Phytoplankton Diversity in Bangalore Lakes, Importance of Climate Change and Nature's Benefits to People

Sabita Kumari P, Gayathri S and Ramachandra Mohan M*

Department of Zoology, Bangalore University, Lake Management and Water Quality Research Unit, Bangalore, India

*Corresponding author: M Ramachandra Mohan, Department of Zoology, Bangalore University, Lake Management and Water Quality Research Unit, Bangalore-560056, India, Tel: 080-2214001; E-mail: mohanramachandr@gmail.com

Abstract

Studies were carried out during the monsoon of 2017 to observe the percentage of phytoplankton in two lakes namely Nirmalagiri Lake & Kengeri Lake in Bangalore. The work gains importance due to long incubation period and scanty rains. Present studies Aims to understand the positive implication of Climate Change and Nature's Benefits to People, and to analysis the distribution of phytoplankton which was influenced after a continuous rain for six months. In these two lakes seven groups of phytoplankton has been observed, which belong to group Chlorophyceae, Euglenophyceae, Bacillariophyceae, Cyanophyceae, Charophyceae, Dynophyceae. Out of which 6 groups were found in Kengeri Lake while 4 groups were found in Nirmalagiri Lake. The percentage of phytoplankton in Nirmalagiri Lake is 63.28% while the percentage of phytoplankton in Kengeri Lake is 36.71%. In case of Nirmalagiri Lake the percentage has been calculated for different groups. The percentage of *Chlorophyceae* is 86.12%, while *Euglenophyceae* is 0.90%, *Bacillariophyceae* is 5.85%, *Cyanophyceae* is 7.11% and incase of Kengeri Lake *Chlorophyceae* is 76.55%, *Euglenophyceae* is 1.24%, *Bacillariophyceae* is 7.14%, *Cyanophyceae* is 12.57%, *Charophyceae* is 2.32%, *Dinophyceae* is 0.15%. *Chlorophyceae* was the most dominating group in the both lakes. The diversity indices of the phytoplankton were found using "PAST" software.

Keywords: Climate Change; Biodiversity; Phytoplankton diversity; Diversity indices; Bangalore Lakes

Introduction

Nature and its contributions to a good quality of life are often perceived and valued by people in starkly different and often conflicting ways. Co-construction of assessments of the state of the world's biodiversity and the benefits it provides to humans Phytoplankton are at the base of aquatic food webs and of global importance for ecosystem functioning and services. The dynamics of these photosynthetic organisms are linked to annual fluctuations of temperature, water column mixing, resource availability and consumption. Biodiversity means the variability among all living organisms in a particular ecosystem. Ecological impacts of recent climate change on ecosystems worldwide. A major challenge in climate change research on phytoplankton succession is to understand the multiple factors, which drive ecological changes in phytoplankton communities. Climate can modify environmental factors and alter phytoplankton structure, seasonal dynamics, and taxonomic composition.

Studies of the ecology of lake phytoplankton have provided a wealth of insight into the interactions between abiotic factors and biotic ones such as competition and predation. Theoretical investigations into the effect of lake thermal stratification on phytoplankton communities have been especially fruitful have provided predictions for the occurrence of plankton blooms among others [1-3].

The continuous heavy rainfall that occurred in Bangalore from June 2017 to November 2017 lead to stratification beginning to diminish completely and rain water mixed in the lake and produced a high concentration of Dissolved Oxygen (DO). Heavy rainfall accelerated the formation of an anoxic zone at the bottom of the Lake and promoted Chlorophyceae and other phytoplanktons due to the high nutrient input and the increased water temperature. Heavy rainfall influences the dynamics of phytoplankton in lake. Growth of phytoplankton is influenced by the presence of limiting nutrient caused by inflow of freshwater. Limiting nutrient of phytoplankton growth was nitrogen on little volume of freshwater inflow. However, the limiting nutrient was changed from nitrogen to phosphorus after heavy rain. This may be due to the high inflow of freshwater containing dissolved inorganic nitrogen and phosphorous.

Some notable studies on phytoplankton diversity have been made by Ariyadej, et al.; Mishra, et al.; and Joseph and Yamakanamardi [4-6]. According to Pawar, et al. the Present plankton study is useful tool for the assessment of biotic potential and contributes to overall estimation of basic nature and general economic potential of water body [7].

Material and Methods

Study Site

The lakes of Bangalore occupy about 4.8% of the city's geographical area (640 Sq. Km.) covering both urban and rural areas. The present study was done in the lakes (Figures 1 & 2) both are situated in Kengeri urban area and its geographical coordinates are 12°54' 0" North, 77°29' 0" East. The lakes are predominantly rain fed and are used for irrigation, agriculture and fish culture etc., Due to its high elevation of 900 m (3,000 ft) above sea level, Bangalore usually enjoys a more moderate climate throughout the year, although occasional heat waves can make summer somewhat uncomfortable. Winter temperatures rarely drop below 14°C (57°F), and summer temperatures seldom exceed 36°C (97°F).
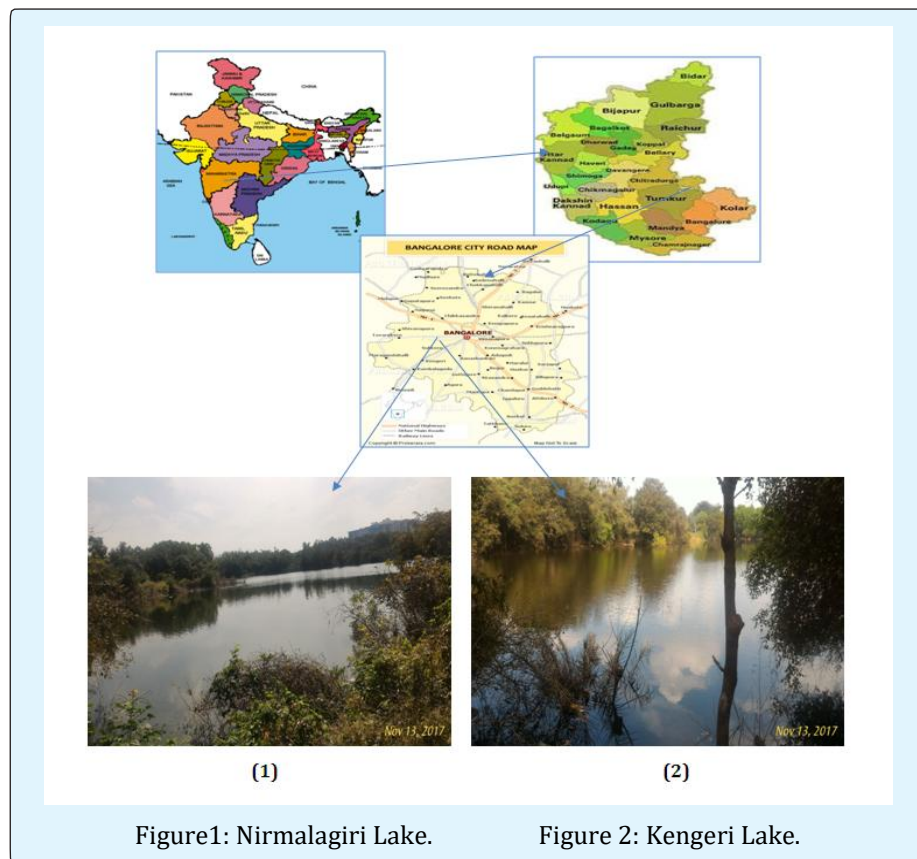

Figure1: Nirmalagiri Lake.   Figure 2: Kengeri Lake.

Sampling

The sampling was done during the monsoon months of year 2017 from two lakes (Nirmalgiri and Kengeri). Collection of phytoplankton samples was made by sieving 25 litres of habitat water from approximately 10 - 12 cm below the surface level passed through a 25 µm mesh net and the collected samples were transferred to 1litre capacity plastic bottles. Then the samples which were collected was allowed to centrifuge to concentrate and made up to 100ml after removing the surface water in the centrifuging tube. The population of plankton accumulated in the container were then transferred to other bottle and immediately preserved in Lugol's Iodine solution, labeled and then transferred to laboratory for further experimentation. Each sample was stirred smoothly just before microscope examination. One ml from agitated sample was transfer to a Sedge-wick Rafter counting cell with a wide mouth graduated pipette. The abundance of plankton was estimated by counting their presence per focus of the microscopic field. Plankton were identified by using the keys of Lloyd M and RJ Ghelardi 1964, Needham JG and PR Needham 1966, Bhouyain AM and SM ASMAT 1992 and Ali S and T Chakrabarty 1992 [8-11].

Results and Discussion

The results of the phytoplankton in the two lakes are presented in Table 1 the abundance and percentage composition of phytoplankton in two lakes are presented in Table 2 and the calculated diversity indices are presented in Table 3. Figure 3 show the microphotographs of phytoplankton in Nirmalagiri lake and Kengeri lake.

Group	Nirmalagiri Lake			Kengeri Lake		
CHLOROPHYCEAE	Organisms/ml	Organisms/L	% age Composition	Cells/ml	Organisms/L	% age Composition
Chlamydomonas sp.	20	80,000	2.09	14	56,000	2.83
Gonium formosum	02	8000	0.20	01	4000	0.20
Volvox sp.	156	6,24,000	16.31	70	2,80,000	14.19
Sphaerocystis sp.	00	00	00	01	4000	0.20
Elakatothrix gelatinosa	189	7,56,000	19.76	72	2,88,000	14.60
Schroederia sp.	00	00	00	01	4000	0.20
Pediastrum simplex	195	7,80,000	20.39	78	3,12,000	15.82
Coelastrum sp.	30	1,20,000	3.13	16	64,000	3.24
Chlorella sp.	54	2,16,000	5.64	12	48,000	2.43
Clostridium sp.	04	16,000	0.41	08	32,000	1.62
Selenastrum sp.	92	3,68,000	9.62	42	1,68,000	8.51
Kirchaneriellah sp.	00	00	00	05	20,000	1.01
Scenedesmus sp.	06	24,000	0.62	04	16,000	0.41
S. Dimerphus sp.	01	4000	0.10	02	8000	0.40
S. bijugarus sp.	07	28,000	0.73	04	16,000	0.81
S. obliquus sp.	07	28,000	0.73	05	20,000	1.01
Phytoconosis sp.	70	2,80,000	7.32	89	3,56,000	18.05
Nostoc muscorum	28	1,12,000	2.92	13	52,000	2.63
Draparnaldia sp.	02	8000	0.20	00	00	00
Spirogyra sp.	13	52,000	1.35	12	48,000	2.43
Closterium sp.	01	4000	0.10	00	00	00
Oocytis sp.	05	20,000	0.52	05	20,000	1.01
Staurastrum sp.	00	00	00	08	32,000	1.62
Euastrum sp.	12	48,000	1.25	02	8000	0.40
Pleurotaenium sp.	52	2,08,000	5.43	14	56,000	2.83
Hyalotheca sp.	10	40,000	1.04	15	60,000	3.04
Total	956	38,24,000	100	493	19,72,000	100
EUGLENOPHYCEAE						
Phacus sp.	10	40,000	100	08	32,000	100
Total	10	40,000	100	08	32,000	100

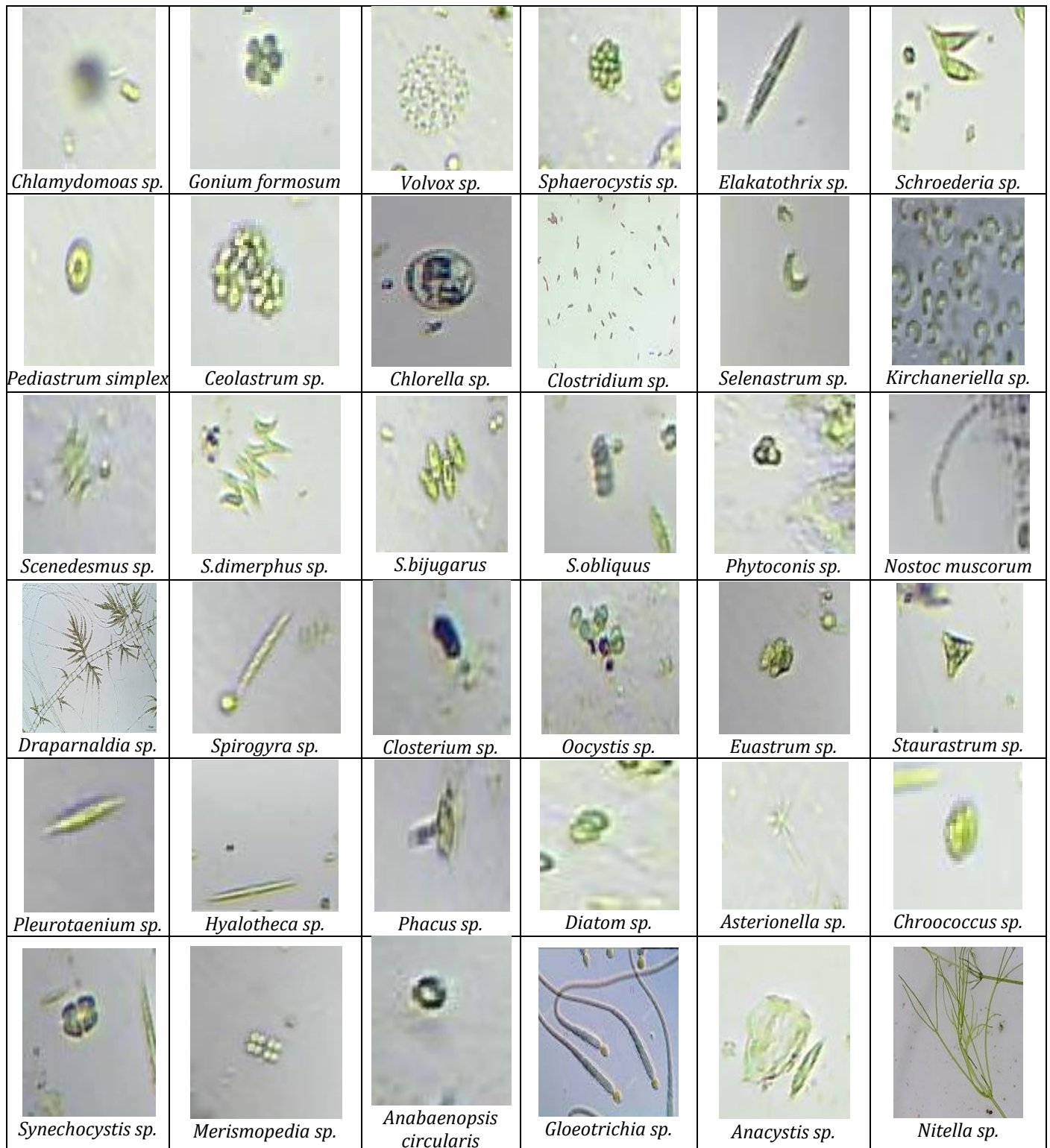| BACLLARIOPHYCEAE						
Diatoms sp.	61	2,44,000	93.84	42	1,68,000	91.30
Asterionella sp.	04	16,000	6.15	04	16,000	8.69
Total	65	2,60,000	100	46	1,84,000	100
CYANOPHYCEAE						
Chroococcus sp.	01	4000	1.26	00	00	00
Synechocystis sp.	00	00	00	01	4000	1.23
Merismopedia sp.	43	1,72,000	54.43	41	1,64,000	50.61
Anabaenopsis circularis	21	84,000	26.58	22	88,000	27.16
Gloeotrichia sp.	00	00	00	03	12,000	3.70
Anacystis	14	56,000	17.72	14	56,000	17.28
Total	79	3,16,000	100	81	3,24,000	100
CHAROPHYCEAE						
Nitella sp.	00	00	00	15	60,000	100
Total	--	--	--	15	60,000	100
DINOPHYCEAE						
Ceratium sp.	00	00	00	01	4000	100
Total	--	--	--	01	4000	100

Table 1: Phytoplankton Species in Nirmalagiri Lake and Kengeri Lake (November 2017).

Group	Nirmalagiri Lake (Organisms/ml)	% Composition	Kengeri Lake (Organisms/ml)	% Composition
Chlorophyceae	956	86.12	493	76.55
Euglenophyceae	10	0.90	08	1.24
Bacillariophyceae	65	5.85	46	7.14
Cyanophyceae	79	7.11	81	12.57
Charophyceae	Nil	Nil	15	2.32
Dinophyceae	Nil	Nil	01	0.15

Table 2: Abundance and Percentage composition of Phytoplankton in Nirmalagiri lake and Kengeri Lake (November 2017).

Nine Diversity Indices of Phytoplankton	Nirmalagiri Lake	Kengeri Lake
Taxa_S	4	6
Individuals	1110	644
Dominance_D	0.7503	0.6077
Shannon_H	0.5253	0.8059
Simpson_1-D	0.2497	0.3923
Evenness_e^H/S	0.4227	0.3731
Menhinick	0.1201	0.2364
Margalef	0.4278	0.7731
Equitability_J	0.3789	0.4498
Fisher_alpha	0.5220	0.9149
Berger-Parker	0.8613	0.7655

Table 3: Nine Diversity Indices of Phytoplankton Using PAST Software of Nirmalagiri Lake and Kengeri Lake.
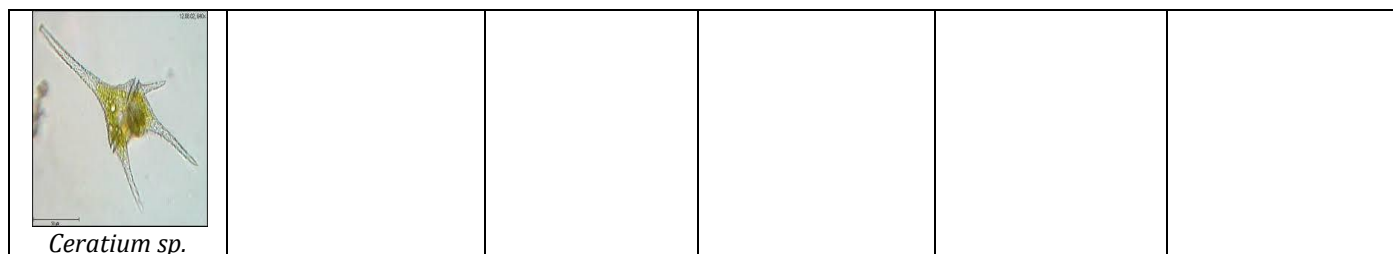
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Chlamydomoas sp.	*Gonium formosum*	*Volvox sp.*	*Sphaerocystis sp.*	*Elakatothrix sp.*	*Schroederia sp.*
Pediastrum simplex	*Ceolastrum sp.*	*Chlorella sp.*	*Clostridium sp.*	*Selenastrum sp.*	*Kirchaneriella sp.*
Scenedesmus sp.	*S.dimerphus sp.*	*S.bijugarus*	*S.obliquus*	*Phytoconis sp.*	*Nostoc muscorum*
Draparnaldia sp.	*Spirogyra sp.*	*Closterium sp.*	*Oocystis sp.*	*Euastrum sp.*	*Staurastrum sp.*
Pleurotaenium sp.	*Hyalotheca sp.*	*Phacus sp.*	*Diatom sp.*	*Asterionella sp.*	*Chroococcus sp.*
Synechocystis sp.	*Merismopedia sp.*	*Anabaenopsis circularis*	*Gloeotrichia sp.*	*Anacystis sp.*	*Nitella sp.*

Ceratium sp.

Figure 3: Microphotographs of Phytoplankton in Nirmalagiri Lake and Kengeri Lake Water November (2017). X 40.

The distribution of species indicates that Nirmalgiri lake has the highest number of phytoplankton having 1110 organisms/ml while the Kengeri lake has 628 organisms/ml. The algae were expressed as organisms per ml for the purpose of calculating diversity indices. A total of 37 algal species belonging to six groups namely *Cholrophyceae, Euglenophyceae, Bacillariophyceae, Cyanophyceae, Charophyceae* and *Dinophyceae* were recorded. The most dominating *Chlorophyceae* group in both the lakes consisted of species *like Pediastrum simplex, Elakatothrix sp., Volvox sp., Selenastrum sp. Phytoconis sp., Pleurotaenium sp.* Similarly the most dominating Euglenophyceae groups in both the lakes consisted of *Phacus sp.*, among Bacillariophyceae the most dominating species are *Diatoms sp.* and among Cyanophyceae most dominating species are *Merismopedia sp.*, and *Anabaenopsis circularis.*

In the present study the species of Euglenophyceae and Dinophyceae were poorly represented when compared to other groups of the study. The occurrence of *Euglenophyceae* and *Dinophyceae* were inversely related to Chlorophyceae. *Chlorophyceae* was the most dominating group in Nirmalagiri lake with 956 organisms/ml with percentage composition of 86.12 while in Kengeri Lake it was 493 organisms/ml with a percentage composition of 76.55. Charophyceae and Dinophyceae were absent in Nirmalagiri Lake and in Kengeri Lake. Charophyceae and Dinophyceae consisted of about 2.32% and 0.15% respectively.
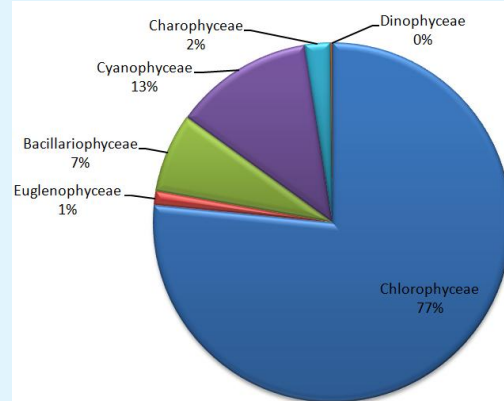
In Nirmalagiri Lake among 29 species of phytoplankton 22 belonged to Chlorophyceae, 1 belonged to Euglenophyceae, 2 belonged to Bacillariophyceae, 4 belonged to Cyanophyceae. During the present investigation, the percentage abundance of phytoplankton in November, 2017 were *Chlorophyceae* (86.12%), *Euglenophyceae* (0.90%), *Bacilllariophyceae* (5.85%), and *Cyanophyceae* (7.11%). In Kengeri Lake 34 species of phytoplankton 24 belonged to *Cholrophyceae*, 1 belonged to *Euglenophyceae*, 2 belonged to *Bacillariophyceae*, 5 belonged to *Cyanophyceae*, 1 belonged to *Charophyceae*, 1

belonged to *Dinophyceae*. During the present investigation the percentage abundance of phytoplankton in November, 2017 was *Chlorophyceae* (76.55%), *Euglenophyceae* (1.24%), *Bacillariophyceae* (7.14%), *Cyanophyceae* (12.57%), *Charophyceae*(2.32%), and *Dinophyceae* (0.15%).

Graph 1 and Graph 2 show the percentage composition of phytoplankton species in Nirmalagiri Lake and Kengeri Lake respectively. Graph 3 represents the comparative abundance of phytoplankton in Nirmalagiri Lake and Kengeri Lake.
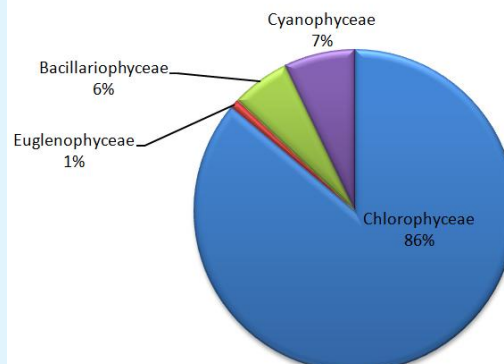
Graph 1: Percentage composition of phytoplankton Species in Nirmalagiri Lake during November 2017

Graph 2: Percentage Composition of Phytoplanton Species in Kengeri Lake November 2017
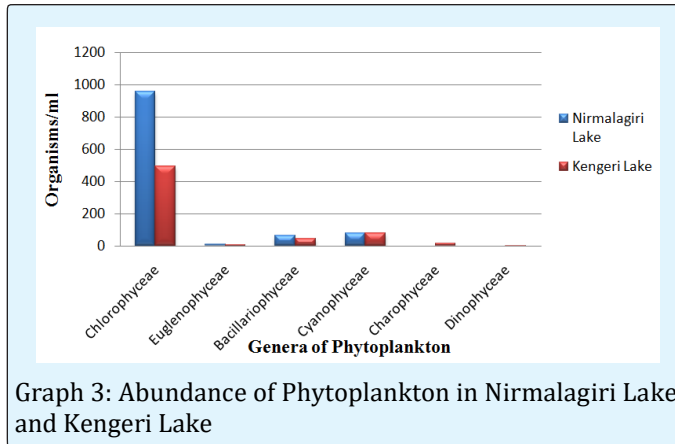
Graph 3: Abundance of Phytoplankton in Nirmalagiri Lake and Kengeri Lake

The above data were subjected to a software program "PAST" which generates nine diversity indices namely Dominance D, Shannon H, Simpson, Evenness, Menhinick, Margalef, Equitability J, Fisher alpha and Berger-Parker. As diversity increases index value gets smaller [12].

Dominance index is a simple measure of the numerical importance of the most abundant species. The Dominance index in the present study indicates that Nirmalagiri lake (0.75) has the highest dominance of planktonic species and Kengeri lake (0.60) has the least dominance.

Shannon and Weiner index represents entropy. It is a diversity index into account the number of individuals as well as the number of taxa [13]. This index can also determine the pollution status of a water body. Normal values range from 0 to 4. Wilham and Dorris concluded that the values of the index greater than 3 indicate clean water, values in the range of 1 to 3 are characterized by moderate pollution and values less than 1 characterized as heavily polluted [14]. According to this index, both Nirmalagiri lake (0.52) and Kengeri lake (0.80) are heavily polluted. The Simpson's index is often used to quantify the biodiversity of the habitats. According to Simpson's index species are not evenly distributed. The values range from a minimum of 0.71 and 0.96. In the present study the value of Simpson's index in Nirmalagiri lake (0.24) and Kengeri lake (0.39). The Pielou's evenness index states that species evenness is diversity index, a measure of diversity that quantifies how equal the community is equally [15]. The Evenness in Nirmalagiri Lake was (0.42) and Kengeri Lake (0.37). Menhinick's and Margalef's indices measure richness of species in an ecosystem. Menhinick's index is low in Nirmalagiri Lake (0.12) and reaches a high value of 0.23 in Kengeri Lake. Menhinick's index is low in Nirmalagiri Lake (0.42) and reaches a high value of 0.77 in Kengeri Lake. The Equitability index is a measure of the evenness with which individuals are divided among the taxa present. Equitability takes the values between 0 and 1, with 1 being complete evenness. The index when applied to the present study indicates that Nirmalagiri Lake has 0.37 and Kengeri Lake 0.44. Fisher's alpha index is a mathematical calculation for determining diversity within a population [16]. It represented the first attempt to describe mathematically the relationship between the number of species and the number of individuals of those species. The index is very low in Nirmalagiri Lake (0.52) and is highest in Kengeri Lake reaching 0.91. This indicates the abundance of species were in Kengeri lake. Berger-Parker dominance index is the number of individuals in the dominant taxon divided by number of individuals (n) [17,18]. The values are high in Nirmalagiri lake (0.86) and is least in Kengeri lake (0.76).

Conclusion

Diversity measures are more useful in Lake Ecosystem, which harbor a large variety of algal species in general and species diversity within genera. Calculating the diversity indices during this period indicated that Nirmalagiri lake had the richness of phytoplankton species when compared to Kengeri lake. This richness of species enhanced the growth of fishes in Nirmalagiri lake. The role of phytoplankton species and their assemblage as bio-indicators reflected the pollution status of the study lakes. Hence both the pollution indicator species and the beneficial species are present in the above investigated lakes. Hence environmental monitoring makes use of the fact that polluted or stressed communities are characterized by a change in the species abundance.

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