UTTAR PRADESH JOURNAL OF ZOOLOGY

42(24): 555-570, 2021
ISSN: 0256-971X (P)

STUDIES ON THE DIVERSITY OF PHYTOPLANKTONS AND THEIR SEASONAL VARIATION IN KUNIGAL TANK, TUMKUR DISTRICT, KARNATAKA

H. M. LALITHA [a*] AND S. RAMAKRISHNA [b]

[a] *Department of Zoology, University College of Science, Tumkur University, Tumakuru- 572103. India.*
[b] *Department of Zoology, Jnana Bharathi Campus, Bangalore University, Bengaluru- 560056. India.*

AUTHORS' CONTRIBUTIONS

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

Article Information

Editor(s):
(1) Dr. Osama Anwer Saeed, University of Anbar, Iraq.
Reviewers:
(1) Emelio Barjau González, Universidad Autónoma de Baja California Sur, México.
(2) Tahir Atici, Gazi Üniversitesi, Turkey.

Received: 09 October 2021
Accepted: 18 December 2021
Published: 20 December 2021

Original Research Article

ABSTRACT

Aquatic water resources play vital role in maintaining environmental sustainability. Surface water bodies like lakes and tanks are degraded by increased industrial activities and urban runoff which deteriorate the water quality and their environment. Phytoplanktons are the autotrophic components of the plankton community and form the important part of the aquatic food chain. Aquatic environmental productivity is directly associated with phytoplankton density. Physico-chemical factors are directly related to their production. The temperature is found to be the main driving force for phytoplankton dominance. The members of phytoplankton community are important for their role in food production and energy transfer in trophic dynamics and water ecosystems. In the pollution study, they are represented as biological indicators of water quality. The purpose of this study was to investigate the phytoplankton diversity for a period of two years from February 2014 to January 2016 in Kunigal tank and to assess the species composition and seasonal variations of this faunal group. The water samples were collected from five sampling sites between 7 am to 9 am on monthly basis. From each sampling site, 50 liters of water sample were collected, filtered through 60µm mesh size plankton net. The concentrated water sample was fixed and preserved in 4% formalin. one ml of concentrated sample was transferred into Sedge-wick Rafter cell and counted under Olympus binocular microscope. The results revealed the occurrence of 62 species of phytoplanktons belonging to five groups - Chlorophyceae, Bacillariophyceae, Cyanophyceae, Desmidaceae and Euglenophyceae. Chlorophyceae is represented by 16 species belonging to 15 genera, Bacillariophyceae is represented by 12 species belonging to 9 genera, Cyanophyceae is represented by 18 species belonging to 17 genera, Desmidaceae is represented by 12 species belonging to 8 genera and Euglenophyceae is represented by 4 species belonging to 2 genera. Among these, Chlorophyceae shows its dominance. The percentage composition of phytoplankton species was found as

**Corresponding author: Email: lalithahm11@gmail.com;*

Chlorophyceae>Bacillariophyceae > Cyanophyceae>Desmidaceae > Euglenophyceae. Shannon-Weiner Index value of phytoplanktons ranged between 2.0 - 3.0 and Simpson Index values are found between 0 and 1, which indicated the good diversity and light pollution level. The results of this study explained the diversity and pollution status of Kunigal tank and helps in implementing strategies for water quality management and productivity of the tank.

Keywords: Physico-chemical parameters; phytoplanktons, diversity; chlorophyceae; bacillariophyceae; diversity indices; simpson index.

1. INTRODUCTION

Fresh water ecosystems include lakes, ponds, rivers, streams, wetland, and bogs which are nurseries of primary production [1 and 2]. The lakes are relatively shallow and highly vulnerable to wind action and oscillations in climatic conditions. Phytoplanktons are the major biological components, which act as producer for energy transfer to most of the organisms through a food chain [2 and 3].

Phytoplanktons are the primary producers as they form the foundation of the aquatic food web. The structure and composition of phytoplankton communities are the fundamental indicators of ecosystem status. Phytoplankton is sensitive to environmental changes at small spatial scales [2]. The dynamic features of lakes such as colour, clarity, trophic status, zooplankton, and fish production depend on the phytoplankton to a greater extent.

The production, distribution and variation of phytoplanktons in the water body is influenced by physico-chemical parameters like pH, CO_2, salinity, temperature, some inorganic nutrients, etc., In India, inland aqua bodies have attracted the attention of different workers leading to the studies on water quality and distribution of phytoplankton from time to time.

Study of Phytoplanktons provides an optimal and convenient focus point for research on eutrophication and its adverse impact on aquatic ecosystems. Although phytoplankton are considered as the good indicators of environmental changes and bioindicators of water quality, they have been little studied in aquatic ecosystems of this region. Therefore, their potential value as indicators of alterations in the water quality of Kunigal tank needs to be assessed.

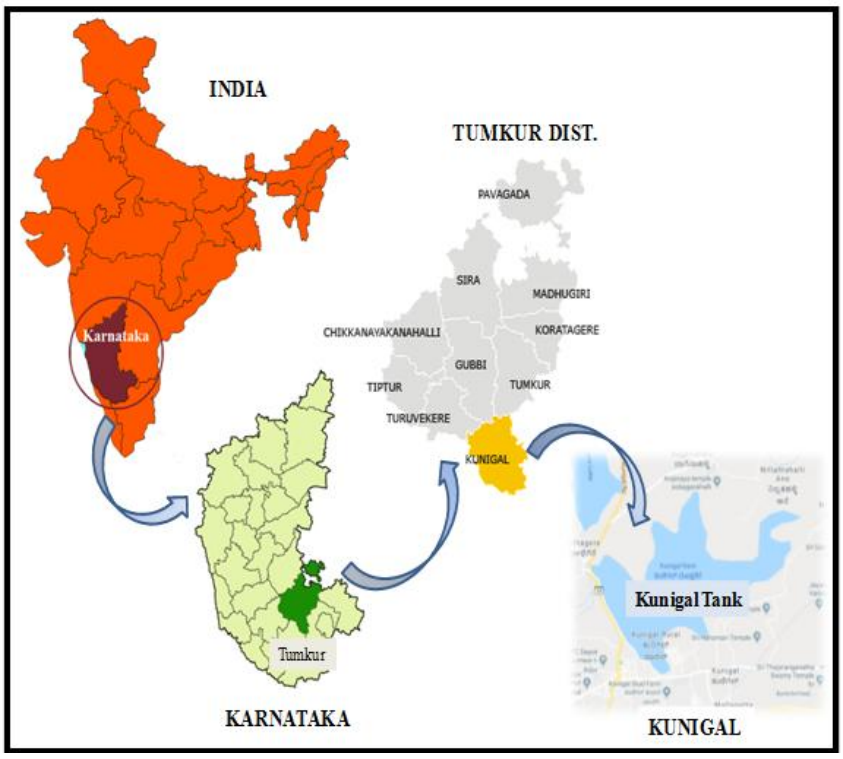

Fig. 1. Map showing Kunigal tank through Kunigal, Tumkur, Karnataka and India

Fig. 2. Staellite view of Kunigal Tank

1.1 Study Area

Kunigal tank is one of the biggest tanks in Tumkur District situated in between Kunigal town and Kottagere village. It is situated between 13° 02′ N 77° 02′ E (Latitude of 130 01′ 30" Longitude of 770 01′ 30") at an elevation of 778.45 meters above the mean sea level. It is rain fed and perennial in nature. The location map and satellite view of study area is shown in Figs. 1 and 2. The tank was mainly constructed for the purpose of irrigation. The sources of water for Kunigal tank are rain fall, Nagini and Hemavathi rivers. The tank has an area of 1030 acres and the catchment area is 339.14 sq. km. It is being utilized enormously for irrigation and fish culture [4].

2. MATERIALS AND METHODS:

The water samples were collected from five sampling sites between 7 am to 9 pm for a period of two years from February 2014 to January 2016 on monthly basis. 50 liters of water sample were collected from each sampling site and filtered through 60µm mesh size plankton net. 50 ml of the concentrated water sample was collected from the bottle attached at the end of plankton net. Then, the concentrated water sample was fixed and preserved in 4% formalin. For the quantitative analysis of planktons, one ml of the concentrated sample from each sampling site was transferred into Sedge-wick Rafter cell and counted under Olympus binocular microscope at 10X magnification [4,5 and 6]. Taxonomic identification of planktons was based on morphological and taxonomic key characters described by [7-11].

The abundance of phytoplanktons was carried out by using the following formula as given in [12].

$$\text{No. of organisms/m}^3 = \frac{C \times V_1}{V_2 \times V_3}$$

Where,C= No. of organisms counted,V_1= Volume of concentrated sample (50 ml),V_2= Volume of sample counted (1 ml),V_3= Volume of grab sample ($0.1m^3$).

Finally, to obtain org /l, the No. of organisms per m^3 was divided by 1000.

2.1 Statistical Analysis

The data obtained during the study period has been subjected to Statistical analysis. Diversity indices such as Shannon-Weiner Index and Simpson Index were used to explain the species diversity in phytoplankton community [13] and calculated using PAST package software.

3. RESULTS

The diversity of phytoplanktons from five sites of Kunigal tank were studied for two years from February 2014 to January 2016 and the results of seasonal group wise population density, percentage composition of phytoplanktons is presented in Tables 1, 2 and 3 and Figs. 3 to 12. The diversity indices

such as Shannon-Weiner Index and Simpson Index were calculated for each group of phytoplanktons and presented in Tables 4 to 8.

3.1 Diversity of Phytoplanktons

In the present study, 62 species of phytoplanktons have been identified under five groups- Chlorophyceae, Bacillariophyceae, Cyanophyceae, Desmidaceae and Euglenophyceae. Among these, Chlorophyceae shows its dominance in all the five sites. Chlorophyceae is represented by 16 species belonging to 15 genera, Bacillariophyceae is represented by 12 species belonging to 9 genera, Cyanophyceae is represented by 18 species belonging to 17 genera, Desmidaceae is represented by 12 species belonging to 8 genera and Euglenophyceae is represented by 4 species belonging to 2 genera.

Chlorophyceae:

- *Ankistrodesmus gracilis, Botryococcus braunii,* Chlorella spp., Coelastrum spp., Coelastrum *chodati, Chlamydomonas* spp., *Cladophora glomerata, Hydrodictyon reticulatum,* Kirchineriella spp., Oocystis spp., Pachycladella spp., Pandorina spp., *Pediastrum duplex, Spirogyra variana,* Tetraedron spp., Ulothrix spp.

Bacillariophyceae:

- Amphora spp., Cymbella spp., *Fragelaria capucina, Fragelaria* spp., *Gyrosigma kutzingii,* Gyrosigma spp., *Navicula cuspidate,* Navicula spp., Amphipleura spp., Nitzscia spp., Pinnularia spp., Melosira spp.

Cyanophyceae:

- *Anabaena arnoldii,* Anabaena spp., Anacystis spp., *Aphanizomenon flos aquae,* Arthospira spp., *Calothrix neberi,* Chroococcus spp., Cylindrospermum spp., Dermocarpa spp., Gloeocapsa spp., Gloeothece spp., Hydrocoelum spp., Lyngbya spp., *Merismopedia glauca,* Microcystis spp., Nostoc spp., Oscillatoria spp., *Spirulina maxima.*

Desmidaceae:

- *Closterium arcuatum, Closterium gracile,* Closterium spp., Cosmarium spp., Cylindrocystis spp., Desmidium spp., *Euastrum didelta,* Euastrum spp., Microsterious spp., Staurastrum spp., *Staurastrum gracile,* Pleurotaenium spp.

Euglenophyceae

- *Euglena elongate,* Euglena spp., *Phacus caudatus,* Phacus spp.

In the study, 2014 - 2015, maximum population density of Phytoplanktons recorded was 57538 org/l at site-5 and minimum population density of phytoplanktons recorded was 48722 org/l at site-3. In the study 2015 - 2016, maximum population density of phytoplanktons recorded was 56718 org/l at site- 5 and minimum population density of phytoplanktons recorded was 45624 org/l at site- 3 (Table 1).

3.2 Chlorophyceae

In the study 2014 - 2015, seasonal population density of phytoplanktons was recorded. Maximum number of Chlorophyceae recorded was 12880 org/l during summer at site-4 and minimum number of Chlorophyceae recorded was 3480 org/l during winter at site-3. In the study 2015 -2016, seasonal population density of phytoplanktons was recorded. Maximum number of Chlorophyceae recorded was 12280 org/l during summer at site-5 and minimum number of Chlorophyceae recorded was 2656 org/l during winter at site -3 (Figs. 3 & 4).

3.3 Bacillariophyceae

In the study 2014 -2015, seasonal population density of phytoplanktons was recorded. Maximum number of Bacillariophyceae recorded was 10020 org/l during summer at site -5 and minimum number of Bacillariophyceae recorded was 2682 org/l during winter at site- 2. In the study 2015-2016, seasonal group wise population density of phytoplanktons was recorded. Maximum number of Bacillariophyceae recorded was 9846 org/l during summer at site-4 and minimum number of Bacillariophyceae recorded was 2492 org/l during winter at site-2 (Figs. 5 & 6).

3.4 Cyanophyceae

In the study 2014 -2015, seasonal population density of phytoplanktons was recorded. Maximum number of Cyanophyceae recorded was 4576 org/l during summer at site1 and minimum number of Cyanophyceae recorded was 1070 org/l during winter at site 3. In the study 2015 -2016, Seasonal group wise population density of phytoplanktons was recorded. Maximum number of Cyanophyceae recorded was 3896 org/l during summer at site 5 and minimum number of Cyanophyceae recorded was 1317 org/l during winter at site-2 (Figs. 7 & 8).

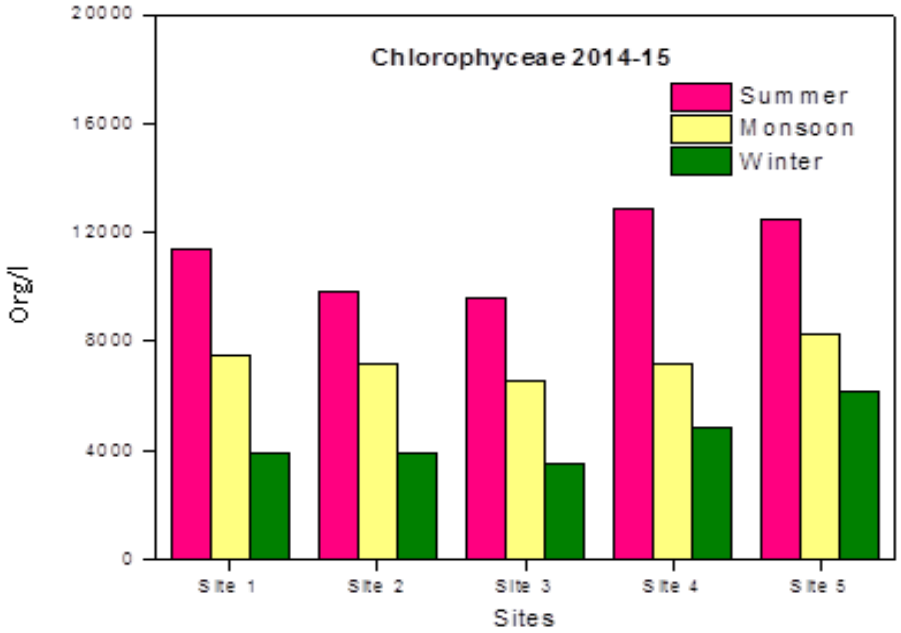

Fig. 3. Seasonal population variation in Chlorophyceae (org/l) at different sites of Kunigal Tank during 2014 – 2015

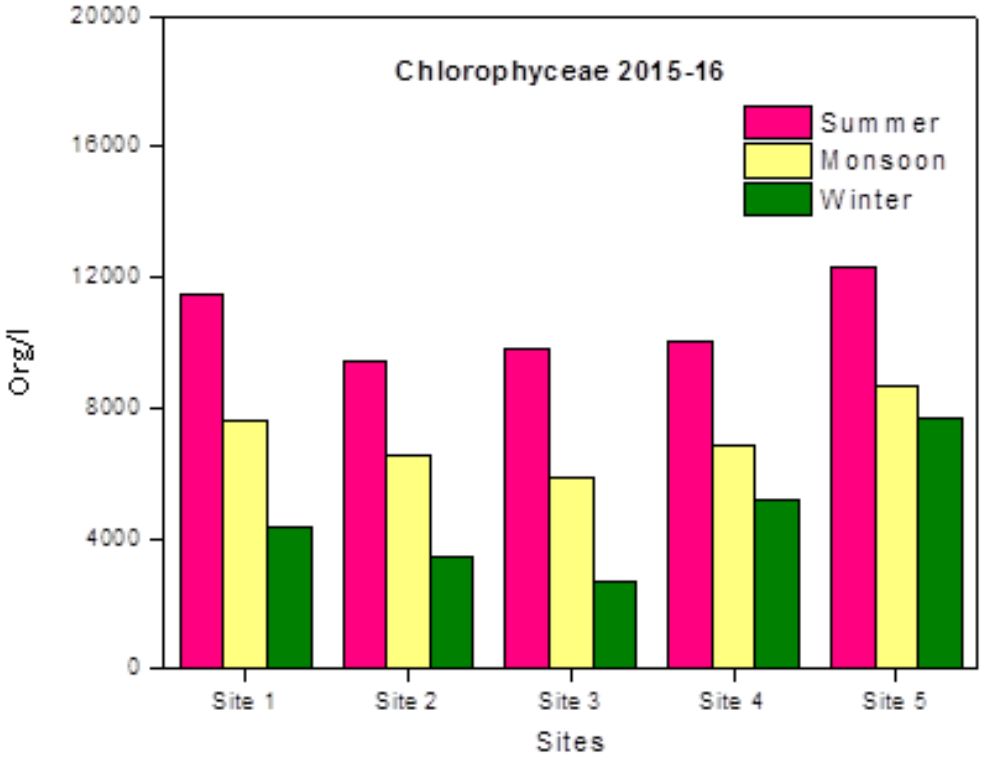

Fig. 4. Seasonal population variation in Chlorophyceae (org/l) at different sites of Kunigal Tank during 2015 - 2016

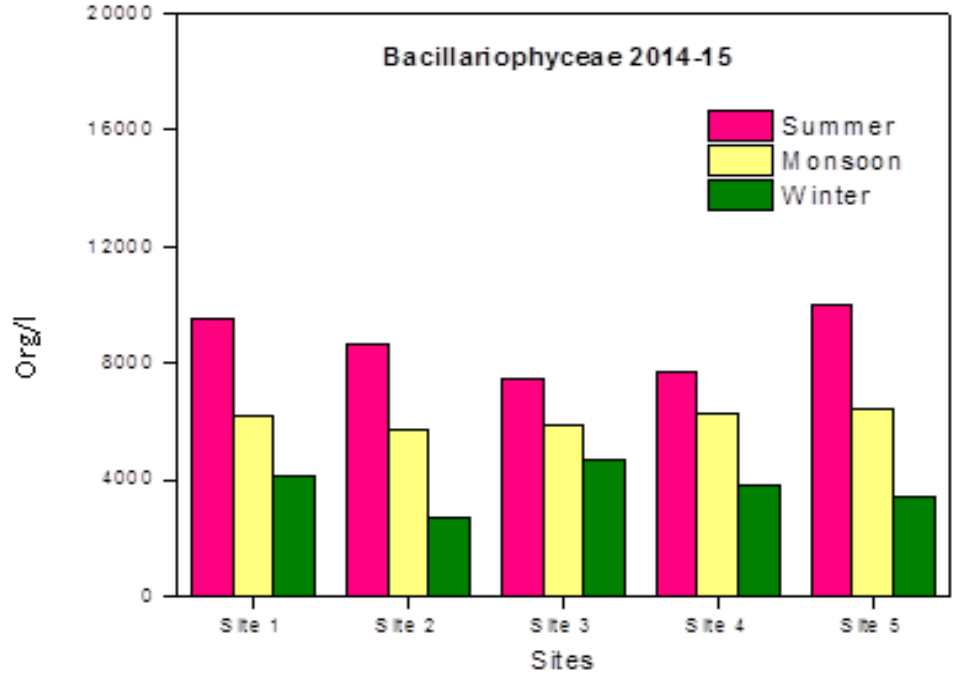

Fig. 5. Seasonal population variation in Bacillariophyceae (org/l) at different sites of Kunigal Tank during 2014 – 2015

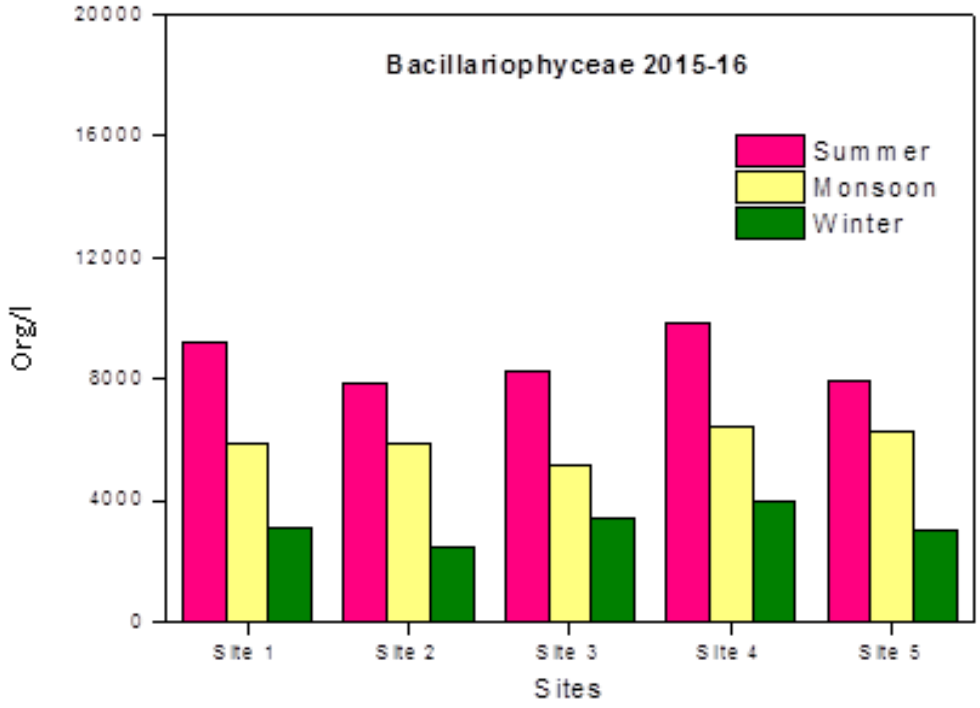

Fig. 6. Seasonal population variation in Bacillariophyceae (org/l) at different sites of Kunigal Tank during 2015 - 2016

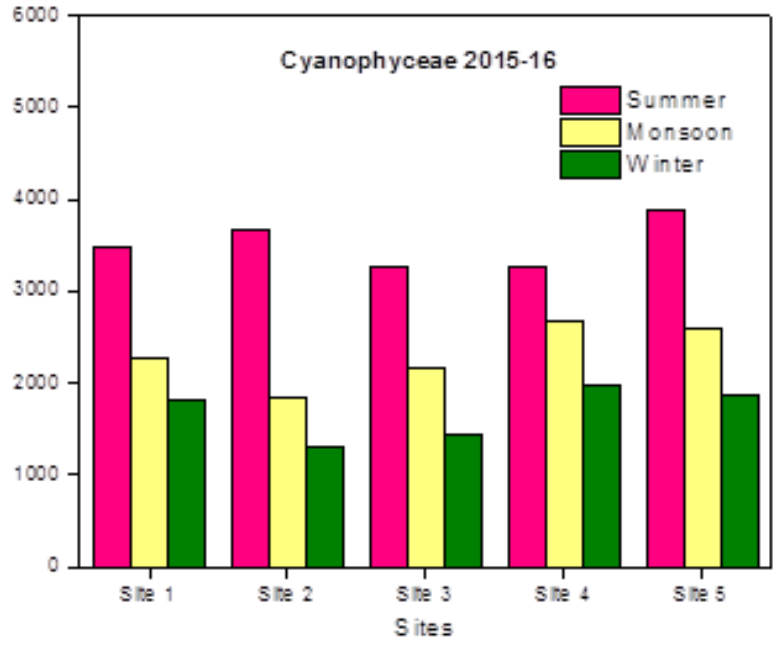

Fig. 7. Seasonal population variation in Cyanophyceae (org/l) at different sites of Kunigal Tank during 2014 – 2015

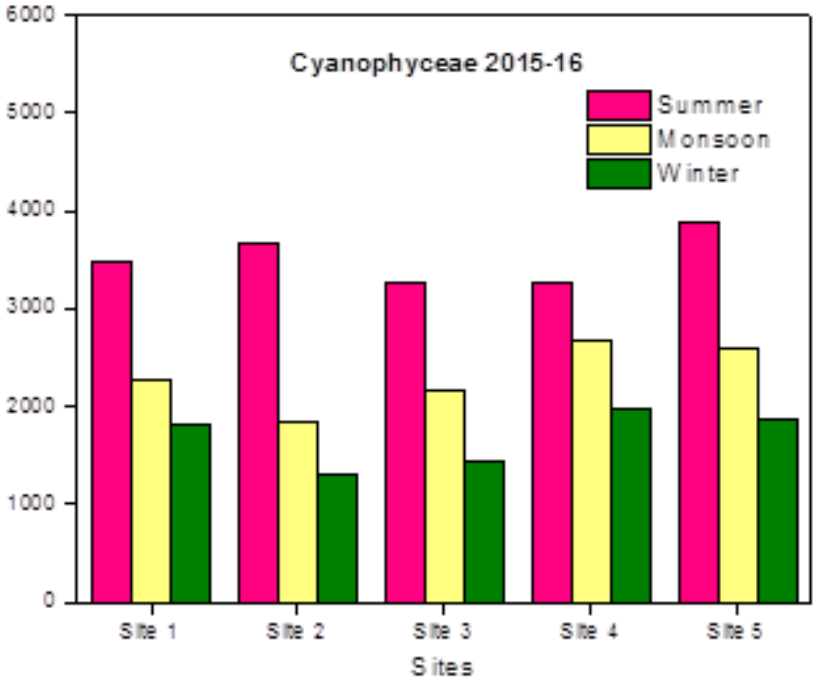

Fig. 8. Seasonal population variation in Cyanophyceae (org/l) at different sites of Kunigal Tank during 2015 - 2016

3.5 Desmidaceae

In the study 2014 -2015, seasonal population density of phytoplanktons was recorded. Maximum number of Desmidaceae recorded was 1370 org/l during summer at site 3 and minimum number of Desmidaceae recorded was 222 org/l during monsoon at site 4.

In the study 2015-2016, seasonal group wise population density of phytoplanktons was recorded. Maximum number of Desmidaceae

recorded was 1290 org/l during summer at site-2 and minimum number of Desmidaceae recorded was 284 org/l during winter at site-5 (Figs. 9 &10).

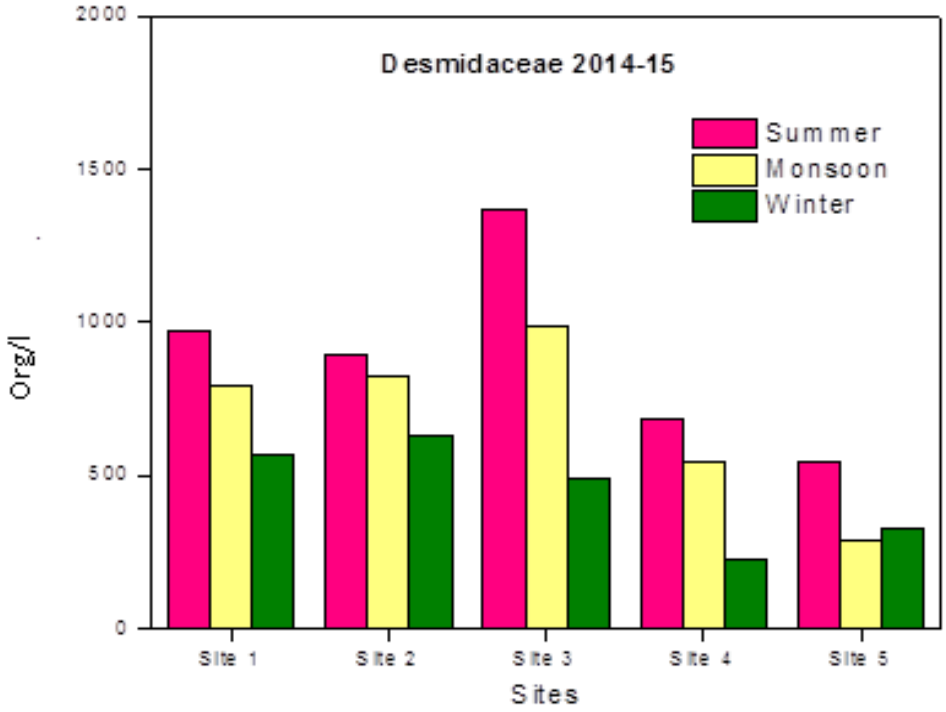

Fig. 9. Seasonal population variation in Desmidaceae (org/l) at different sites of Kunigal Tank during 2014 - 2015

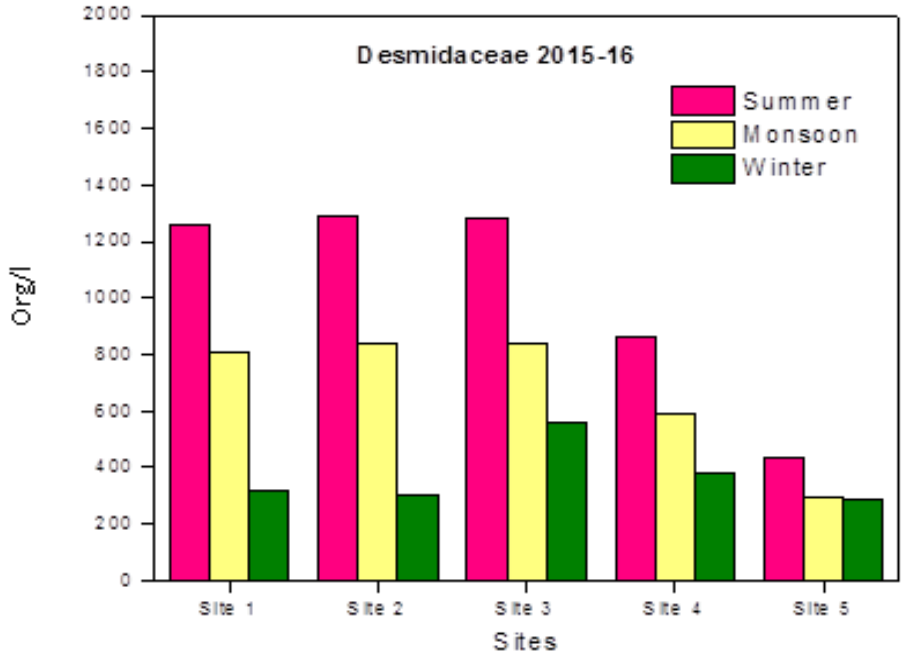

Fig. 10. Seasonal population variation in Desmidaceae (org/l) at different sites of Kunigal Tank during 2015 – 2016

3.6 Euglenophyceae

In the study 2014 -2015, seasonal group wise population density of phytoplanktons was recorded. Maximum number of Euglenophyceae recorded was 640 org/l during summer at site 5 and minimum number of Euglenophyceae recorded was 154 org/l during winter at site 3. In the study 2015-2016, seasonal group wise population density of phytoplanktons was recorded. Maximum number of Euglenophyceae recorded was 770 org/l during summer at site-5 and minimum number of Euglenophyceae recorded was 164 org/l during winter at site 5 (Figs. 11 & 12).

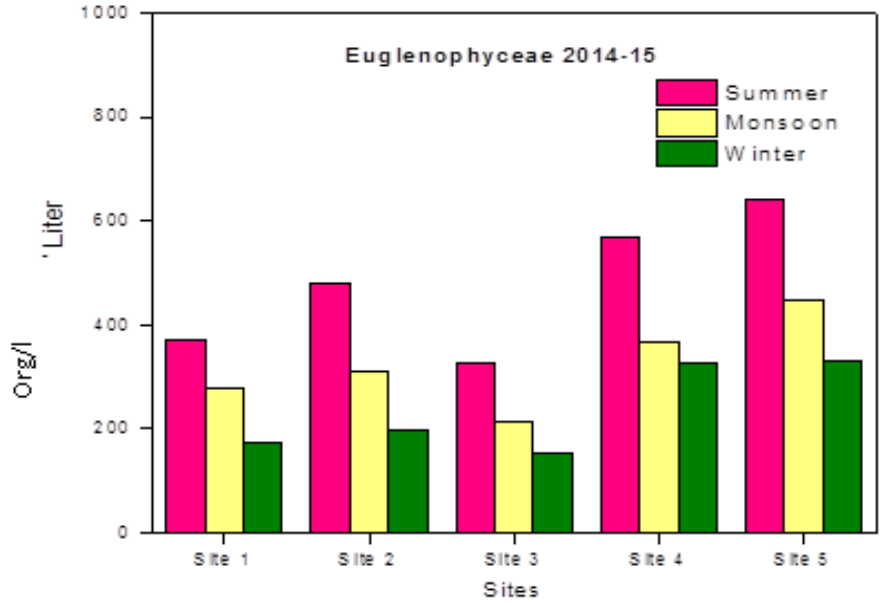

Fig. 11. Seasonal population variation in Euglenophyceae (org/l) at different sites of Kunigal Tank during 2014 – 2015

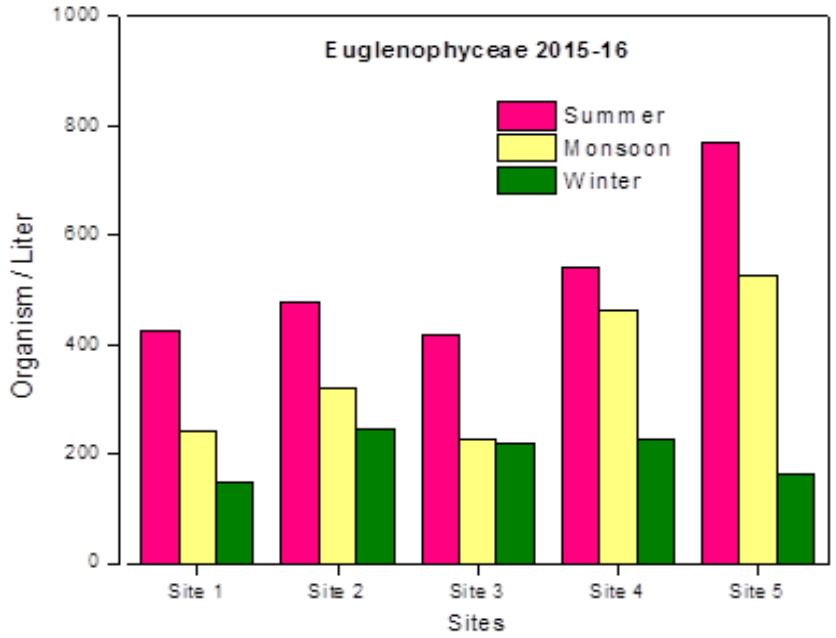

Fig. 12. Seasonal population variation in Euglenophyceae (org/l) at different sites of Kunigal Tank during 2015 - 2016

3.7 Percentage Composition of Phytoplanktons

Percentage composition of phytoplanktons from five sites of Kunigal tank during 2014 -2016 is presented in Table 1.

In the study 2014 -2015 and 2015-2016, at site-1, Chlorophyceae constitutes 40.86%, 44.73%, Bacillariophyceae 35.64%, 34.71%, Cyanophyceae17.84%, 14.45%, Desmidaceae 4.18%, 4.55% and

Euglenophyceae 1.48%, 1.55% respectively.

In the study 2014 -2015 and 2015-2016, at site-2, Chlorophyceae constitutes 42.73%, 42.31%, Bacillariophyceae 34.85%, 35.26%, Cyanophyceae 15.62%, 14.87%, Desmidaceae 4.79%, 5.29% and Euglenophyceae 2.01%, 2.27% respectively.

In the study 2014 -2015 and 2015-2016, at site-3, Chlorophyceae constitutes 40.41%, 40.18%, Bacillariophyceae 36.99%, 37.01%, Cyanophyceae 15.33%, 15.04%, Desmidaceae 5.84%, 5.88% and Euglenophyceae 1.43%, 1.89 % respectively.

In the study 2014 -2015 and 2015-2016, at site-4, Chlorophyceae constitutes 48.81%, 42.27%, Bacillariophyceae 34.77%, 38.72%, Cyanophyceae 11.12%, 13.16%, Desmidaceae 2.82%, 3.5% and Euglenophyceae 2.47%, 2.35% respectively.

In the study 2014 -2015 and 2015-2016, at site-5, Chlorophyceae constitutes 45.32%, 50.41%, Bacillariophyceae 36.38%, 30.47%, Cyanophyceae 14.02%, 14.75%, Desmidaceae 1.96%,1.79% and Euglenophyceae 2.32%, 2.57% respectively.

Table 1. Total number and group wise total percentage in phytoplanktons (org/l) at Kunigal Tank during 2014-2016

Year		**2014-2015**		**2015-2016**	
Site	**Order**	**Total phytoplankton**	**Total percentage (%)**	**Total phytoplankton**	**Total percentage (%)**
Site 1	Chlorophyceae	55668	40.86	52463	44.73
	Bacillariophyceae		35.64		34.71
	Cyanophyceae		17.84		14.45
	Desmidaceae		4.18		4.55
	Euglenophyceae		1.48		1.55
Site 2	Chlorophyceae	49044	42.73	46032	42.31
	Bacillariophyceae		34.85		35.26
	Cyanophyceae		15.62		14.87
	Desmidaceae		4.79		5.29
	Euglenophyceae		2.01		2.27
Site 3	Chlorophyceae	48722	40.41	45624	40.18
	Bacillarophyceae		36.99		37.01
	Cyanophyceae		15.33		15.04
	Desmidaceae		5.84		5.88
	Euglenophyceae		1.43		1.89
Site 4	Chlorophyceae	51096	48.81	50692	42.27
	Bacillariophyceae		34.77		38.72
	Cyanophyceae		11.12		13.16
	Desmidaceae		2.82		3.5
	Euglenophyceae		2.47		2.35
Site 5	Chlorophyceae	57538	45.32	56718	50.41
	Bacillariophyceae		36.38		30.47
	Cyanophyceae		14.02		14.75
	Desmidaceae		1.96		1.79
	Euglenophyceae		2.32		2.57

Table 2 Percentage composition of phytoplanktons at Kunigal Tank during 2014-2015

Sl. No.	Order	Number of organisms	Total	Percentage
1.	Chlorophyceae	115244		43.97
2.	Bacillariophyceae	92616	262068	35.34
3.	Cyanophyceae	38908		14.84
4.	Desmidaceae	10111		3.85
5.	Euglenophyceae	5189		1.98

Table 3. Percentage composition of phytoplanktons at Kunigal Tank during 2015-2016

Sl. No.	Order	Number of organisms	Total	Percentage
1.	Chlorophyceae	111994		44.23
2.	Bacillariophyceae	88878	253176	35.10
3.	Cyanophyceae	36541		14.43
4.	Desmidaceae	10354		4.08
5.	Euglenophyceae	5409		2.13

Table 4. Species diversity indices of Chlorophyceae in Kunigal Tank during 2014-2016

Sites	Year	Shannon-Weiner Index	Simpson Index
	2014-15	2.40	0.90
Site 1	2015-16	2.41	0.90
	2014-15	2.42	0.91
Site 2	2015-16	2.40	0.90
	2014-15	2.40	0.90
Site 3	2015-16	2.35	0.89
	2014-15	2.40	0.90
Site 4	2015-16	2.43	0.91
	2014-15	2.43	0.91
Site 5	2015-16	2.46	0.91

Table 5. Species diversity indices of Bacillariophyceae in Kunigal Tank during 2014 – 2016

Sites	Year	Shannon-Weiner Index	Simpson Index
	2014-15	2.41	0.90
Site 1	2015-16	2.39	0.90
	2014-15	2.38	0.90
Site 2	2015-16	2.38	0.90
	2014-15	2.38	0.90
Site 3	2015-16	2.45	0.91
	2014-15	2.43	0.91
Site 4	2015-16	2.41	0.90
	2014-15	2.45	0.90
Site 5	2015-16	2.46	0.90
	2015-16	2.44	0.91

Table 6. Species diversity indices of Cyanophyceae in Kunigal Tank during 2014-2016

Sites	Year	Shannon-Weiner Index	Simpson Index
	2014-15	2.44	0.91
Site 1	2015-16	2.44	0.91
	2014-15	2.44	0.91
Site 2	2015-16	2.38	0.90
	2014-15	2.37	0.90

Sites	Year	Shannon-Weiner Index	Simpson Index
Site 3	2015-16	2.43	0.91
	2014-15	2.44	0.91
Site 4	2015-16	2.46	0.91
Site 5	2014-15	2.43	0.91

Table 7. Species diversity indices of Desmidaceae in Kunigal Tank during 2014-2016

Sites	Year	Shannon-Weiner Index	Simpson Index
	2014-15	2.45	0.91
Site 1	2015-16	2.35	0.90
	2014-15	2.47	0.91
Site 2	2015-16	2.34	0.90
Site 3	2014-15	2.4	0.90
	2015-16	2.42	0.91
	2014-15	2.39	0.90
Site 4	2015-16	2.43	0.91
	2014-15	2.43	0.91
Site 5	2015-16	2.45	0.91

Table 8. Species diversity indices of Euglenophyceae in Kunigal Tank during 2014-2016

Ites	Year	Shannon-Weiner Index	Simpson Index
	2014-15	2.43	0.91
Site 1	2015-16	2.35	0.90
	2014-15	2.41	0.90
Site 2	2015-16	2.43	0.91
	2014-15	2.43	0.91
Site 3	2015-16	2.43	0.91
	2014-15	2.45	0.91
Site 4	2015-16	2.42	0.91
	2014-15	2.42	0.90
Site 5	2015-16	2.33	0.89

4. DISCUSSION

Seasonal fluctuations are caused mainly due to the nutrient concentrations and the environmental variables of the habitat for the specified time period which affect the phytoplankton population.

[13] identified a total of 103 Bacillariophyta species, 47 Chlorophyta species, 20 Streptophyta species, 36 Cyanobacteria species, 6 Dinoflagellata species, 8 Euglenophyta species and 4 Crytophyta species from planktonic samples of four freshwater lakes of Turkeya. [14] determined algal species belonged to genera Euglena, Oscillatoria, Cyclotella, Synedra, Navicula, Nitzschia and Gomphonema which showed highest tolerance to pollution in Ankara stream and observed increase in species diversity and Cyanophyta and Euglenophyta concentrations.

The present findings were supported by [15] who studied the water quality status of river Bhadra and reported a total of 45 species of phytoplankton belonging to 5 classes (Chlorophyceae-19 species, Bacillariophyceae - 16 species, Cyanophyceae-07 species, Euglenophyceae-2 species and Chrysophyceae-1 species), [16] recorded 34 species of phytoplanktons from Chatla Lake, Assam, [17] studied phytoplankton population in Bugudana Halli Lake and Mydala Lakes of Tumkur and recorded five major groups namely Chlorophyceae, Bacillariophyceae, Euglenophyceae, Cyanophyceae and Desmidaceae. [18] have reported dominancy of Chlorophyceaen members in the lakes of Kolhapur city and in water bodies of Kavathe Mahankal tahasil. (19) identified Bacillariophyceae as the dominant species followed by Chlorophyceae and Cyanophyceae in the samples in Artabel Lakes Natural Park. (20) also found abundance of Bacillariophyta and Chlorophyta in in Sarıyar Dam Reservoir of Turkey. In Mamasın Dam Lake of Turkey (21) recorded 60 phytoplanktonic algal taxa and found that members of Bacillariophta were dominant.

In the present study, total phytoplanktons showed their high population density during summer season and low during winter. The results of the present work were supported by [19] who recorded maximum phytoplankton population density during summer season followed by winter and monsoon season in Harsool-Savangi dam. [16] also reported maximum density of phytoplankton during summer and minimum density during monsoon in Chatla Lake, Assam. The high phytoplankton population density during the summer season could be related to stable, hydrological factors and low water level and low density during the monsoon season attributed to heavy flood and fresh water inflow.

4.1 Chlorophyceae

The Chlorophyceae known as green algae, is an extremely large class of algae and the range of vegetative structure is greater than any other algal class.

In the present study, Chlorophyceae showed dominance among the other groups and showed dominance during summer and the results were supported by [20] observed the dominance of Chlorophyceae in Hemavathy reservoir. [19] also observed the dominance of Chlorophyceae with 15 species and showed dominance during summer season followed by winter season in Harsool-Savangi dam. [21] recorded dominance of Chlorophyceae during summer season followed by winter season. But [22] have reported maximum Chlorophyceae density during winter.

During 2014-15, maximum Shannon-Weiner Index 2.43 and minimum 2.40 was recorded. During 2015-16, maximum Shannon-Weiner Index 2.46 and minimum 2.35 was recorded. During 2014-15, maximum Simpson Index 0.91 and minimum 0.90 was recorded. During 2015-16, maximum Simpson Index 0.91 and minimum 0.89 was recorded.

4.2 Bacillariophyceae

Bacillariophyceae are also known as diatoms. They occur as the dominant organisms and inhabit many diverse habitats. Diatoms are ubiquitous, unicellular microorganisms form the basic bulk of planktonic population in freshwaters, characterized by siliceous cell wall [23].

Diatoms are one of the important biological organisms as they are the sources of oxygen, like other algal divisions, and form the first ring of dominant primary producers and important food resource. Sunlight, temperature, salinity and physicochemical characteristics have a great influence on diatoms [24].

In the present study, Bacillariophyceae showed dominance during summer. These findings were supported by [21] recorded dominance during summer season followed by winter and monsoon season. But [25] observed maximum population of Bacillariophyceae during winter and minimum during summer in freshwater tank of Talsande, Maharashtra and [26] found minimum population density of Bacillariophyceae in monsoon in Bibi Lake, Ahmedabad. [27] also observed maximum density of Bacillariophyceae in spring and autumn. [24] mentioned that the diatoms are usually abundant in alkaline water which correlates with the alkaline nature of Kunigal tank.

During 2014-15, maximum Shannon-Weiner Index 2.45 and minimum 2.38 was recorded. During 2015-16, maximum Shannon Weiner Index 2.46 and minimum 2.38 was recorded. During 2014-15, maximum Simpson Index 0.91 and minimum 0.90 was recorded. During 2015-16, maximum Simpson Index 0.91 and minimum 0.90 was recorded.

4.3 Cyanophyceae

The members of Cyanophyceae known as blue-greens exhibit heavy growth in polluted water bodies and dominated over Chlorophyceae and Bacillariophyceae [28]. Bloom of blue-green algae in wetland is an obvious sign of cultural eutrophication caused by addition of sewage effluents.

In the present study, maximum population density of Cyanophyceae found in summer may be due to high concentration of dissolved oxygen. Similar observations were made by [25] who recorded increasing numbers of blue green algae in early summer in freshwater tank of Talsande, Maharashtra. [29] also observed blue green algae increasing in early summer and attained maxima at the end of summer season. [30] are of the opinion that the Cyanophyceae members found at high concentration of dissolved oxygen during summer indicate that they prefer oxygenated waters.

During 2014-15, maximum Shannon-Weiner Index 2.44 and minimum 2.37 was recorded. During 2015-16, maximum Shannon Weiner Index 2.46 and minimum 2.38 was recorded. During 2014-15, maximum Simpson Index 0.91 and minimum 0.90 was recorded. During 2015-16, maximum Simpson Index 0.91 and minimum 0.90 was recorded.

4.4 Desmidaceae

Desmids are the unicellular algae belong to the class Zygnematophyceae characterized by the absence of flagella. Desmids are the sensitive organisms and act as indicators of water pollution. Abundance of desmids clearly indicates the unpolluted condition of the wetland [31-33].

[29 and 34] have pointed out that the desmids prefer clear and uncontaminated water and avoid polluted waters.

The results of the present work showed maximum population of desmids during summer season and minimum during rainy season. This is in agreement with the work of [35] who observed that the desmids were found to be more during summer (58174 org/l) and low during rainy season (42016 org/l) in Bhadra reservoir. The low density of plankton during rainy season was due to turbid water, which reduced the light penetration and adversely affects the plankton production.

During 2014-15, maximum Shannon-Weiner Index 2.47 and minimum 2.39 was recorded. During 2015-16, maximum Shannon Weiner Index 2.45 and minimum 2.34 was recorded. During 2014-15, maximum Simpson Index 0.91 and minimum 0.90 was recorded. During 2015-16, maximum Simpson Index 0.91 and minimum 0.90 was recorded.

4.5 Euglenophyceae

The members of Euglenophyceae members are microscopic, solitary and free-living organisms common in stagnant pools, ponds and lakes etc. They are abundant where water is contaminated by organic pollution or decaying organic matter. Usually larger water bodies like rivers, lakes and reservoirs etc., have high population of euglenoids.

The results of the present investigation showed the dominance during summer which were supported by [26] who recorded maximum Euglenophyceae during summer in Bibi Lake, Ahmedabad and [36] found maximum Euglenophyceae in summer season and totally absent during the rainy season in river Narmada. But [37] reported high density of Euglenophyceae during post monsoon and [25] observed maximum population density of Euglenophyceae during monsoon and minimum during summer season.

During 2014-15, maximum Shannon-Weiner Index 2.45 and minimum 2.41 was recorded. During 2015-16, maximum Shannon Weiner Index 2.43 and minimum 2.33 was recorded. During 2014-15, maximum Simpson Index 0.91 and minimum 0.90 was recorded. During 2015-16, maximum Simpson Index 0.91 and minimum 0.89 was recorded.

Results of the diversity indices of phytoplanktons of the present investigation were supported by [38] found maximum and minimum Shannon-Weiner Index of phytoplanktons as 2.94 for Chlorophyceae and 2.15 for Bacillariophyceae and maximum Simpson's Index 0.94 for Chlorophyceae and minimum Simpson's Index 0.88 for Cyanophyceae in Nangal Wetland, Punjab. But, [39] recorded Shannon-Wiener's diversity index of phytoplankton population ranged from 1.52 to 2.69 in Nethravati – Gurupura estuary, south west coast.

In the present study, Shannon-Weiner Index value of Phytoplanktons ranged between 2.0 - 3.0 which indicated the moderate diversity and light pollution level. Simpson Index values are found between 0 and 1, where the greater value indicates the good diversity. The Shannon-Weiner Index and Simpson Index values of the present work indicate good diversity with less water pollution of the Kunigal tank.

In the present study, the percentage composition of phytoplankton species during the year 2014-2015 and 2015-2016 in Kunigal tank were Chlorophyceae 43.97%, 44.23%, Bacillariophyceae 35.34%,35.10%, Cyanophyceae14.84%,14.43%, Desmidaceae 3.85%, 4.08% and Euglenophyceae 1.98%, 2.13%. (Table 2 and 3).

The trend of phytoplanktons with respect to number is found as Chlorophyceae> Bacillariophyceae>Cyanophyceae>Desmidaceae > Euglenophyceae.

5. CONCLUSION

Implementation of restoration programs and controlling the anthropogenic activities in and around the lakes will reduce the eutrophication (13). In the present study, values of Shannon-Weiner diversity Index & Simpson Index for phytoplanktons in Kunigal tank shows that the tank is diversified with a greater number of species making the tank least polluted with good quality of water. The study revealed the rich abundance of phytoplanktons which has increased the zooplanktons and fish productivity in Kunigal tank. In the pollution study, as the phytoplanktons are represented as biological indicators of water quality, hence the results help in planning strategies for water quality management and fish productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Dhanam S, Sathya A, Elayaraj B. Study of physico-chemical parameters and phytoplankton diversity of Ousteri lake in Puducherry. World Scientific News. 2016; 54:153-64.
2. Lalitha HM, Shree Jani HK, Ramakrishna S. Effect of physico-chemical parameters on phytoplankton diversity of Durgada Halli lake. International journal of Research and Analytical reviews. 2020; 7(4): 647-52.
3. Tiwari A, Chauhan SV. Seasonal phytoplanktonic diversity of Kitham lake, Agra. Magnesium. 2006;7(17.5):8-5.
4. Lalitha HM, Ramakrishna S. Diversity and seasonal variations of zooplankton community in Kunigal tank, Tumkur District, Karnataka. Uttar Pradesh Journal of Zoology. 2021;42(24):165-79.
5. Kumar S, Sharma BK, Sharma SK, Upadhyay B. Primary productivity and phytoplankton diversity in relation to fisheries potential of the Lake Udai Sagar, Udaipur. International Journal of Fauna and Biological Studies. 2015;2(5):09-12.
6. Raghavendra M, Nandini N, VijayKumar M, Bheemappa K. Seasonal Variation of Phytoplankton Diversity in Anchepalya Lake, Bengaluru Urban, India. International Journal of Advanced Research. 2015;3(6):2400-5.
7. Fritsch FE. Structure and Reproduction of the Algae. *Cambridge University Press*. 1. 1959.
8. Desikachary TV. Cyanophyta. New Delhi: Indian Council of Agricultural Research;1959; 1-686.
9. Prescott. The Algae - A review. Thomas Nelson and Sons Ltd., Great Britain. 1969.
10. Needham and Needham. A guide to the study of freshwater biology, 4th (ed), Comstock publishing company, NewYork; 1941.
11. Adoni AD. Work book of Limnology, pratibha publication Sagar. MP India. 1985:1126.
12. Federation WE, APH Association. Standard methods for the examination of water and wastewater. American Public Health Association (APHA): Washington, DC, USA. 2005.
13. Atici T, Tokatli C. Algal diversity and water quality assessment with cluster analysis of four freshwater lakes (Mogan, Abant, Karagöl and Poyrazlar) of Turkey. Wulfenia. 2014;21(4):155-69.
14. Atici T, Ahiska S. Pollution and algae of Ankara Stream. Gazi University Journal of Science. 2005;18(1):51-9.
15. Shekhar TS, Kiran BR, Puttaiah ET, Shivaraj Y, Mahadevan KM. Phytoplankton as index of water quality with reference to industrial pollution. Journal of Environmental Biology. 2008 Mar 1;29(2):23.
16. Laskar HS, Gupta S. Phytoplankton diversity and dynamics of Chatla floodplain lake, Barak Valley, Assam, North East India-A seasonal study. Journal of Environmental Biology. 2009 Nov 1;30(6):1007-12.
17. Ravishankar HG, Murthy GP, Lokesh S, Hosmani SP. Diversity of Fresh water algae in two Lakes of Tumkur, Karnataka State, India. In13th Wuhan Conference 2009;1-17.
18. Bhosale LJ, Patil SM, Dhumal SN, Sathe SS. Phytoplankton biodiversity in water bodies of Tahasil Kavathe Mahankal (Sangli District) during post summer period. Indian Hydrobiology. 2010;12(2):190-4.
19. Shinde SE, Pathan TS, Sonawane DL. Seasonal variations and biodiversity of phytoplankton in Harsool-Savangi dam, Aurangabad, India. Journal of environmental biology. 2012 May 1;33(3):643.
20. Devaraj KV, Mahadeva HS, Pazal AA. Hydrobiology of the Hemavathy reservoir. Proc. of Asian Fish. Soc., Mangalore. 1988:323-7.
21. Begum NB, Narayana J. Phytoplankton diversity of four lentic water bodies in and around Davangere city, Karnataka. Journal of Aquatic Biology. 2006;21(2):13-8.
22. Kulshrestha SK, Joshi M. Periphyton community of lower lake of Bhopal in relation to sewage pollution. Aquatic Science in India. Indian Association for Limnology and Oceanology. 1991:65-75.
23. Round FE, Crawford RM, Mann DG. Diatoms: Biology and morphology of the genera. Cambridge university press. 1990:747.
24. Philipose MT. Freshwater phytoplankton of inland fisheries. In Proceeding of the symposium on Algology 1960;279: 291.
25. Hujare MS. Seasonal variations of phytoplankton in the freshwater tank of Talsande, Maharashtra. Nature environment and pollution technology. 2008;7(2):253.
26. Qureshimatva Umerfaruq M, Maurya Rupesh R, Gamit Sandip B, Solanki Hitesh A. Seasonal Variation of Phytoplankton in Bibi Lake, Ahmedabad, Gujarat, India. Preservation. 2015 Oct;4(10).

27. Atici T, Obali O. The diatoms of Asartepe Dam Lake (Ankara), with environmental and some physicochemical properties. Turkish Journal of Botany. 2010 Nov 30;34(6):541-548.
28. Paramasivam M, Sreenivasan A. Changes in algal flora due to pollution in Cauvery River. Indian Journal of Environmental Health,1981;23(3): 222-38.
29. Zafar AR. On the ecology of algae in certain fish ponds of Hyderabad, India. Hydrobiologia. 1967 Jul;30(1):96-112.
30. Albay M, Akçaalan R. Factors influencing the phytoplankton steady state assemblages in a drinking-water reservoir (Ömerli reservoir, Istanbul), In Phytoplankton and Equilibrium Concept: The Ecology of Steady-State Assemblages, Springer. 2003; 85-95.
31. Atici T. Use of cluster analyze and similarity of algae in Eastern Black Sea Region Glacier Lakes (Turkey), Key area: Artabel Lakes Natural Park. Gazi University Journal of Science. 2018;31(1):25-40.
32. Atici T, Ahiska S, Altindag A, Aydin D. Ecological effects of some heavy metals (Cd, Pb, Hg, Cr) pollution of phytoplanktonic algae and zooplanktonic organisms in Sarýyar Dam Reservoir in Turkey. African Journal of Biotechnology. 2008;7(12). 1972-1977.
33. Atici T, Alas A. A study on the trophic status and phytoplanktonic algae of Mamasin Dam Lake (Aksaray-Turkey). Turkish Journal of Fisheries and Aquatic Sciences. 2012 Sep 1;12(3): 595-601.
34. Seenayya G. Ecological studies in the plankton of certain freshwater ponds of Hyderabad, India. Phytoplankton-1. Hydrobiologia. 1971 Feb;37(1):55-88.
35. Kiran BR. Distribution and occurrence of desmids in Bhadra Reservoir Karnataka. International Journal of Research in Environmental Science. 2016;2(3):16-23.
36. Sharma S, Singh K, Prajapati R, Solnki CM, Sharma D, Sengupta T, Gandhi T, Chouhan M, Vyas A. Diversity and Seasonal Abundance of Phytoplankton of River Narmada Madhya Pradesh (India). World Rural Observations. 2011;3(2):14-28.
37. Kulshrestha SK, Joshi M. Periphyton community of lower lake of Bhopal in relation to sewage pollution. Aquatic Science in India. Indian Association for Limnology and Oceanology. 1991:65-75.
38. Brraich OS, Kaur R. Phytoplankton community structure and species diversity of Nangal Wetland, Punjab, India. International Research Journal of Biological Sciences. 2015;4(3):76-83.
39. Shruthi MS, Rajashekhar M. Ecological observations on the phytoplankton of Nethravati-Gurupura estuary, south west coast of India. Journal of the Marine Biological Association of India. 2013;55(2):41-7.