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SEASONAL DISTRIBUTION OF PHYTOPLANKTON DIVERSITY AND PRIMARY PRODUCTION IN A FRESH WATER POND AT KUMBAKONAM, TAMIL NADU, INDIA

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ABSTRACT

Measurement of primary production is essential for assessing the level of fish production and potential of exploitable fisheries. Hence the present study was focused on assessing the seasonal distribution of phytoplankton, its diversity and primary productivity in a fresh water system located in Kumbakonam, Tamil Nadu. The present study could record 4 groups of phytoplankton, Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae. Amoung these Cyanophycae was found to be the most dominant group in terms of planktonic count in all the three seasons followed by Chlorophyceae. Further, Cyanophyceae and Chlorophyceae preferred presummer to record their highest counts while Bacillariophyceae and Euglenophyceae preferred post summer season. The Shannon's index of species diversity, diversity index of family and species richness indices were highest during the presummer and lowest during the rainy season. Similarly among the 3 seasons, GPP was highest during the presummer season.

Keywords: Seasonal Distribution, Phytoplankton Diversity, Species Diversity Indices and Productiviy

INTRODUCTION

Water is cue of the most important natural resources that are required for the life and health of organisms. The unique peculiarity of an aquatic ecosystem is its inhabitation by planktonic organisms (Umavathy *et al*., 2007). Phytoplankton being autotrophs initiate the aquatic food chain and the secondary producers (Zoo plankton) and tertiary producers depend on them directly or indirectly for food (Thirunavukkarasu *et al*., 2013). Phytoplanktonic study is a very useful tool for the assessment of water quality (Jiji Joseph, 2017) and natural regions which are characterized by typical species or species groups (Sampathkumar and Ananthan, 2007). On addition phytoplankton plays a significant role in the global biogeo-chemical cycling of many nutrients (Thirunavukkarasu, *et al*., 2013). Phytoplankton has also been recently used as an indicator to observe and understand changes in the ecosystem because it seems to be strongly influenced by climatic factors (Li *et al*., 2000; Soni and Thomas, 2014). Further, phytoplankton plays a major role in aquaculture as they serve as food for the larval stages of crustaceans, fish and all stages of bivalves (Volkman *et al*., 1989).

One of the best ways to feed the increasing Indian population is to use fish which is a source of cheap animal protein. Hence the measurement of primary production becomes essential for assessing the level of fish production and potential exploitable fisheries as suggested by Thirunakkarasu *et al.,* (2013). Hence the present study was focused on assessing the seasonal population density, diversity and primary production in a fresh water pond at Kumbakonam, Tamil Nadu.

MATERIAL AND METHODS

Study Area

The aquatic system chosen for the present investigation is a pond situated in Kumbagonam District, Tamil Nadu, India and referred to as fish culture pond. The pond is located at Swamimalai at an elevation of about 80MSL and it is mostly perennial.

It has a water spread area of about 0.5 ha and a depth of about 4m when full. As the pond is close to the Cauvery River; it is currently used for agriculture, cattle bathing and building constructions. On the other hand, environmental degradation is fell intensely in this area (Jayaram, 2000; Kalavathy *et al.,* 2011). Thus this system is prone to more pollution.

Physico – Chemical Variables

Water samples were drawn from surface and bottom and stored in separate polyethylene bottles for later analyses in the laboratory. While some physico-chemical variables like estimation of dissolved oxygen (DO), hydrogen-ion concentration (pH), free carbondioxide (free CO_2), phenolphthalein alkalinity (PPA) and methyl orange alkalinity (MOA) were analysed in the field itself, all other variables were analysed in the laboratory, Duplicate sample of all variables were taken and the average values taken.

The atmospheric, surface and bottom water temperatures were measured using a centigrade mercury thermometer calibrated to 100°C. Atmospheric temperature was measured in shade, while surface water temperature was analysed by taking the surface water in a container and then measuring it. The water level of the pond was measured using a graduated rope provided with a weight at one end. The measurement was done on every sampling day at a particular spot. While the transparency of the water column was measured using a Secchi's disc, total dissolved solids (TDS) was estimated by evaporating the water samples in a porcelain dish (Saxena, 1987); dissolved oxygen (DO) was estimated using unmodified Winkler's method (Ellis *et al.,* 1984). While free carbondiozide (free CO_2) and alkalinity (phenolphthalein and methyl orange) were determined according to Saxena (1987), pH was measured in the field itself with a digital pH pen (Hanna) and electrical conductivity was measured using a water analysis kit (Elico). Nutrients like phosphate, silicate, ammonia-nitrogen, nitrite-nitrogen, sulphate, calcium and magnesium were estimated according to APHA (1995). Nitrate-nitrogen (NO_3-N) was estimated after Mackereth (1961) and chloride after Strickland and Parsons (1972). While oxidizable organic matter, nitrogenous organic matter and suspended solids were done following APHA (1995), Trivedy and Goel (1986) and Taylor (1949), biological oxygen demand (BOD) was estimated following the procedure of Sawer and Bradney (1946) and chemical oxygen demand (COD) as per Moore *et al.,* (1949).

Phytoplankton Analysis

Surface water samples were collected with the help of a satin net (pore diameter 4.5µ) fitted to an aluminum frame between 7:00 and 8.00 am for a period of one year (2019). Collection was done on a monthly basis. The Sample were immediately transferred to glass containers for later microscopic analyses. Lugol's solution was also added as a preservative. Care was also taken to observe some fresh samples. The counting of algae was done using a Sedgwick-Rafter Counting cell (Saxena, 1987). Samples were isolated and identified by standard methods (Pearsall *et al.,* 1946; Desikachary, 1959; Starmach, 1966; Pennak, 1978; Rippka *et al.,* 1979; Prescott *et al.,* 1982; Adoni and Vaishy, 1985; Trivedy *et al.,* 1987; Sridharan 1989) In addition, diversity indices and productivity were also calculated following Trivedy *et al.,* (1987). Finally, the results obtained in the present study were statistically treated for a meaningful discussion.

RESULTS AND DISCUSSION

Table 1 shows the various physicochemical factors that were analysed along with the ranges during the three seasons of the year. Table 2 records the various phytoplankton that were recorded during the three seasons. As evident from the Table, Phytoplankton that occurred in the system belonged to Cyanophyceae Chlorophyceae, Bacillariophyceae and Euglenopohyceae.

On the whole, a total of 21 species were noticed for the three seasons. A comparison of the 3 seasons (May-Aug.) record 20 species each while the rainy season (Sep. – Dec.) recorded only 16 species.

A groupwise comparison reveal that cyanophyceae was recorded by 5 species during presummer and rainy season and only 4 species during the post summer season as *Synecocystis aquatilis* was absent during this period. Among the cyanophycean species, *Microcystisaeruginosa* was found to dominate all the three periods.

The group Chlorophyceae was represented by 9 species were found to occur during the presummer period, the post summer period was recorded by 8 species as *Volvox aureus* was absent. However, the rainy season was recorded by only 7 species as *Chlorella vulgaris* and *Chlamydomonas simplex* were absent. During the presummer seasons in terms of count *C. vulgaris* was found to dominate why in post summer*C.simplex* dominated and in rainy season *Eudorina elegans*dominated.

Bacillariophycene was represented by 4 species during the period of study. All the four species were recorded during the post summer season while only 3 were found during the presummer season as *Pinnularia major*was absent. The rainy season recorded only 2 species as *Nitzhia sigmoidea* and *P. major* were absent during this period. Among this group, *Cyclotella compta* was found to dominate during presummer and rainy season while in post summer, *Synedra ulna* was found to dominate in terms of count.

Euglenophyceae was represented by 3 species during the presummer and post summer periods while the rainy season recorded only 2 species as *Trachelomonas hispida* was absent. *Euglena viridis* was found to dominate during presummer and post summer seasons while *Phacus suecica* dominated rainy season in terms of count.

Cyanophycean class count was found to vary between 200 (rainy) to 470 i/l (presummer) while Chlorophycean count ranged between 160 (presummer) and 390 i/l (presummer) and Bacillariophycean count from 30 (rainy) to 100 i/l (post summer). Euglenophycean count on the other hand ranged between 30 (rainy) to 200 i/l (postsummer). Thus in terms of group count Cyanophyceae and Chlorophyceae preferred presummer while Bacillariopohyceae and Euglenophyceae preferred post summer to record their highest class counts. Phytoplankton total count reveals that the count ranged between 420 to 980 i/l. While the highest count was recorded during the presummer season the lowest was recorded in the rainy season. (Table 1-2)
The comparison of the percentage composition in

Table 1: Physico – Chemical Analysis of water of a pond at Kumbokonam

S.No	Physico-chemical Analysis	Unit	Ranges	Average
1.	Atmospheric Temperature	°C	28 - 37	32.5
2.	Water Temperature	°C	26.0 - 34.0	30
3.	pH	unit	7.0 - 8.8	7.9
4.	Dissolved Oxygen	mg/l	4.7 - 7.9	6.3
5.	Carbondi Oxide	mg/l	0.5 - 1.4	0.95
6.	Alkalinity	mg/l	180 - 290.6	253.3
7.	Total Dissolved Solids	mg/l	160 - 270	90
8.	Phosphate-P	mg/l	1.2 - 2.4	1.8
9.	Nitrate-N	mg/l	0.96 - 1.8	1.38
10.	Ammonia-N	mg/l	0.11 - 0.26	0.37
11.	Calcium	mg/l	40.6 - 72.0	56.3
12.	Magnesium	mg/l	16.7 - 24.5	41.2
13.	Chloride	mg/l	26.5 - 42.5	69
14.	BOD	mg/l	13.5 - 29.5	21.5
15.	COD	mg/l	25.5 - 38.6	32.05
16.	Water level	cm	140 - 420	280
17.	Transparency	cm	48 - 69	58.5

terms of class count for the three periods reveals that Cyanophyceae dominated in all the three seasons followed by Chlorophyceae. However, the percentage composition was the same for Bacillariophyceae and Euglenophyceae for presummer season while in the post summer Euglenophyceae dominated over Bacillariophyceae.

In the present study, 4 groups of phytoplankton belonging to Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae were recorded. A perusal of literature reveals that many workers (Devi and Singara, 2007; Rout and Borah, 2009; Mahor and Singh, 2010; Jiji Joseph, 2017) have also reported the presence of the above groups in the various aquatic systems analysed.

Among the various groups, Cyanophyceae was the most dominant member in all the three seasons. Literature reveals that similar observations were also noticed by others in other systems of India (Santhosh *et al*., 2007; Hudder, 1995, Hujare, 2008; Khanna and Indu, 2009; Jeyabaye, 2010; Arumugam, 2017). Ganapati *et al.,* (1953) suggested that Cyanophyceae dominates while temperature, pH, alkalinity, silicate and phosphate levels are high. Neelam (2009) reported that the dominant native of Cyanophycean members are the characteristic features of eutrophic environments as they have high concentrations of nutrients especially phosphate and nitrate.

In the present study *M. aeruginosa* was the most dominant Cyanophyceae. Literature reveals that this species has been reported to be the commonest algal to occur in almost all tropical ponds including many fresh water systems of Tamil Nadu (Ganapati, 1955, Sreenivasan, 1968; Nandan and Patel, 1983; Sivakami, 1996; Sirajunisa, 2014).

Literature reveals that chlorophytes prefer different seasons in different aquatic systems. However, Melack *et al.,* (1982) reported that phosphate influenced their growth more than nitrate. While Pearsall (1932) suggested that they occurred when nitrate and phosphate were moderate. However, Kavitha *et al.,* (2005) suggested that low temperature during monsoon coupled with average pH and average nutrient content favors the growth of Chlorophyceae.

In the present study, Bacillariophyceae was recorded in high numbers during the post summer season. Similar observation were also recorded by Kastoori bai (1991); Kundangar and Zutshi (1985) and Hegde and Bharti (1985). According to Munawar (1970) regular supply of nutrients encouraged the growth of diatoms while Ansar (2015) reported that the presence of phosphate, nitrate, silicate and total hardness promoted their growth. However, Wetzel (1983) reported that of all the aspects of chemical determination of succession and productivity, the negative relationship between diatoms and silicate contration is among the most apparent.

In the present study, Euglenophyceae recorded maximum count during the post summer season. Similar report was suggested by Jiji Joseph (2017). Jasprica *et al.,* (2006) reported that higher temperature and nitrate content increased the growth of Euglenophyceae while Ansari *et al.,* (2015) suggested that high temperature chloride; TDS and BOD play an important role in their growth.

The various indices of phytoplankton diversity are presented in Table 3. While the Shannon's index of species diversity was found to range while between 0.94 (rainy)

Table 2: Seasonal changes of Phytoplankton in a Freshwater pond at Kumbakonam

S.No	Phytoplankton	Rainy Season Sep.-Dec.	Pre Summer Jan.-Apr.	Post Summer May-April
	Cyanophyceae			
1.	*Anabena circinalis*	10	40	20
2.	*Microcystis aeruginosa*	140	310	230
3.	*Chrococcus giganteus*	10	30	60
4.	*Spirulina major*	30	70	40
5.	*Synechocystis aquatilis*	10	20	-
	Class Count	**200**	**470**	**350**
	Percentage Occurrence	**47.61**	**47.96**	**41.18**
	Chlorophyceale			
1.	*Chlorella vulgaris*	-	120	20
2.	*Pediastrum duplex*	20	30	10
3.	*Scenedesmus obliquus*	20	40	50
4.	*Ankistrodesmus falcatus*	30	20	10
5.	*Ulothrix zonata*	10	10	10
6.	*Chlamydomonas simplex*	-	40	60
7.	*Zygnema stellinum*	20	30	10
8.	*Eudorina elegans*	40	70	40
9.	*Volvox aureus*	20	30	-
	Class Count	**160**	**390**	**210**
	Percentage Occurrence	**38.09**	**39.79**	**24.71**
	Bacillariophyceale			
1.	*Nitzschia sigmoidea*	-	10	30
2.	*Synedra ulna*	10	20	30
3.	*Cyclotella comta*	20	30	10
4.	*Pinnularia major*	-	0	20
	Class Count	**30**	**60**	**90**
	Percentage occurrence	**7.14**	**6.12**	**10.59**
	Euglenophyceae			
1.	*Euglena viridis*	10	20	130
2.	*Phacus suecica*	20	30	40
3.	*Trachelomonas hispida*	-	10	30
	Class count	**30**	**60**	**200**
	Percentage Occurrence	**7.14**	**6.12**	**23.53**
	Total Count	**420**	**980**	**850**

Table 3: Seasonal changes of Phytoplankton diversity in a Freshwater pond at Kumbakonam

S.No	Details	Shannan Weiner's Diversity Index of species	Shannan Weiner's Diversity Index of Family	Species Richness Index (d)
1.	Rainy/ winter season	0.94	1.14	1.32
2.	Presummer season	1.44	1.49	1.84
3.	Postsummer season	1.26	1.20	1.60

Table 4: Seasonal changes of Phytoplankton productivity in a Freshwater pond at Kumbakonam

S.No	Details	GPP $gO_2/m^2/day$	NPP $gO^2/m^2/day$	CR $gO_2/m^2/day$
1.	Rainy/ winter season	35.4	22.5	12.9
2.	Presummer season	42.2	34.6	7.6
3.	Postsummer season	38.6	29.9	9.0

and 1.44 (summer), the diversity index of family ranged between 1.14 (rainy) and 1.49 (post summer) and species richness index from 1.32 (rainy) to 1.89 (post summer). According to Odum (1971) higher diversity means larger food chains and greater possibilities for negative feedback control which in turn will increase stability.

The details of productivity are presented in Table 4. The GPP was found to range between 35.4 (rainy) to 42.2g O_2/M^2/day (presummer) while NPP ranged between 22.5 (rainy) and 34.76g O_2/M^2/day (presummer) and CR from 7.62 - 12.09g O_2/M^2/day.

In the present study minimal GPP was recorded in the rainy season. This is in conformity with the report of Sreenivasan (1964) who suggested that productivity decreased during the cooler months in addition to deterioration of phytoplankton. Goldman and Wetzel (1963) attributed temperature as an important factor in determining seasonal productivity while Sultan *et al.,* (2003) reported that temperature, Solar radiation and available nutrients are important limiting factors contributing to seasonal variation in any aquatic system. Kund Hansen (1997) opined that productivity is influenced by availability of nutrients while Lin *et al.,* (1997) suggested that nitrogen and phosphorus are mostly responsible for algal growth while Umavathi *et al.,* (2007) reported that in a producture system, respiration accounts for a large proportion of GPP.

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