated the other groups fallowed by Cyanophyceae (22.45%), Chlorophyceae (20.40%), Desmidaceae and Euglenophycean each with 12.24%. It is evident from the results that, Chlorophyceae did not supported by any of the physico-chemical parameters where as some of the physico-chemical parameters had indirect bearing on the population of Desmids and Euglenoids. Density of Diatoms was positively supported at significant level by air temperature and concentration of pH and nitrate having negative a correlation with silica. Blue greens were significantly supported by nutrient elements such as nitrate, phosphate and sulpahate. Mixophycean and Euglenophycean indices of Nygaard for water pollution indicated that the lake is oligotrophic. However, It is urged the local governmental authorities to control the anthropogenic activities and save the lake from further anthropogenic disturbances for the welfare of the present and future generations.

Keywords: Biological productivity, phytoplankton, macrophytes, zooplankton

Introduction
The freshwater ecosystems are represented by different freshwater such as lakes, tanks, rivers, ponds, streams and puddles. The inland freshwater ecosystems exhibit heterogeneity in their physicochemical composition accommodates higher percentage of the global biodiversity. Lakes support both micro and macroscopic flora and fauna such as phytoplankton, macrophytes, zooplankton and benthos forms the important freshwater ecosystems having wide-range of importance and extends various goods and services. The lakes are largely being used for the purposes of drinking, irrigation, fishing, eco-tourism, etc. (Bhatt *et al*., 2014) [4]. Generally, lakes situated in and around urban settlements are mainly used for recreational purposes and such lakes are also being used for the discharge of industrial and domestic wastes and thereby cause the deterioration of the water quality. Heterogeneous assemblage of microscopic organisms which float and also drift along the course of water current in aquatic habitats are referred to as phytoplankton which forms important components of freshwater ecosystems. In view of their high sensitivity to the changes in water quality, status of aquatic ecosystem such as eutrophication and pollution some phytoplankton are considered to be indicator organisms (Jena *et al*., 2017) [8]. The status of aquatic ecosystems is depending on variation in the density and diversity of phytoplankton. Population in fresh water ecosystem is represented by many species (Manickam *et al*., 2020) [10]. Abundance, distribution, diversity, periodicity, growth & reproduction of phytoplankton are mainly depending on the interactions between the physico-chemical parameters of water in fresh water ecosystem (Anne Rebecca, 2019; Deepak & Singh, 2014) [2, 5]. Biological productivity of fresh water ecosystem found to be greatly influenced by physico-chemical parameters specially temperature, light intensity, micro and macro-nutrients of the water as well as the soil (Ahmed *et al*., 2013; Bais & Agarwal, 1990) [1, 3].

Bloom formation in lakes mainly caused due to the movement of nutrient elements from sediments to water column, (Ekholm and Mitikka, 2006) [7]. Oligotrophic lakes are transparent and hypertrophic lakes are turbid, the shallow lakes may exhibit either clear water or turbid state (Scheffer *et al*., 2001) [21]. Research in the field of aquatic ecosystems and phytoplankton was carried out in India since 1950 onwards (Rajashekhar *et al*., 2009) [20]. The present investigation in Tumbadi Lake of Koratagere in the state of Karnataka pertains to the diversity, density and periodicity of phytoplankton in relation to physico-chemical parameters.

Study area

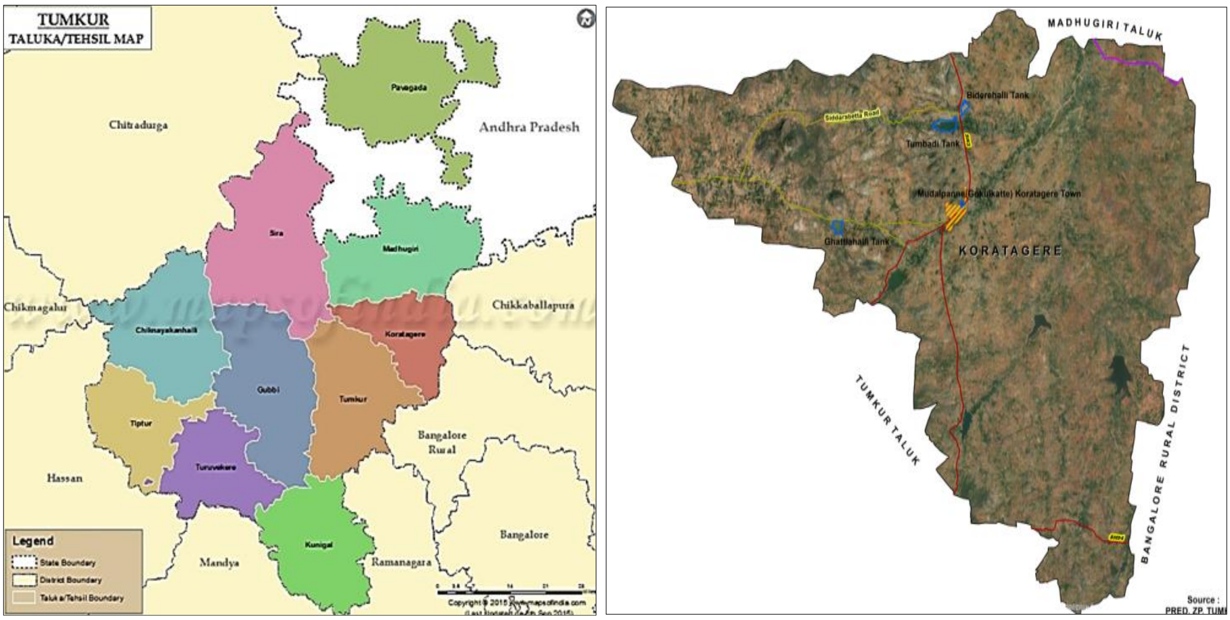

Fig 1: Map of Koratagere Taluk in Tumkur District

Tumbadi lake, a perennial fresh water tank situated at a distance of 6 kms North of Koratagere town between $13^0 34^{II}75^I$ North latitude and $77^0 10^{II} 21^I$ East longitude (Figure-1). The lake is rectangle to boat shaped (Figure-2) with raised northeast - southwest earthen bund with stone-work along the inner side (Figure-3). As per the available records of the department of Zillapanchayat the foundation stone for the construction of this lake was laid down on 21st March1933 by the then Deevan of Mysore Sir. Mirza M. Ismail. The lake receives water from the surface run-off from the hill slopes of Muggondanahalli and Tumbadi during monsoon, also receives water from Channarayanadurga, Dugganahalli and Byrenahalli canals. The average depth of this lake is 10-12 feet's with clay bed along with loamy soil mixed with fine grained sand beds. The water is mainly used for agricultural practices. The lake is subjected to anthropogenic pressure as washing (Figure-4) and bathing activities were commonly seen during sampling. Detailed morphometric features are appended in table –1.

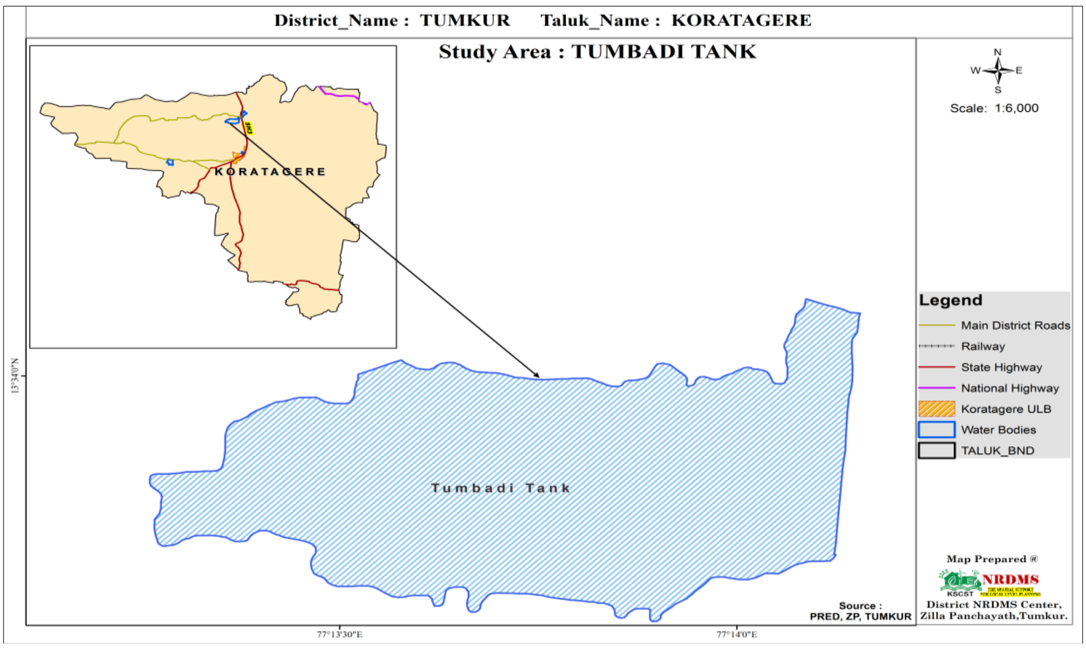

Fig 2: Map of Tumbadi Lake in Koratagere in Tumkur District

Table 1: Morphometric features of Tumbadi lake

Sl. No	Morphometric Features	
1	Basin	North Pennar
2	Sub basin	Jayamangali
3	Bund type	Earthern
4	Bund length	480 meters
5	Width of the bund	1.8 meters
6	Bund height	13.4 meters
7	Catchment	10.91 Km^2
8	Area benefitted	243 hectares
9	Purpose	Irrigation and domestic

Fig 3: View of Tumbadi Lake

Fig 4: View of Tumbadi Lake showing Anthropogenic Pressures

Materials and Methods

Sampling of Water

Surface water samples for the analysis of physico-chemical parameters were collected at four fixed stations of the lake at monthly intervals from June 2019 to May 2020. All the four representative samples were mixed thoroughly for composite sample and filled in black colored plastic can of two litres capacity. pH, temperature of air and water were measured on the spot. Water samples were fixed on the spot using Winkler's reagent for the estimation of dissolved oxygen. Methods of Trivedi and Goel (1986) were fallowed during sampling, transportation, preservation and analysis.

Enumeration of Phytoplankton

For the enumeration of diversity, density and periodicity of phytoplankton two litres of surface water samples were collected from all the fixed stations simultaneously along with the samples for chemical analysis in black colored plastic cans at an interval of 30 days. Collected water samples were mixed thoroughly and fixed with 20 ml of 1% lugol solution for 24 hours. After sedimentation 100 ml of the sample was subjected to centrifugation at 1500 rpm for 20 minutes and used for further investigation. For phytoplankton composition, camera-lucida diagrams were drawn under 10x40 magnifications. The identification of phytoplankton was made up to the level of species with the help of specific monographs. For the quantitative estimation of phytoplankton a drop of the sediment sample was scanned in ten different microscopic fields under 10x40 magnifications and phytoplankton were counted and expressed in terms of organisms per litre following Rao's method (1955). Trophic status of the lake was assessed by Nygaard's algal indices (1949) [16].

Results and Discussion

Table 2: Mean and seasonal variations of physico-chemical parameters of Tumbadi lake

Sl. No.	Physico-Chemical Parameters	Jan 2020-Dec 2021			Mean Value
		Summer	Rainy	Winter	
1	Air temperature	35	31	28	32.04
2	Water temperature	31.25	29	26	29.88
3	pH	7.1	6.67	7.15	6.91
4	Dissolved oxygen	4.02	3.07	3.95	3.48
5	BOD	3.22	3.17	2.5	2.64
6	Total hardness	160.25	324.75	202	195.17
7	Sulphate	290.87	216.50	66.72	202.7
8	Chloride	93.66	87.27	39.54	82.55
9	Phosphate	2.65	1.8	1.25	2.54
10	Silica	0.12	0.09	0.107	0.10
11	Nitrate	4.4	6.575	5.725	0.29

Mean and seasonal variations of physico-chemical parameters have been appended in table-2 whereas table-3 explain Karl Pearson's correlation Between Physico-chemical parameters V/s Physico-chemical parameters. Present study recorded mean value of 32.04^{o}C air temperature with seasonal maxima observed during summer and that of minimum values during winter, similarly water temperature with mean value of 29.88^{o}C reached its highest peak during summer and that of lowest during winter (Table-2). The role of light and temperature in determining the density of phytoplankton has been reported earlier by Nazneen (1980) [15]. Both air and water temperatures remained positively correlated to chloride, sulphate and phosphate at 0.01 significant level where as they achieved similar positive correlation with BOD and to nitrate at 0.05 level (Table-3). Mean value of pH appears to be acidic having almost neutral appearance in all the seasons (Table-2) and showed positive bearing on the concentration of dissolved oxygen at 0.01 levels (Table-3). Higher pH (8.0) is favourable for the growth of phytoplankton (Murulidhar and Murthy, 2014) [12] similar observations were made earlier by Ekhande *et al*. (2013) [6]. Dissolved oxygen appeared more during summer and less during rainy with a mean value of 3.48 mg/l (Table-2). Biological oxygen demand recorded its highest value during summer and lowest during winter with a mean value of 2.64 mg/l (Table-2). Highest value of total hardness was recorded during rainy and that of lowest during summer with a mean value of 195.17mg/l (Table-2). Values of total hardness had a direct bearing on the concentration of silica at significant level (Table-3). Values of chloride, sulphate and phosphate recorded more during summer and less during winter (Table-2) and their inter relationships with other physico-chemical parameters has been.

Table 3: Karl Pearson's correlation Between Physico-chemical parameters V/s Physico-chemical parameters in Tumbadi Lake

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
P1	1										
P2	0.904**	1									
P3	0.343	0.131	1								
P4	0.161	0.051	0.843**	1							
P5	0.381	0.422*	0.111	0.21	1						
P6	-0.203	0.045	-0.463*	-0.376	0.264	1					
P7	0.808**	0.858**	-0.031	-0.117	0.37	-0.08	1				
P8	0.648**	0.677**	0.022	-0.004	0.346	-0.093	0.874**	1			
P9	0.78**	0.778**	0.022	-0.075	0.345	-0.286	0.870**	0.797**	1		
P10	-0.358	-0.207	-0.368	-0.281	-0.01	0.815**	-0.261	-0.195	-0.462*	1	
P11	0.465*	0.338	0.358	0.253	0.127	-0.653**	0.422*	0.391	0.601**	-0.881**	1

** Correlation is significant at 0.01 levels, *Correlation is significant at 0.05 levels

Given in table-3. Concentration of silica had a negative correlation with phosphate and nitrate (Table-3). Mean value of nitrate obtained was 0.29 mg/l with seasonal maxima during rainy and that of minimum during summer (Table-2). Nitrate was positively correlated to the concentration of air temperature, sulphate and phosphate (Table-3).

Phytoplankton

The identified phytoplankton species and their abundance have been listed in Tables 4 to 8. Total of 49 species of phytoplankton were identified under 31 genera belonging to 5 different taxonomic groups. With regard to relative abundance, Bacillariophyceae with 36.65% dominated the other groups fallowed by Cyanophyceae (22.45%), Chlorophyceae (20.40%), Desmidaceae and Euglenophyceae each with 12.24% (Figure-6).

Present studies recorded 16 species of Diatoms and are listed in table-4 with seasonal maxima during summer and minima during rainy (Figure- 5) where similar findings were proposed earlier by (Murulidhar and Murthy, 2014) [12]. Patric (1977) [18] had corroborated the importance of water temperature in determining the periodicity of diatoms and observed inverse relationship between temperature and diatoms population. Singh and Swarup (1979) [23] opinioned that higher temperature promotes the growth of Diatoms. In the present investigation, Diatoms were found peak during summer showing significant positive correlation with the air temperature at 0.05 levels. Manikya Reddy and Venkateshwaralu (1992) [11] reported similar observations. Five out of sixteen species appeared between 100 and 500 org/l. Parameters such as air temperature, pH and nitrates exhibited positive correlations with the populations of Diatoms and whereas total hardness and silica had negative correlations (Table-9). Bacillariophyceae encompasses most pollution tolerant species such as Melosira *granulata, Navicula cuspidata, Navicula cryptocephala and Surirella ovata* (Palmer, 1969) [17].

Cyanophyceae harboured 11 species constituting 22.45% (Figure-6) emerged as second biggest group of phytoplankton where all the species appeared between 50 to 100 org/l (Table-5). Seasonally Cyanophyceae reached higher peak during summer and lower peak during winter (Figure-5) where similar observations were made by Tripathi and Pandey (1995) [24] added to this Murulidhar and Murthy (2015) [13] also were of the same opinion. Chloride along with nutrient elements like sulphate, phosphate and nitrate are positively correlated with density and periodicity of Cyanophyceae (Table-9). *Oscillatoria tenuis, Oscillatoria chlorina and Oscillatoria princepis* appeared as most pollution tolerant species (Palmer, 1969) [17].

Table 4: Diversity and distribution of Bacillariophyceae in Tumbadi Lake

SL. No.	Bacillariophyceae	Periodicity
1	*Cocconeis placentula*	+
2	*Cymbella cymbiformis*	+
3	*Fragillaria voucheriae*	++
4	*Gomphonema accuminatus*	+
5	*Melosira granulata*	+
6	*Navicula cuspidata*	++
7	*Navicula pupula,*	+
8	*Navicula radiosa*	+
9	*Navicula acicularis*	++
10	*Navicula linearis*	+
11	*Navicula cryptocephala*	++
12	*Pinnularia biceps*	+
13	*Pinnularia major*	+
14	*Stauraneis anceps*	++
15	*Surirella ovata*	+
16	*Synedra ulna*	+

Table 5: Diversity and Distribution of Cyanophyceae in Tumbadi Lake

SL No.	Cyanophyceae	Periodicity
1	*Anabaena spiroides*	+
2	*Chroococcus turgidus*	+
3	*Gloeocapsa punctata*	+
4	*Merismopedia glauca*	+
5	*Microcystis aeruginosa*	+
6	*Microcystis viridis*	+
7	*Mixosarcina burmensis*	+
8	*Oscillatoria tenuis*	+
9	*Oscillatoria chlorina*	+
10	*Oscillatoria princepis*	+
11	*Spirulina spiroides*	+

Table 6: Diversity and distribution of Chlorophyceae in Tumbadi Lake

SL No.	Chlorophyceae	Periodicity
1	*Ankistrodesmus falcatus*	+
2	*Crucigenia tetrapedia*	+
3	*Crucigenia quadricauda*	+
4	*Pediastrum duplex*	++
5	*Pediastrum tetras*	+++
6	*Pediastrum simplex*	+
7	*Senedesmus accuminatus*	+
8	*Senedesmus quadricauda*	+
9	*Selenastrum gracile*	+
10	*Tetraedon muticum*	+

The abundance of Chlorophyceae was reported by Pawar and Phulle (2006) [19] and Malik and Umesh Bharti (2012) [9]. In contrary to above researchers during present study Chlorophyceae with ten species was found as third dominant group (Figure-6). Seasonally, density of Chlorophyceae reached its highest peak during summer and lowest peak during rainy (Figure-5). Parameters such as turbidity, conductivity, total hardness and chloride are positively correlated with dynamics of Chlorophyceae (Murulidhar and Murthy, 2015) [13]. Contrary to this in the present study none of the physico-chemical parameters established correlations with the population of Chlorophyceae (Table-9). The presence of pollution tolerant species like *Ankistrodesmus falcatus, Pediastrum duplex and Tetraedon muticum* shows that the lake is moving towards eutrophic condition.

Table 7: Diversity and Distribution of Desmidaceae in Tumbadi Lake

SL No.	Desmidaceae	Periodicity
1	*Closterium ascicularíae*	++
2	*Closterium aerosum*	+
3	*Cosmarium melanosporum*	+
4	*Cosmarium retusiformae*	+
5	*Euastrum serratum*	++
6	*Staurastrum gracile*	+

Desmids are sensitive organisms act as indicators of water pollution. In the present investigation six species were identified (Table-7) and recorded maximum during pre-monsoon and minimum during monsoon months (Figure-5). Desmids population showed significant positive correlation with air and water temperature, pH, sulphate and nitrate (Murulidhar and Murthy, 2015) [13] in contradiction with this during present studies no correlations were observed (Table-9). Poor diversity and low density of Desmids is attributed to the habitat of these wetlands where they do not receive directly any type of pollutants (Shalini and Murulidhar, 2023) [22] the same is true to the present investigation.

Table 8: Diversity and Distribution of Euglenophyceae in Tumbadi Lake

SL No.	Euglenophyceae	Periodicity
1	*Euglena minuta*	+
2	*Euglena viridis*	+
3	*Phacus ankylonoton*	+
4	*Phacus caudatus*	+
5	*Tracheolomonas armata*	+
6	*Tracheolomonas robusta*	+
+++	++	+
Above 500 Org / L	100 to 500 Org / L	1 to 100 Org / L

Index

Euglenoids occur in greater number in polluted water bodies. Tripathi and Pandey (1995) [24] have recorded maximum euglenoids during monsoon and low during post-monsoon. Similar findings have been made in the present study. Density and diversity of euglenoids is positively correlated with air and water temperature, sulphate, nitrates and silica (Murulidhara and Murthy, 2015) [13]. During present studies nitrates established positive correlations with euglenoid population, hence we are in partial conformity with above findings (Table-9). It is concluded that, the higher concentration of euglenoids during summer season is due to surface runoff from agricultural fields (Murulidhara and Murthy, 2019) [14] the same is true to the present studies (Figure-5).

Table 9: Karl-Pearson's correlation between physico-chemical parameters and phytoplankton groups in Tumbadi Lake

	P1	P2	P3	P4	P5	P6	P7	P8	P9	P10	P11
Chlorophyceae	0.25	0.05	0.199	0.054	-0.35	-0.384	0.143	0.089	0.142	0.007	.0.01
Bacillariophyceae	.430*	0.352	.435*	0.288	-0.15	-.491**	0.185	-0.04	0.248	-.621**	.458*
Desimidaceae	0.398	0.17	0.345	0.112	-0.15	-.511**	0.176	-0.04	0.192	-.568**	0.395
Cyanophyceae	0.344	0.399	-0.13	-0.198	0.155	-0.187	.667**	.670**	.629**	-.440**	.555**
Euglenophyceae	0.298	0.089	0.162	0.112	-0.07	-.656**	0.245	0.349	0.361	-.600**	.640**

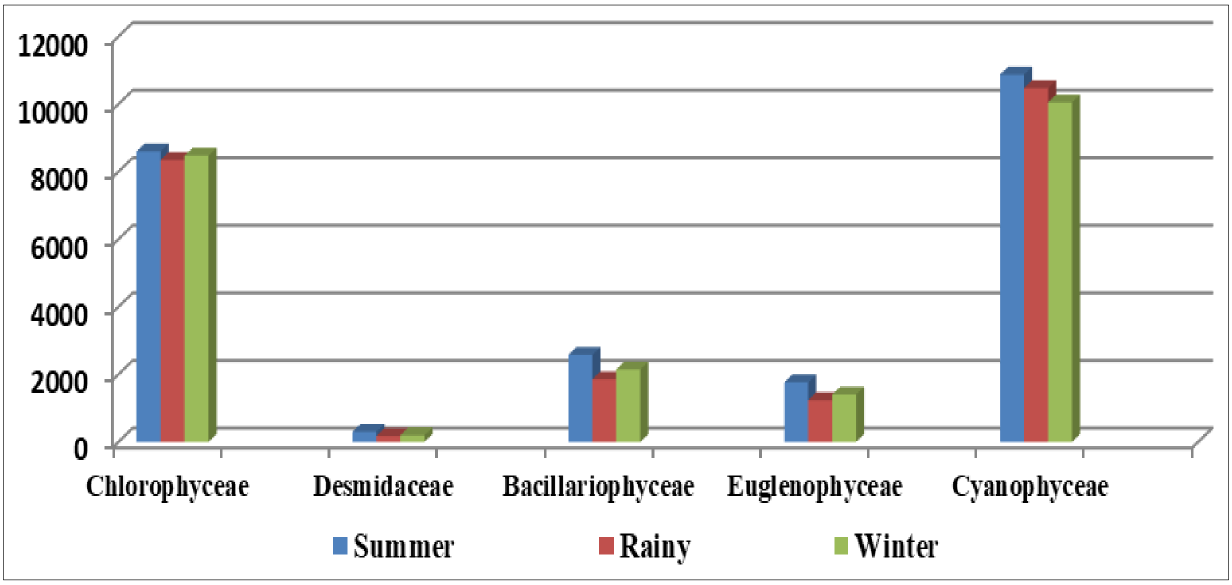

Fig 5: Seasonal variations of Phytoplankton

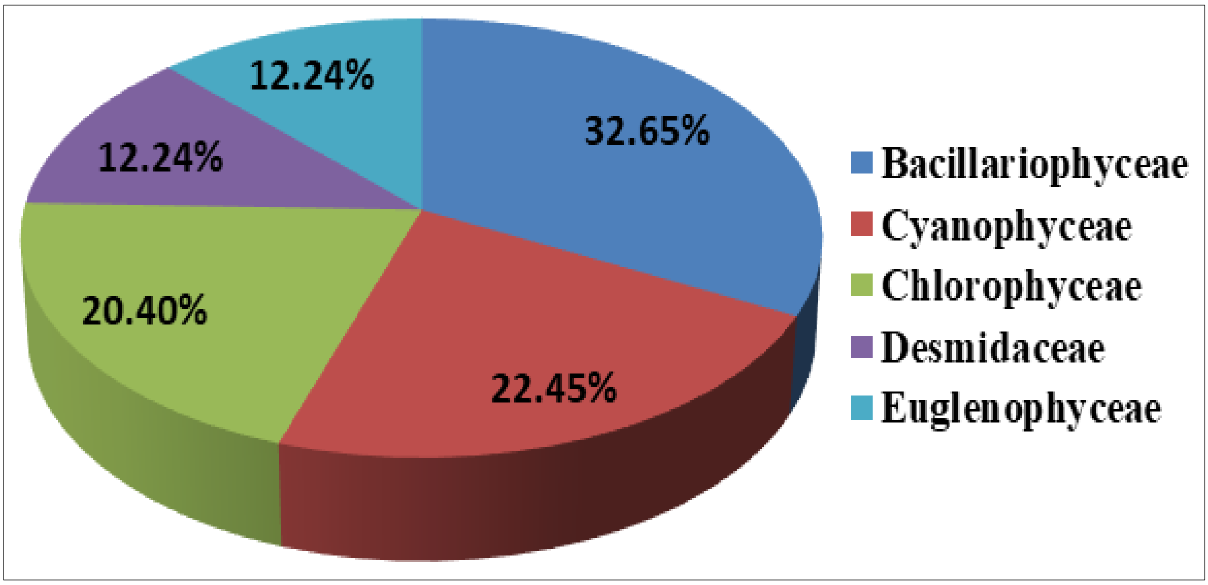

Fig 6: Relative abundance of Phytoplankton

Conclusion

It is concluded that physico-chemical parameters found within the standards of BIS. 49 species of phytoplankton were identified under 31 genera belonging to 5 different taxonomic groups dominated by Bacillariophyceae. Mixophycean and Euglenophycean indices of Nygaard for water pollution indicated that the lake is oligotrophic. However, presence of most pollution tolerant species is tending lake towards eutrophic in its condition. Hence, it is urged the local governmental authorities to control the anthropogenic activities and save the lake from further anthropogenic disturbances for the welfare of the present and future generations

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