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Phytoplankton diversity of Suchindram pond of Kanyakumari district, Tamil Nadu, south India

[1] Mary Kensa V, [2] Jespin Ida C
[1] PG Department of Botany and Research Centre, ST Hindu College, Nagercoil, Tamil Nadu, India
[2] Department of Botany, Holy Cross College (Autonomous), Nagercoil, Tamil Nadu, India

Abstract
The study discusses the phytoplankton diversity of the Suchindram pond for a period of two years (2011-2013). Through a field survey, the population density of phytoplankton and their percentage composition observed in Suchindram pond varied much between sampling months during the study period. Among the identified groups Cyanophyceae was dominant. The next dominant groups were Chlorophyceae and Bacillariophyceae. Flagellates were recorded as the least dominant group in this pond. The lowest biomass value was recorded for Flagellates. The class Dinophyceae and Chrysophyceae were represented with minimum biomass while the class Euglenophyceae contributed to the maximum. Genera such as *Ceratium and Peridinium* of Dinophyceae were noticed during the northeast monsoon season in both the years of study. The class Chrysophyceae was represented with one genus with only one species *i.e. Dinobryon sertularia.* This species showed its appearance during southwest monsoon. The different species of each genus were distributed more frequently during summer months and with less frequency in other months. Low representation of desmids in Suchindram kulam represents the eutrophic nature of that pond. The data of Suchindram pond confirmed that the pond is already in eutrophic conditions. Among the various Phytoplankton species identified, the study area was noted for its frequent occurrence of large number of pollution indicating algae. Statistical analysis revealed that, the influence of monsoon seasons and sampling ponds on the distribution of phytoplankton groups was statistically significant.

Keywords: bacillariophyceae, chlorophyceae, frequency, phytoplankton and southwest monsoon

Introduction

Phytoplankton could be used as the indicator of physicochemical status of any water body. Aquatic ecosystems are vulnerable and the loss of biodiversity may cause catastrophic consequences such as algae blooms or secondary extinctions (Weyhenmeyerey *et al*., 2013; Zhao, 2016) [53]. Thus, studies on the relationship between phytoplankton diversity and ecosystem functioning are essential to develop appropriate conservation strategies in aquatic ecosystems.

Phytoplankton diversity has relationship with productivity in ecology (Newall, 2011; Vallina *et al*., 2014) [48]. In addition, the diversity index may be used for habitat characterization (de Domitrovic *et al*., 2007; Cardoso *et al*., *2012*) [9, 5]. The changes in nutrients have strongly influenced the phytoplankton community structure in this area. Increasing nutrients from anthropogenic discharge stimulate the growth of phytoplankton through photosynthesis. The diversity, distribution, abundance of plankton and the variation according to the abiotic factors afford information of energy turnover in the aquatic ecosystem. Damodharan *et al*. (2010) stated that it also offers an important food source for larval fishes and other crustaceans in natural waters.

The present study aims to update the list of phytoplankton species occurring in the fresh water bodies in and around Suchindram pond and to provide much needed information on species composition and diversity.

Study area

This is a large perennial water body located about 2 km away from Nagercoil town. The total area of the pond is approximately 108.86.0ha. The adjoining areas of this pond are residential and thickly populated. The major source of water to the pond is through Suchindramkal from Kumarianai, which is fed by the rivulet Pazhayar. The Suchindramkal traverses through Nagercoil town collecting urban sewages and also the agricultural run-off, and finally enters Suchindram Kulam.

On the northern side of the pond is the National Highway (NH 47). On the eastern side is a big bund, but now it is encroached by slums. The western and southern sides are completely occupied by villagers. The northwest corner of the pond is used as a dumping place of solid waste and now there is a heap of waste materials instead of water. The catchment area is mainly agricultural fields. It irrigates about 277.99 ha of paddy fields. This pond is extensively used for fishing, bathing, washing clothes, disposal of urban waste and often used for open defecation. The sewage alters the status of the pond. It brings an enormous quantity of nutrients into the system, which enables unregulated growth of algae.

Materials and Methods

Plankton collection was made in pond during the first week of every month around 6 a.m. Ten litres of water was collected separately and the collected water was filtered through a cone shaped plankton net made of bolting silk (standard grade no: 25 with mesh size 60μ for phytoplankton). The concentrates were collected by a vial tied in the lower end of the cone. The samples were then centrifuged and preserved in 10 ml of 4% formaldehyde. The plankton concentrate was agitated to distribute the organisms evenly. Using the Sedge wick – Rafter plankton counting cell, plankton in 1 ml of the sample was counted. The quantity of plankton is expressed as organisms per litre. Phytoplankton species were identified with the help of monographs and standard books of Fritsch (1965) [15], Prescott (1978) [32], and Anand (1998) [2].

Result and Discussion

Population Density of Phytoplankton

The population density of phytoplankton and their percentage composition observed in Suchindram pond varied much between sampling months during the study period (Table 1 and 2). Among the identified groups, Cyanophyceae was dominant. The next dominant groups were Chlorophyceae and Bacillariophyceae. Flagellates were recorded as the least dominant group in this pond. For instance, the density of Cyanophyceae varied from 7770 nos/*l* to 19670 nos/ *l* in the months of December and March with the percentage composition range of 43.26% to 51.20% during (2011-2013). In the succeeding year (2011-2013), the density range registered for the same group was from 6190 nos/ *l* in January to 21210 nos/ *l* in April with the percentage composition range of 37.97% to 57.50%. Similarly the population density and percentage composition range of 2180 nos/ *l* and 8.19% in February to 9090 nos/ *l* and 39.80 % in August were observed for Chlorophyceae during (2011-2013). For the same group, the population density range of 2620 nos/ *l* in April to 10540 nos/ *l* in June with the percentage composition range of 7.1% to 38.60% was recorded during (2011-2013). Bacillariophyceae recorded the population density ranges of 2340 nos/ *l* in August 2011 and 13.50 nos/ *l* in April 2013 and from 3320 nos/ *l* in December 2011 to 10730 nos/ *l* in April 2013. The corresponding percentage composition ranges of 10.20% to 33.10% and 16.60% to 29.10% were noticed for the same group. During the study period (2011-2013) the population density ranges of 1320 nos/ *l* in July 2000 to 4890 nos/ *l* in April 2011 and 850 nos / l in June 2001 to 3080 nos/ *l* in August 2013 were recorded in Flagellates.

In the study area, the lowest biomass value was recorded for Flagellates. The class Dinophyceae and Chrysophyceae were represented with minimum biomass while the class Euglenophyceae contributed to the maximum. Genera such as *Ceratium and Peridinium* of Dinophyceae were noticed during the northeast monsoon season in both the years of study. The class Chrysophyceae was represented with one genus with only one species *i.e. Dinobryon sertularia.* This species showed its appearance during southwest monsoon. The class Euglenophyceae was represented with three genera such as *Euglena, Phacus and Trachelomonas.* The different species of each genus were distributed more frequently during summer months and with less frequency in other months.

Also the mean seasonal variation in population density of different phytoplankton groups fluctuated much between seasons and also between groups (Table 2). For example the Chlorophyceae recorded the maximum cell density of 8300 nos/ *l* and 9030 nos/ *l* in northwest monsoon season during the study period (2011-2013). Likewise, the minimum densities of 3440 nos/ *l* in summer (2011-2013) and 4340 nos/ *l* in northeast monsoon seasons (2011-2013)) were recorded. The Cyanophyceae members were maximum in summer and the minimum cell densities were recorded in northeast monsoon season. The Bacillariophyceae registered its maximum cell densities of 11450 nos/ *l* and 9350 nos / *l* in summer during (2011-2012) and 2012 – 2013 respectively. The same group during (2011-2013) registered the minimum cell densities of 4150 nos/ *l* in southwest monsoon and 4190 nos / *l* in northeast monsoon seasons. The Flagellates were maximum (3860 nos/ *l* and 2380nos/*l*) in summer and minimum (1910 nos/ *l* and 1570 nos/*l)* in southwest monsoon and northeast monsoon seasons respectively during 2011 – 2012 and 2012 – 2013.

The dominance index registered in study area for Chlorophyceae was high (0.145 and 0.136) during southwest monsoon and low (0.025 and 0.032) in summer during the study period. But the Cyanophyceae members showed high C values (0.224 and 0.236) during summer and low values (0.186 and 0.193) during southwest monsoon season. Bacillariophyceae showed the minimum C value of 0.014 and 0.072 in northeast monsoon, and maximum value of 0.105 and 0.136 in summer respectively. In the study period the Flagellates showed the maximum C value during summer (0.018) season and minimum during southwest monsoon (0.006) season. For this same group more or less a similar trend was noticed for C value during the second year. The results on diversity index registered in Suchindram pond during the study period were found to be less when compared with the values recorded in other three experimental ponds. The low diversity value was an indication of high pollution and eutrophication. During the first year of study period for the different groups of phytoplankton, the range of diversity index value recorded was 0.76 to 1.36. Likewise during the second year study period the values varied from 0.48 to 1.88.

Richness Index (d)

Species richness index recorded in Suchindram kulam for Chlorophyceae during study period ranged from a minimum of 1.046 (summer) to a maximum of 2.520 (northeast monsoon). For the same group, during study period the d value ranged between 1.756 (northeast monsoon) and 2.490 (southwest monsoon). The Cyanophyceae members were found to have d value ranges of 2.326 to 3.494 and 2.260 to 3.267 during study period. The maximum value recorded for Bacillariophyceae was 1.272 (summer) against minimum of 0.363 (southwest monsoon) during 2011– 2012, while during the next year (2012 – 2013), the minimum and maximum values recorded for the same group were 0.566 (southwest monsoon) and 1.856 (summer). The group Flagellates recorded a low d values of 0.769 and 0.826 (northeast monsoon) and high values of 1.374 and 1.526 (summer) during the study period.

Species Evenness Index (J')

The data on the species evenness index recorded in Suchindram kulam showed that for Chlorophyceae, the values ranged from 0.086 to 0.277 and 0.084 to 2.279. The

Cyanophyceae showed high species evenness values in almost all seasons. The species evenness values of Bacillariophyceae fluctuated from 0.251 to 0.460 and from 0.39 to 0.426. Flagellates recorded minimum range between seasons and the average mean species evenness values were 0.233 and 0.205 during the first year and second year study period respectively.

In the present study, the results on population density of phytoplankton and percentage composition were also elucidated as noteworthy information. The density as well as percentage composition varied much among sampling months and between experimental ponds. The different phytoplankton identified was categorized into five different classes such as Chlorophyceae, Cyanophyceae and Euglenophyceae. The different indices calculated such as dominance, diversity, richness and evenness of the identified phytoplankton groups also varied much among ponds as well as between monsoon seasons.

Among the various Phytoplankton species identified, the Suchindram pond was noted for its frequent occurrence of large number of pollution indicating algae. Statistical analysis revealed that, the influence of monsoon seasons and sampling ponds on the distribution of phytoplankton groups was statistically significant (Two-way ANOVA, P <0.05 to < 0.01).

Phytoplankton are the easiest food source for most of the aquatic beings like zooplanktons, fishes and thus are the basic food producers in any aquatic ecosystem (Suseela, 2009). Various studies have been carried out in the Indian context related various aspects of phytoplankton such as seasonal distribution (Jyothi, and Narasimha, 2013., Shiddamallayya, and Pratima, 2011). diversity of fresh water algae (Kanagasabapathi, and Rajan, 2010; Ravishankar *et al*., 2009; Shankar, and Mruthunjaya, 2012; Ramesha, and Sophia, 2013; Komala, 2013; Suresh, and Puttaiah, 2013; Venkateshwarlu and Honneshappa, K., 2011; Singh, and Balasingh, 2011; Manickam, 2012; Senthilkumar, and Sivakumar, 2008) [36, 39, 35, 22] seasonal variations and physical-chemical aspects (Sureshand Puttaiah, 2011; Sedamkar, and Jayashree, 2011; Gayathri *et al*, 2011; Shiddamallayya, and Pratima, 2011) and algal blooms (Divya, and Puttaiah, 2013).

It is observed that there is increased nutrient content in the water bodies due to the anthropogenic activities which has led to the decline in the phytoplankton diversity and also led to the dominance of a few pollutant resistant species in all the water bodies investigated in the present study. Appearance and massive growth of phytoplankton in water bodies depend not only on factors such as light and temperature but also on the nutrient load, which affect species composition. In India, diversity of phytoplankton in different freshwater water bodies was studied by various scholars (Veereshakumar and Hosmani, 2006; Ravikumar *et al*. 2006; Tiwari and Shukla, 2007 and Senthilkumar and Das, 2008).

Further, other studies reported the distribution pattern of phytoplankton with respect to the degree of water pollution, impact of aquaculture and climatic change (Chattopadhyay and Banerjee, 2007; Pradhan *et al*., 2008), role of macrophyte's root and shoot system (Raut & Pejaver, 2005) and harmful and toxic effects of cyanobacteria in Indian freshwater lakes (Chaudhary & Meena, 2007; Maske *et al*., 2010).

The density of phytoplankton was as follows: Cyanophyceae followed by Bacillariophyceae and then by Chlorophyceae. The seasonal variations in total phytoplankton numbers were due to varies factors such as temperature, intensity of light, bicarbonate, pH, nutrients etc. Certain planktonic populations apparently disappear at a specific period and reappear during the other periods. This disappearance may be due to the fact that same species either become scarce or occur in spores, which cannot be easily detected. However on the return of favourable conditions spores again germinate and the plankton reappears.

In the present investigation, the order Chlorococcales were found to be the most conspicuous order of Chlorophyceae. It multiplied profoundly in March and April, when water temperature was high. The present investigation was similar to the findings of Pendse *et al.* (2000). It could be inferred from the present study that well –oxygenated water is a prerequisite for harbouring larger numbers of Chlorococcales. This is in accordance with the views of Eshwarlal and Angadi (2003). Members of Chlorococcales are especially abundant in sewage oxidation ponds (Vincent *et al.*, 1984; Dryden and Vincent, 1986).

Desmids are often considered as indicative of oligotrophy by various authors. Low representation of desmids in Suchindram kulam represents the eutrophic nature of that pond. During the present study, desmids were found to be more abundant during southwest monsoon season. Similar observation was already made by Pendse *et al.* (2000).

Death and decomposition of macrophytes result in the release of nutrients especially phosphorus, into the water column. This may lead to an immediate increase in *Oscillatoria* and *Lyngbya* population during the dense growth of macrophytes in Suchindram kulam, with concurrent decrease in nitrogen fixing cyanobacterial from like *Anabaena* sps. and *Nostoc* sps. This finding is in consistence with the findings reported by Baliar singh *et al.* (1993) in a polluted pond in Orissa. Depletion of dissolved inorganic nitrogen during late summer favours the growth of nitrogen fixing Cyanobacteria (Mur *et al*., 1993). Nostocales have a high light and temperature demand (Dokulil and Teubner, 2000) especially under depletion and thrive well in summer. This agrees with the present results. Among the Cyanophyceae, the *Microcystis* sps was the prominent one. Blooming of *Microcystes* has been observed in many inland water bodies (Mukherjee and Pankajakshi, 1995; Rajeevkumar and Asif Khan, 1995; Mohan Raj, 2001; Pulle and Khan, 2003) suggested that the occurrence of *Microcystis* and *Spirulina* as a permanent bloom in ponds receiving high quality of detergents and their death and decay accelerated the growth of same forms causes a high degree of organic pollution. This confirms the result of Suchindram kulam of the present study.

The Suchindram pond was highly polluted and represented by different species of Euglenophyceae throughout the year just like the findings of Eshwarlal and Angadi (2003) and Mruthunjaya and Hosmani (2004) [26]. Presence of Chrysophyceae was scanty in Suchindram kulam. The low density of Chrysophyceae as noticed by Harikrishnan *et al*.,

(1999) can be attributed to a high concentration of detergents.

The data of Suchindram kulam confirmed that the pond is already in eutrophic conditions. Eutrophication also affects the species composition, biomass and structure of zooplankton community too. Losses of nitrogen and phosphorus in land run-off and drainage from agricultural land can impair pond water quality and may pose a potential health hazards as well as dramatic changes in biomass (Axler and Reuter, 1996; Paul and Eunice 2002 and Mischke, 2003). Addition of nitrate and phosphate were identified as causing eutrophication and enhanced the growth of *Aphanizomenan, Microcystis, Phormidium, Lyngbya and Stigeoclonium* were reported in the present study as well as the earlier studies by Swarnalatha and Narsing Rao (1997), Hosmani *et al*. (1999) and Walter K. Dodds (2003).

Phytoplankton is an important primary producer, since it is the basis of the whole food chain in open waters. Muhammad *et al*. (2005) reported that the maximum production of phytoplankton is obtained when the physico-chemical factors are at optimum level. Species composition of phytoplankton community is an efficient bio-indicator for water quality (Peerapornpisal *et al*., 2004). The Bacillariophyta (diatoms), Chlorophyta (green algae), and Cyanophyta (blue green) make up the three major groups of algae in fresh water ecosystems. Most identified taxa belong to the green algae, which are known as an extremely diverse group of algae especially in freshwater environments (SWCSMH, 2006).

Waste discharge into water and fertilizer applications around water sources increase nitrogen and phosphorus levels in systems (Fonge *et al*., 2012). Also untreated car wash effluents have been reported to contain phosphates and nitrates above limit (Aisling *et al*., 2011) and these are nutrients which encourage algal growth. In this study, nutrients correlated positively with phytoplankton abundance while diversity correlated negatively with nutrients in agreement with the fact that increase in nutrients reduce diversity but increase abundance of tolerant species (Chislock *et al*., 2013; Fonge *et al*., 2015).

Conclusion

The results of this study demonstrated the importance of phytoplankton diversity in maintaining ecosystem functioning and how the diversity effects were influenced by nutrient enrichment. Therefore, protecting species diversity and limiting anthropogenic import of nutrients are critical to prevent ecological catastrophe in eutrophic lakes. Therefore, it can be considered a baseline data source for researchers conducting further research in semiarid regions. Local initiatives such as bioremediation, effective waste management, sustainable farming and fishing, and proper information dissemination must be continuously implemented to prevent the further degradation of the lake's water quality; and ultimately to prevent the loss in phytoplankton composition and diversity.

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