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Research Article

Diversity and Seasonal Fluctuations of Phytoplankton in Temple Pond at Thiruvottiyur, Chennai, South India

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Abstract

The present study was about the diversity of phytoplankton in the temple pond situated at Thiruvottiyur Thiagarajar temple, Chennai, India. The sampling was done in the first week of month and sub-surface water samples were collected from pond at four different seasons. Plankton was identified up to generic level following standard methods. Totally 5 groups of phytoplankton taxa were identified (Chlorophyceae 10, Bacilliariophyceae 11, Cyanophyceae 6, Euglenophyceae 3 and Dinophyceae 2). Among the Chlorophyceae, Volvox sp.; among the Bacillariophyceae, Gamphonema sp.; among the Cyanophyceae, Merismopedia sp.; among the Euglenophyceae, Astasia sp. and among the Dinophyceae, Ceratium sp. were abundant. Seasonal variation in the abundance of phytoplankton was observed. Phytoplankton can act as a biological indicator to assess the qualities of the habitat studied.

Keywords: Phytoplankton, diversity, temple pond, seasonal variation, biological indicator.

Introduction

Planktons, particularly, phytoplanktons were used as an indicators of water quality (APHA, 2005). Phytoplankton initiates the marine food chain by serving as food to many consumers (Saravanakumar *et al.,* 2007). The plankton occurs is all natural waters as well as in artificial impoundment like ponds, tanks, reservoir and irrigation channels etc. Phytoplankton are autotrophs and belonging to first trophic level. The primary production of organic matter is in the form of phytoplanktons which are more intense is reservoir, lake than in rivers (Mahor *et al*., 2010). Phytoplankton, the most important biological phenomenon in nature on which the entire array of life depends is the integral component of riverine ecosystem which determines the primary productivity of the system. It is the bio-indicators of water pollution. Its appearance, disappearance, density and pattern of distribution depend on biotic and abiotic factors (Lewitus *et al*., 1998; Escaravage *et al*., 1999; Escaravage *et al*., 2002; Kauppila *et al*., 2004; Gupta *et al*., 2005; LeQuere *et al*., 2005; Komala *et al*., 2013). Phytoplankton is the major primary producers in many aquatic ecosystems (Kensa, 2011). Phytoplankton form good indicators of water quality as they have rapid turn-over time and are sensitive indicators of environmental stresses and survey thus helps to find out the trophic status and the organic pollution in the ecosystem (Ramchandra and Solanki, 2007). Several studies on phytoplankton diversity of ponds, lakes and reservoirs have also been conducted in India (Tiwari and Chauhan, 2006; Shridhar *et al*., 2006; Tas and Gonulol, 2007; Ekhande, 2010; Patil, 2011) and abroad (Round, 1985; Cleber and Giani, 2001; Sandra *et al.,* 2007) revealed the importance of this type of study. Phytoplanktons are tiny, free-floating and photosynthetic in aquatic systems. These microscopic organisms inhabit the upper sunlit layer of almost all oceans and fresh water bodies. They are agents for 'primary production', which results in accumulation of organic compounds from carbon dioxide dissolved in the water, a process that sustains the aquatic food web (Ghosal *et al*., 2011). Phytoplanktons are primary producers and form the base of most freshwater and marine food webs. They play important roles in carbon, nutrient, and oxygen cycling in aquatic ecosystems (Khan, 2003; Kang *et al*., 2006). Variation in species composition can be estimated by a number of beta diversity measures (Adon *et al*., 2011).

Ponds are generally small natural or artificial, shallow, confined bodies of standing water usually have a muddy or silty bottom that provides habitat and food for many species. It is too small for wave action and too shallow for major temperature differences from top to bottom. These freshwater communities are extremely sensitive to environmental variations. Phytoplanktons are microscopic free floating algal communities of water bodies and productivity of an aquatic system is directly related to diversity of phytoplankton.

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Fig. 1. Thiruvottiyur temple pond.

The phytoplanktonic study is a very useful tool for the assessment of water quality and productivity of any type of water body and also contributes to understanding of lentic water bodies (Pawar *et al.,* 2006). Phytoplankton has been used recently as an indicator to observe and understand changes in the ecosystem because it seems to be strongly influenced by climatic features (Li *et al*., 2000 and Soni and Thomas, 2014).

Materials and Methods

Area of Sampling: The present investigation was conducted in a pond situated at Thiruvottiyur Thiagarajar temple (Fig. 1). The area of the pond was 1.0 ha and means depth is 2 m.

Sampling period and collection: The sampling was done in the first week of every month in early hours of the month around 9 to 11 a.m. The sub-surface water samples were collected from pond at four different seasons with the help of bucket. Care was taken to avoid any kind of spilling of water or air bubbling at the time of sample collection.

Collection of phytoplankton samples: The plankton samples were collected from subsurface water by filtering 50 L of water through plankton net made up of bolting silk no. 25. The concentrated plankton samples were preserved by adding 5% formalin. The Sedgwick Rafter cell was used for quantitative estimation. Plankton was identified up to generic level following standard methods (APHA, AWWA, WEF, 2012).

Qualitative and quantitative studies of phytoplankton: Preserved phytoplankton samples were identified up to *species* level wise by observing them under a microscope. Systematic identification was done up to *species* level wherever possible by taking the help of Edmondson (1992) and APHA (1998) and several research publications.

For quantitative phytoplankton study, a sedge-wick rafter cell was used which is 50 mm long, 20 mm wide and 1 mm deep. The samples were transferred to the cell with a dropper. The air bubbles were avoided while transferring the sample to the cell. Before counting the phytoplankton, it was ensured that all the organisms have settled down. Every sample was counted for the phytoplankton at least five times and an average was taken for the samples of each month for one year during 2015-2016. The number of plankton per mL of the concentrate was calculated by using the formula:

$$\textbf{Phytoplankton (No./mL)} = \frac{C \times 1000}{A \times D \times F}\ m^3$$

Where, C = No. of organisms counted, A = area of the field, D = depth of the field (mm), (S-R depth of = 1 mm), F = No. of fields counted.

Results and Discussion

Data obtained from the study indicates that phytoplanktons of 32 taxa were observed (Table 1). Totally 5 groups of phytoplankton taxa were identified namely Chlorophyceae, Bacilliariophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae. The number and percentage belonging to Chlorophyceae was 10(37%), Bacillariophyceae was 11(27%), Cyanophyceae was 6(18%), Euglenophyceae was 3(12%) and Dinophyceae was 2(6%). Phytoplanktons were dominated by Chlorophyceae followed by Bacillariophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae (Chl > Bac > Cya > Eug > Din) (Fig. 2). From the findings we have noted that the ranges of phytoplankton population density (cells 1^{-1}) were 968. In the observed species, maximum richness values during monsoon season and minimum values was recorded during premonsoon season. Among the four seasons, chlorophyceae was abundant in summer > postmonsoon > monsoon > premonsoon; Bacilliariophyceae was abundant in premonsoon > monsoon > summer > post monsoon; Cyanophyceae was abundant in post monsoon > monsoon > premonsoon > summer; Euglenophyceae was abundant in monsoon > postmonsoon > summer > premonsoon and Dinophyceae was abundant in monsoon > summer > postmonsoon > premonsoon was recorded. The findings showed that among the algal groups, chlorophyceae was the most dominant group when compared to Bacilliariophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae. Similar observations were recorded by Pandey *et al*. (1995) who showed that among the four algal groups (chlorophyceae, bacillariophyceae, myxophyceae and euglenophyceae) in river Saura with chlorophyceae being the most dominant group. Jeelani *et al.* (2005) found bacillariophyceae as the most dominant group out of the six major groups of phytoplanktons, recorded from Dal Lake, Kashmir.

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Table 1. List of phytoplankton observed in the study area.

Plankton species	Summer	Premonsoon	Monsoon	Postmonsoon
Chlorophyceae				
Volvox sp.	20	12	15	11
Dictyosphaerium sp.	15	9	11	19
Micractinum sp.	12	7	-	21
Scenedesmers sp.	-	12	15	-
Pediastrem duplex	15	-	9	8
Claddophora sp.	13	-	-	14
Closterium sp.	20	15	12	7
Onynchonema sp.	5	7	-	12
Ozygnema sp.	-	-	13	7
Cylindrocystis sp.	17	2	-	-
Bacillariophyceae				
Melosira	17	-	12	1
Cymbella leptoceros	-	15	7	-
Gamphonema	20	7	15	5
Navicula cryptocephala	-	-	7	5
Oscillatoria	12	7	-	-
Fragilaria	-	15	17	12
Bacillaria sp.	-	-	-	5
Nitzchia cuspidate	-	15	-	-
N. obtuse	-	-	7	5
Pinnularia sp.	8	12	-	-
Asterionella	-	13	17	7
Cyanophyceae				
Chloriva sp.	-	-	-	-
Oscillatoria curviceps	11	7	5	9
O. limosa	7	6	5	4
Microcystis	7	9	8	5
Coelosphaerium	12	-	7	15
Anabaena sp	-	-	9	7
Merismopedia sp.	-	17	13	12
Euglenophyceae				
Astasia	7	13	21	18
Tracheolomonas	18	-	-	7
Euglena	-	-	20	15
Dinophyceae				
Ceratium	7	5	12	8
Peridinium	8	5	5	6

They also observed seasonal variations in the distribution of phytoplanktons with bacillariophyceae peak during autumn and chlorophyceae, cyanophyceae, euglenophyceae, chrysophyceae showed peak in summer. Seasonally the numbers were more during summer, followed by monsoon and lowest during winter.

Tiwari and Chauhan (2006) observed chlorophyceae being the most dominant during winter, followed by bacillariophyceae in Kitham Lake, Agra. During summer, cyanophyceae and euglenophyceae were the most dominant groups.

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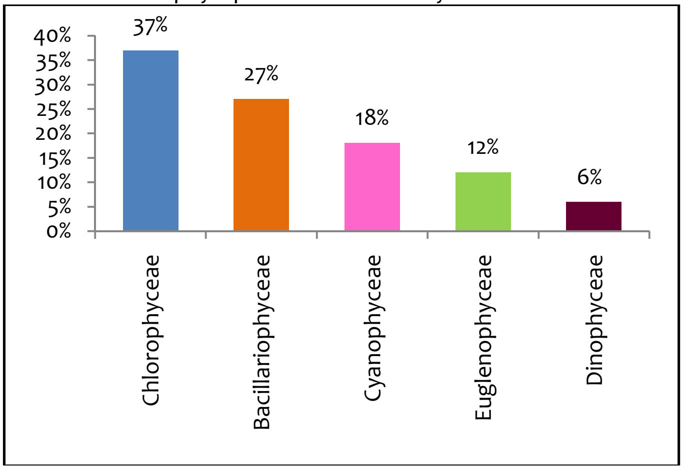
Fig. 2. Percentage of seasonal distributions of phytoplankton in the study area.



Harsha and Malammanver (2004) recorded maximum density of cyanophyceae in their studies on Gopalaswamy pond at Chitradurga, Karnataka. They observed considerable fluctuations in phytoplankton density in relation to environmental variables. The number was lower during winter months in comparison to summer months. Laskar and Gupta (2009) found a total of 34 phytoplanktons, belonging to cyanophyceae, chlorophyceae, bacillariophyceae and euglenophyceae in Chatla flood plain lake, Barak Valley Assam. They recorded highest number of species (29) in premonsoon and lowest (23) in winter. In their studies, they observed Chlorophyceae to be the most abundant in premonsoon and monsoon. Bacillariophyceae and cyanophyceae did not show much seasonal variations. Sahib (2011) recorded 35 species of phytoplanktons in the Parappar reservoir, Kerala. Chlorophyceae represented the maximum density. He also observed maximum density of planktons in winter and the minimum during rainy season. The low temperature and velocity coupled with good transparency of water may be considered as the factors that favoured the optimum growth of phytoplanktons of the Parappar reservoir during winter.

In India, the study on phytoplankton especially their density and diversity and their association as biological indicators in the assessment of water quality or trophic status has been made by several workers (Ingole *et al*., 2010; Gayathri *et al*., 2011; Nagabhushan and Hosetti, 2012). For instance, a temporal increase in turnover may indicate increasing local community differentiation as a result of different successional trajectories (Angeler, 2013). Reservoirs also undergo environmental changes due to land use shifts, catchment hydrology, climatic change and species invasions (Angeler and Johnson, 2012; Daga *et al.*, 2015) and are also an appropriate model system to analyze environmental variations over time.

Nevertheless, while several studies have distinguished nestedness from turnover in studies of spatial beta diversity (Hortal *et al*., 2011; Leprieur *et al*., 2011; Svenning *et al*., 2011) reported the temporal dynamics of these patterns have been evaluated less frequently (Gayathri *et al*., 2011; Soares *et al*., 2015). Some authors suggest that species-sorting mechanisms prevail in environments with limited resources because high productivity should strengthen the role of stochasticity in assembling local communities (Svenning *et al*., 2011; Chase, 2010; Bini *et al*., 2014). Similar observations were made by Sivakumar and Karuppasamy (2008) who reported that the low level of phytoplankton may also be due to gracing by zooplankton and fishes. The ranges of phytoplankton population density (cells 1^{-1}) were 25, 693, the observed density during summer could be attributed to the more stable hydrographical conditions prevailed during that period, due to the occurrence of Allochthonous species (Senthilkumar *et al*., 2002; Thillai Rajasekar *et al*., 2005; Saravanakumar *et al*., 2008). The environmental variables such as temperature, pH and phosphate play a decisive role in altering the phytoplankton density. The diversity and seasonal fluctuation of phytoplankton observed in Khairkatta Dam during one year study period. Similar attempts have also been made in different freshwater body of India by (Zafar, 1957; Philipose, 1960; Sharma *et al*., 1982; Velecha and Bhatnagar, 1988; Mahazan, 1995; Davis, 1955; Mishra, 2005). Communities vary over space and time and investigating the causes of variation in species composition has become a pivotal goal in community ecology from theoretical and practical viewpoints (Socolar *et al*., 2016). Phytoplankton responds quickly to environmental changes and is used to assess the ecological status of water body. Phytoplankton diversity and successions in small man-made ponds are largely ignored. Hence, in the present study an attempt has been made to assess the diversity of phytoplankton and their distribution and fluctuations in the hydrological variables in an artificial pond.

Conclusion

The findings of this study revealed a clear seasonal pattern of changes in phytoplankton communities in the temple pond. The results provide an insight into the distribution, abundance, diversity and ecology of phytoplankton in the pond. It is evident that the ecological conditions of pond support a rich diversity of algal flora. The pond had a diversified group of phytoplankton dominated by Chlorophyceae followed by Bacilliariophyceae, Cyanophyceae, Euglenophyceae and Dinophyceae (Chl > Bac > Cya > Eug > Din). Plankton is the most sensitive floating community which is being the first target of water pollution, thus any undesirable change in aquatic ecosystem affects diversity as well as biomass of this community. Phytoplankton is autotrophs and belongs to first trophic level.

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The presence of various microalgae in this investigation helps for maintenance of ecological balance in the fresh water bodies.

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