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Studies on Primary Production and Physico-Chemical Variables in Summer at Vellore Fort Moat, Tamilnadu

[1]C. Govindasamy, S. Shahida Begam and [2]R. Kannan

[1]School of Marine Sciences, Department of Oceanography and Coastal Area Studies,
Alagappa University, Thondi Campus-623 409, Tamilnadu, India
[2]Depratment of Plant Science and Bioinformatics, NGM College,
Bharathiar University Pollachi-642 007, Tamilnadu, India

Abstract: Primary production and physico-chemical variable studies were carried out for summer months in two Moat stations, i.e., the Entrance zone of the moat and the Boating zone, in Vellore Moat, a water body situated on the north eastern part of Vellore Fort. A total of 14 and 28 species of phyto and zooplankton were recorded at both the stations. Rotifers were the largest contribution in term of density (47%) at both the stations. At both the stations, Bacillariophyceae (45%) appeared as a dominant group followed by Chlorophyceae (31%) and Cyanophyceae (24%) of phytoplankton groups. Summer variations in hydrographical variables and dissolved nutrient such as PO_4-P, NO_3-N, NO_2-N, Cl-C and Fl-F were high at both the stations. In the Moat water, TDS concentrations varied from 5299-6377 mgl^{-1}, EC from 7570-9110 µmhos cm^{-1}, O_2 from 3.04-5.06 O_2 mg l^{-1}, Ca from 402-683 mg l^{-1}, Mg from 170-260 mg l^{-1}, Na from 628-690 mg l^{-1}, Fe from 0.03-0.13 mg l^{-1} and NH_3 from 0.90-11.28 mg l^{-1} at both the stations. The primary productivity varied from 0.315-0.756 mgC l^{-1} $hr.^{-1}$ at both stations. In general, the concentration of physico-chemical variables were relatively high in the boating zone than in the entrance zone. Attention should be paid immediately to boating zone region fairly which these will be contaminant loss of valuable moat water resources due to high eutrophication.

Key words: Summer · Moat water · Population density · Species composition · Physical and Chemical variables · Nutrients · Primary production

INTRODUCTION

Water is a "Cradle of life" on which all organisms play. Water is one of the most peculiar of our natural resources for life; next to air it is likely to become a critical scarce resource in the coming decades. Most of the water on this planet is stored in oceans and ice caps, which is difficult to be recovered for our diverse needs. Most of our demands for water are fulfilled by rainwater that gets deposited in surface and groundwater sources. The quantity of this utilizable water is very much limited on the earth. Though water is continuously purified by evaporation and precipitation, pollution of water has emerged as one of the most significant environmental problem [1] [2]. Lakes and ponds are economically important ecosystems in the aquatic region phytoplankton are the initiators for the synthesis of organic matter and the energy of which is transferred to higher organisms through the food chain. The Knowledge of micro and macronutrient and their effect in relation to productivity is highly essential in aquatic ecosystems. In case of allergenic surface run off water is responsible for carrying the nutrient where as in case of autogenic, the nutrients are produced as a result of decay process [3].

Life in aquatic environment is largely governed by physico-chemical characteristics and their stability. Most of the forms exist only within narrow range of conditions. The changes in the water quality may be essential for the existence of some organisms while for others such changes may not be desirable. Aquatic environment depicts ecological feature that lead to the establishment of a very dynamic system in which the plankton communities play an important role [4]. Phytoplankton is a fundamental component of aquatic ecosystems as they are the major source of biologically important and labile

Corresponding Author: C. Govindasamy, School of Marine Sciences, Alagappa University, Thondi Campus-623 409, Tamilnadu, India, E-mail: drcgsamy@gmail.com

organic carbon, located at the base of food chain. The magnitude and dynamics of phytoplankton population becomes an essential tool to asses the general health of an aquatic ecosystem [5]. The primary producers (phytoplankton) are capable of taking up dissolved organic carbon and incorporating into particulate organic carbon that forms the energy sources for organisms at higher trophic levels. Lakes have a more complex and fragile ecosystem as they do not have self-cleaning ability and therefore readily accumulate pollutants. The Increasing anthropogenic influences in recent years in and around aquatic systems and their catchment areas have contributed to a large extent to deterioration of water quality and dwindling of water bodies leading to their accelerated eutrophication [6].

Productivity is of great importance in ecosystem analysis as it integrates the cumulative effects of many physiological processes, which occurs simultaneously within the ecosystem [7]. Primary productivity of aquatic ecosystems is essential for a proper assessment of the biological potential of that habitat. The primary role of phytoplankton is to fix solar energy by photosynthesis and make it available to other organisms. The rate of energy fixation by primary producers is higher in the tropics due to long hours of sunshine and high temperature [8]. The quality of water resources is usually described according to its physical, chemical and biological characteristic [9]. For conforming the good quality of water resources large number of physico-chemical and biological parameters are to be studied in detail and must be found in normal range. In any rational formulation and deciding quality of water resource an adequate knowledge of existing nature of water quality parameter magnitude and source of any pollution load must be known, for which monitoring of physico-chemical parameters and pollutants is essential [10]. The planktonic organisms in aquatic systems are essential links in the food chain, plankton are highly sensitive to the environment where they live. Any change in the environment leads to the variation in the plankton population with reference to their tolerance, dominance and diversity [11]. Hence, both phytoplankton and zooplankton population may be used as reliable tools for bio-monitoring studies to evaluate the pollution status of aquatic ecosystem. The production, consumption and decomposition are the three important eco-regulatory and balancing processes in an aquatic habitat, the interplay between which determine and regulate the out put levels. Natural eutrophication is a slow process of enrichment and is part of aging phenomenon. The natural eutrophication is a beneficial process in turn enhanced productivity in the water mass [12]. This invariably results in deterioration of water quality, which in many cases causes significant economic loss.

In the present investigation, is therefore focused on the ecological events of the Vellore Fort Moat to collect information on the state of the art by regarding the Summer variations in hydrobiology, primary productivity and diversity of phytoplankton and zooplankton distribution in Moat water with a view to select the particular diversity of phytoplankton and zooplankton quality. Moreover, different type of pollutants that is increasing in recent times in Vellore Moat investigation was carried out for a total period of three months (April-June 2006) at Entrance zone and Boating zone of the Vellore Moat.

MATERIALS AND METHODS

Description of the Study Area: The Vellore Fort Moat selected for the present study is situated in Northeastern part of Tamil Nadu in Vellore (Lat. 12°-15'N; Long. 79°-50'E) (Fig. 1) about 140 km from Madras and has wide water spread area suitable for inland fish culture.

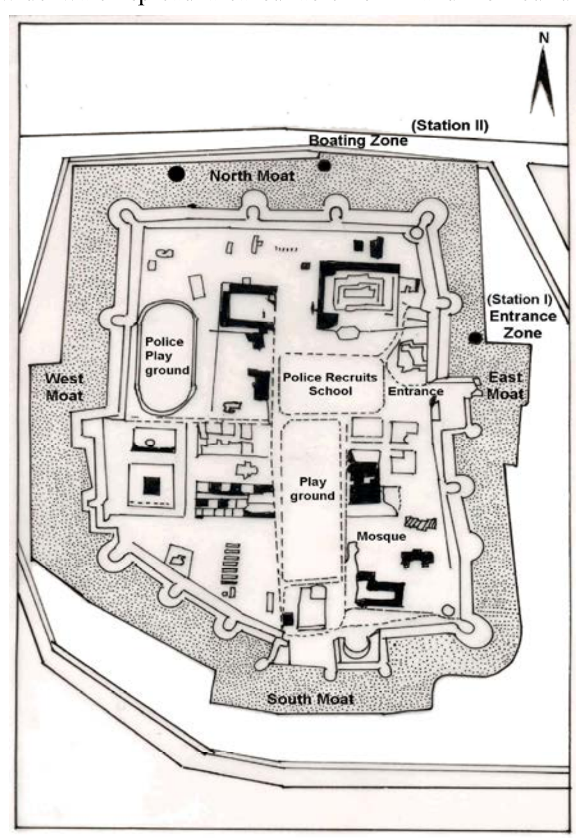

Fig. 1: Map showing the study areas

At present there are about 2500 forts existing in India and in Vellore Districts alone there are twenty forts, hence it is called as "District of Forts". One such beautiful land fort is located in the heart of the Vellore town and it is one of the best-preserved fort in Tamil Nadu today and is surrounded by a Moat. The Vellore Fort Moat occupies 7.8 hectares of perennial water body thus it has been considered as one among the important reservoir in Vellore.

The Moat receives water from the run off during rainy season through in and around catchment areas. The average depth of water level during summer is 10 feet while, during rainy season the water level is about 20 feet. The study area selected has been divided into two stations. Both these stations are situated in the fort along the National Highway. The entrance zone of the Moat (station I) is situated in the eastern part of Jalagandeeswarar temple, while, the boating zone (station II) located half a kilometer from the north of station I.

Surface water samples were collected at both the stations. Temperatures (air and surface water) were measured in the field using a standard centigrade thermometer. Turbidity was measured with the help of a Secchi's disc; and the light extinction co-efficient was calculated using Pool and Atkins [13] formula. pH was measured using a ELICO pH meter and dissolved oxygen was estimated using the methods given by APHA [14]. For the analysis of dissolved nutrients, water samples were collected in clean polypropylene container of two-litre capacity and immediately kept in ice box and transported to the laboratory to avoid contaminations, the water samples were then filtered through a Millipore filtering unit using Millipore filter paper (mesh 0.05µm). The filtered samples were deep-frozen and the nutrients were analyzed in the next day. PO_4-P, NO_3-N, NO_2-N, NH_3-N, SO_4-S, Cl-C and Fl-F were analysed in the laboratory. Total dissolved solids, Electrical conductivity, Total hardness, Calcium, Magnesium, Sodium, potassium and Iron were estimated by standard methods [15].

Plankton: For quantitative analysis, collection were made in fine meshed plankton net (94µm for Phytoplankton; 225µm for Zooplankton) made of bolting silk (No.15 for phytoplankton; 10 for zooplankton) and the plankton were preserved in 5% neutralized formalin. Plankton (zooplankton) samples were than passed through a sieve (48µm) to remove all debris's that might affect isolation of other unwanted particles [14]. For quantitative analysis of phytoplankton and zooplankton, sedimentation technique was followed. The water samples were collected in clean 1litre polythene containers and added 5% neutralized formalin and kept undisturbed in a laboratory. The phyto and zooplankton were settled at the bottom after 48 hours. For each sample, counting's was made 5 times and the mean was taken and the population density, expressed as number of Cells litre^{-1} (phytoplankton) and number of Organisms litre^{-1} (zooplankton). The light and dark bottle method as outlined by Strickland and Parsons [16] was followed for assessing the primary productivity.

Statistical Analysis: All sets of data were subjected to correlation analysis to see the level of significance. These analyses were carried out using the Poly statistics computer programmer of Simpson [17].

RESULTS AND DISCUSSION

Summer variations of different environmental features in the Moat ecosystem depend on the fresh water discharge, which in turn is chiefly controlled by the pattern of rainfall in the study areas, environmental conditions in most of the tropical pond and lake are also largely governed by marked seasonal and summer changes induced by the monsoon cycle. Temperature is one of the most important parameters for the biochemical and physiological process in the aquatic organisms. Atmospheric and surface water temperatures values were ranged from 20ºC to 31.00ºC at stations I and II (Table 1). Atmospheric and surface water temperatures are the important environmental factors and the summer variation of atmospheric and surface water temperatures are varied at both the stations. Moreover cloudy weather decreases the atmospheric temperature and consequently the water temperature to the minimum [18]. Further, it is evidenced by the statistical analysis which showed between temperatures and population density ($r= 0.897$; atmospheric temperature) and ($r= 0.879$; surface water temperature) at $p<0.001$ levels at both the stations.

Secchi disc transparency depends upon the suspended particles present in water therefore; it can be a good index of phytoplankton population, especially in productive waters. The transparency values were ranged between 2.088 to 2.103 at stations I, where as it was found between 2.029 to 2.085 at station I (Table 1). The wide Summer variations in light extinction co-efficient observed during the month of May, 2006 was high at both the stations caused by the turbulence and fresh water inflow low light extinction co-efficient was recorded during the month of April due to the copious fresh water discharges carrying a lot of terrigenous materials coupled with very

Table 1: Summer variations in environmental variables (mgl^{-1}) recorded from stations I and II during the study period from April to June 2006

		April		May		June	
Sl.No	PARAMETERS	Station I	Station II	Station I	Station II	Station I	Station II
	Physical Parameters						
1	Atmospheric temperature (°C)	20.00	23.00	25.00	27.00	27.00	28.00
2	Surface water temperature (°C)	26.00	27.00	29.00	30.00	31.00	31.00
3	Light extinction co-efficient (K)	2.103	2.029	2.092	2.085	2.088	2.039
4	Total Dissolved Solids (TDS)	5376	5369	5418	5299	5481	6377
5	Electrical Conductivity (µmhos cm^{-1})	7680	7670	7740	7570	7830	9110
	Chemical Parameters						
6	Dissolved Oxygen (O_2 mgl^{-1})	3.04	3.38	5.06	4.39	3.71	3.38
7	pH	7.46	7.51	7.51	7.66	7.63	7.39
8	Alkalinity	553	589	577	605	597	561
9	Total hardness	1829	2090	1950	2171	2070	2714
10	Calcium (Ca)	426	402	482	442	523	683
11	Magnesium (Mg)	183	260	170	256	183	241
12	Sodium (Na)	640	628	660	635	690	680
13	Potassium (K)	42	54	54	60	60	48
14	Iron (Fe)	0.04	0.08	0.08	0.03	0.13	0.03
15	Free Ammonia (NH_3)	0.91	0.09	0.96	0.14	1.05	1.28
16	Nitrite (NO_2)	0.03	0.02	0.03	0.31	0.05	0.06
17	Nitrate (NO_3)	202	193	203	194	212	331
18	Phosphate (PO_4)	0.14	0.12	0.15	0.14	0.19	0.24
19	Chloride (Cl)	1752	1574	1802	1614	1752	2030
20	Fluoride (Fl)	0.8	0.8	0.8	0.8	0.8	0.8
21	Sulphate (SO_4)	367	428	379	442	397	469
	Biological Parameters						
22	Primary Productivity ($mgCl^{-1}hr^{-1}$)	0.315	0.453	0.751	0.756	0.452	0.454
23	Phytoplankton Biomass (Cells l^{-1})	782	550	515	725	790	480
24	Zooplankton Biomass (Org. l^{-1})	412	240	515	365	550	260

low intensity of Solar radiation. Golterman [19] reported that the water transparency is highly variable parameter and helps in determining productive zone of water body.

The total dissolved solids of the water samples were ranged from $5376mgl^{-1}$ to $5481mgl^{-1}$ at station I while it varied between $5299mgl^{-1}$ to $6377mgl^{-1}$ at station II (Table 1). This may be due to the various kinds of mineral present in water. In natural water TDS is composed mainly of carbonates and bicarbonates, Cl^-, So_4^{-S}, Po_4^{-P}, No_3^{-N}, Ca^+, Na^+, K, Fe^{++}. Further, Patel [20] reported that the dissolved solids influence the turbidity of waters and in turn affect light penetration. The TDS values in both the stations were showed higher than the permissible limit [21]. Electrical conductivity is a good and rapid method to measure the total dissolved solids and is directly related to total solids. The EC values were recorded between 7680 to 7830 mic mho/cm at station I, where as it was varied between 7570 to 9110 mic mho/cm at station II (Table 1). Highest value of conductivity at station II may be due to high concentration of ionic constituents present in the Moat water bodies.

Measurement of hydrogen ion concentration is represented as pH. The pH concentration of the Moat water was found to be alkaline in nature. The hydrogen ion concentration showed a narrow range from 7.39 to 7.66 during the study period at both the stations. High pH of 7.66 was recorded during the month of May at station II coinciding with high productivity of phytoplankton (0.76 $mgCl^{-1}hr^{-1}$ at station II, while 0.75 $mgCl^{-1}hr^{-1}$ at station I) with the removal of carbon dioxide by photosynthesis (Table 1). Alkalinity is a measure of the capacity of water to absorb hydrogen ion; the most common constituents of alkalinity are carbonates, bicarbonates and hydroxide ions. The Alkalinity of the water samples was noted between 553 to 597 mgl^{-1} at stations I. The maximum concentration was noted in the June. The concentration of alkalinity (Boating zone) in station II varied between 561-605 mgl^{-1}. Thus the total alkalinity of the water increases with an increase in pH and calcium. Moreover alkalinity of the water samples in both the stations exceeded the permissible limits [22].

The total hardness of Moat water at station I (Entrance zone) was ranged between 1829 to 2070 mgl^{-1}. The higher concentration was noticed at station II (Boating zone) and varied between 2090 to 2714 mgl^{-1}. Thus the hardness of water samples was found to be increase gradually at station II, while it decreases from station I. Calcium is found in great abundance in all natural waters, its concentration varies depending upon the nature of basin. It is also important micro-nutrient in an aquatic environment. The calcium concentration was found to range from 426-523 mgl^{-1} at station I, while at station II it was noted between 402-683 mgl^{-1}. The maximum concentration of calcium in both the stations was recorded during June. The high concentration of calcium might be contributed to the geological formations in the area [23].

Magnesium is a necessary constituent of chlorophyll without which no ecosystem could operate. The concentration of magnesium was fluctuated between 178-183 mgl^{-1} at station I. The maximum concentration (183 mgl^{-1}) was noted in April and June while minimum concentration (178 mgl^{-1}) was recorded in May (Table 1). Higher concentration of magnesium was recorded at station II ranged from 241-260 mgl^{-1}. Sodium is one of the important cations occurring in the water required for its natural softening. Sodium concentration of Moat water station I varied between 640 mgl^{-1}-690 mgl^{-}.^{1} The concentration of sodium at station II was within the range of 628 to 680 mgl^{-1}. At both the stations, higher concentration of sodium acts as a deflocculating agent and displaces the divalent cations like Ca and Mg and cumulatively the soil loses its productivity [24]. Potassium concentration was found between 42 to 60 mgl^{-1}) at station I. While at station II it was recorded between 48-60 mgl^{-1} (Table 1). Potassium found in small amounts it plays a vital role in metabolism of fresh water environments and considered to be an important macronutrient [24].

Iron concentration varied from 0.04 to 0.13 mgl^{-1} during the study period at station I. Low concentration (0.04 mgl^{-1}) was recorded during the April and high concentration (0.08 mgl^{-1}) during the June at station I (Table 1). Wetzel [25] and Luoma [26] reported that the availability of iron depend on the redox potential, temperature and pH. Free ammonia is present naturally in surface water and wastewater. It is produced largely by domination of organic nitrogen containing compounds and hydrolysis of urea. Free ammonia concentration was found between 0.91 to 1.05 mgl^{-1} at station I, where as the concentration of free ammonia was ranged between 0.09 to 1.28 mgl^{-1} at station II. Ammonia in the form of ammonium salts is one of the most important nitrogenous nutrients and its concentration is known to determine the fertility of the pond. In general, ammonia values were found to decrease with increasing depth and the summer variations is more pronounced than that of the spatial, variations. However, Reddy [27] worked in the pond water and reported higher values in shallow zone and the summer variations are attributed to discharge of terrestrial raw water.

Nitrite is the intermediate state of nitrogen. During the present investigation, the concentration of nitrite was found between (0.03 to 0.05 mgl^{-1}) at station I, while the concentration at station II, varied from 0.02 to 0.31mgl^{-1}. The nitrite concentration was relatively lower at station I during the entire study period and the higher concentration of nitrite was recorded at station II during May. The nitrite concentration was maximum during the study period at both the stations. This might be due to the influence of turbulence as a recorded for phosphate and nitrate during study (Table 1), these features could be attributed to the oxidation of organically derived ammonia or to the cellular production of nitrite by phytoplankton production during assimilation of nitrate [28]. Moreover, the concentration of nitrate varied from 202 to 2123 mgl^{-1} at station I, while at station II it was ranged from 193 to 331 mgl^{-1}. This was due to the addition of nitrogenous nutrients mainly by surface run off, oxidation of ammonia from nitrate and subsequently to nitrite [29].

Chloride content of Vellore fort Moat at station I (Entrance zone) was ranged between 1752 to 1802 mgl^{-1}. No observable differences were recorded during Feb and June (1752 mgl^{-1}) except May it showed 1802 mgl^{-1}. The higher concentration was recorded at station II and showed variations and the values were ranged between 1574 to 2030 mgl^{-1} (Table 1). High concentration of chlorides during summer months might be due to decomposition of organic matter as advocated by Adoni [30]. Fluoride is the most exclusive bone-seeking element owing to its activity for calcium phosphate [31]. The fluoride concentration showed 0.8 mgl^{-1} follows the similar trends in all three months at both the stations. Thus the fluoride concentration was remained same during the investigation (Table 1). Low concentration of fluoride below 0.5 mg/l courses dental caries and higher concentration beyond 1.5 mg/l causes dental and skeletal fluorosis [32]. Surface water generally contains less than 0.5 mgl^{-1} fluorides. When present in much greater concentration, it becomes a pollutant [1]. The concentration of sulphate varied from 367 to 469 mgl^{-1} at both the stations. The maximum concentration of sulphate was observed during June at both the stations. Sulphate is ecologically important for growth of plants and its deficiency may inhibit the development of plankton [33].

At station I, higher concentration of 0.19 mgl^{-1} phosphates was noted in the month of June and the lower concentration of 0.14 mgl^{-1} during April. The maximum concentration (0.24 mgl^{-1}) was recorded at station II in June. Heron [34] has indicated that the phosphate increase may be due to decreased phytoplankton and concentration of zooplankton excreta. Lower concentration during summer may be due to higher consumption by macrophyts [35]. High phosphate content might be attributed to sewage water in the lake [1]. The Phosphate concentration in general increased at both the stations during the months of May and June. Maximum phosphate at both the stations might have been promoted by the liberation of inorganic. Phosphate from bottom under high oxygen tension and also enhanced by turbulence [36]. The dissolved oxygen is one of the important parameter in water quality assessments. Its presence is essential in aquatic ecosystem in bringing out various biochemical changes and their effects on metabolic activities of organisms. Dissolved oxygen was varied between 3.036 to 5.060 mgl^{-1} at station I while, at station II it was ranged between 3.380 to 4.394 mgl^{-1} (Table 1). The higher concentration of dissolved oxygen was observed in May at both stations while, minimum values were recorded in April 2006. Further, it is evidenced by the statistical analysis which showed relation between phosphate and phytoplankton population ($r = -0.988$; $p < 0.001$ and $r = -0.867$; $p < 0.001$ level) at stations I and II. This is in conformity with the earlier reports [37] [38] [4].

With regard to primary production it was found to be slightly high at station I when compared to station II during the study period. The maximum and minimum production rates were recorded during the month of May (0.751$mgCl^{-1}hr^{-1}$) and April (0.315$mgCl^{-1}hr^{-1}$) at station I (Table 1). The high production rate may be due to increase in the concentration of mineralized nutrients causing phytoplankton density. Rodh [37] and Aguigo [38] considered a primary production value above 350 mgC $m^{2\text{-}1}yr^{-1}$ to be normal for polluted waters. Further the physico-chemical environment in the lake ecosystem influences temperature, dissolved oxygen, pH, carbon dioxide and hydrogen sulphide. Moreover, the photosynthetic activity of phytoplankton, which was especially higher during the summer months, at both the stations, should have increased the dissolved oxygen concentrations in the lake ecosystem [39][40].

A total number of 14 species of phytoplankton were recorded in Entrance zone and Boating zone of Moat water at different stations during the study period (Table 2). Of these, *Scenedesusm sp. Pediastrum duplex, Bacillaria sp., Cymbella leptoceros, Gomphonema sp., Melosira sp., Navicula cryptocephala, N. caspidata, N. viridula, Nitzschia obtusa, Pinnularia sp., Chlloriva sp., Oscillatoria curviceps and O. limosa* were recorded. The genus *Navicula* and *oscillatoria* were dominant with more species. Among different genera *Navicula* ranked first out of 14 followed by *Oscillatoria* with 2 species. There was a rather group of phytoplankton from April to June registered.

With regard to zooplankton, a total of 28 species of zooplankton and 4 species of insects were recorded at both the stations during the study period (Table 3).

Table 2: Checklist of phytoplankton group, species recorded from stations I and II during the study period from April to June 2006

Sl.No.	Name of the phytoplankton groups and species	Station I	Station II
	Chlorophyceae		
1	*Scenedesmus sp.*	+	+
2	*Pediastrum duplex*	+	-
	Bacillariophyceae		
3	*Bacillaria sp.*	+	+
4	*Cymbella leptoceros*	+	+
5	*Gomphonema sp.*	+	+
6	*Melosira sp.*	-	+
7	*Navicula cryptocephala*	+	+
8	*N. cuspidata*	+	+
9	*N. viridula*	+	+
10	*Nitzrchia obtusa*	+	-
11	*Pinnularia sp.*	-	+
	Cyanophyceae		
12	*Chlloriva sp.*	+	+
13	*Oscillatoria curviceps*	+	+
14	*O. limosa*	+	+

+ presence;-absence.

Table 3: Checklist of major zooplankton groups and insects recorded from stations I and II during the study period from April to June 2006

SI. No	Name of the zooplankton group, species and Insects	Station I	Station II
	Protozoa		
1	Arcella discoidae	+	+
2	*A. vulgaris*	+	+
3	*Difflugia sp.*	+	-
4	*Euglypha sp.*	+	+
5	*Vorticella sp.*	+	-
	Rotifers		
6	*Anuraeopsis fissa*	+	+
7	*Brachionus calciflorus*	+	+
8	*B. rubens*	-	+
9	*B. quadridentata*	+	-
10	*B. angularis*	+	+
11	*Euchlanis dilita*	+	+
12	*Filinia longiseta*	+	+
13	*Kertella cochlearis*	-	+
14	*Lecane luna*	+	+
15	*L. bullet*	+	+
16	*Monostyla bulla*	+	-
17	*Synchaeta sp*	+	+
	Copepods		
18	*Nauplius larva*	+	+
19	*Cyclops sp.*	+	+
20	*Diptomus sp.*	+	+
21	*Mesocyclops hyaliners*	-	+
	Cladocerans		
22	*Daphnia sp.*	+	+
23	*Moina brachiatce*	+	-
24	Naupli	+	+
25	*Ceriodaphnia reticulata*	+	+
26	*Chydorus sp.*	+	-
	Ostracoda		
27	*Cypris sp.*	+	+
28	*Postomes cypris*	+	-
	Insect		
29	*Culex sp.*	+	+
30	*Corixa sp.*	+	-
31	*Helocharcs lividus*	+	+
32	*Tipula sp.*	+	-

+ presence;-s absence

Of these, *Arcela discoidae, A.vulgaris, Difflugia sp., Euglypha sp. Vorticella sp. Anuraeopsis fissa, Brachionus angularis, B. calciflorus, B. rubens, B. quadridentata, Euchlaris dilita, Filina longiseta, Keratella cochlearises, Lecane luna, L. bullet, Monostylla bulla, Synchacta sp., Diatrons sp., Mesocydops hyalinus, Daphnia sp., Moina branchiata, Naupli, Ceriodapherie reticulata, Chydornus sp. Cypris sp. Postomu cypris, Culex sp. Corixa sp. Helochorcs lividus* and *Tipula sp.* occurred at both the stations, at all the collections. The genus *Brachionus* and *Lecane* were dominates with more species.The summer distribution of 32 species of zooplankton recorded in the present study. Among different groups *Brachionus* ranked first out of 32 followed by *Lecane* with 2 species. There was a moderately group population of zooplankton from April to June registered. In the present study, it was noted that whenever two or more species of a genus occurred, only one species was dominant. Further, whenever more than one zooplankton genus dominated the situation, any one species in each group was found to be dominant. These observations agree well with the findings of Govindasamy and Kannan [41] [42].

Peak of 790 (Cell l^{-1}) as phytoplankton and 550 (Org. l^{-1}) zooplanktons were recorded during study period (Tables 2 and 3). Further, the biomass of phytoplankton and zooplankton dominant at station I when compared to station II. This is clearly indicating that station I have higher biomass, species composition and diversity. Relation between physico-chemical parameters and diversity of phytoplankton are important component of many aquatic ecosystems as they participate in natural purification of water and acts as a primary and secondary consumer. It has been observed that phytoplankton and zooplankton constitute the main food of fish and fish larvae. Thus phytoplankton has a direct bearing on the

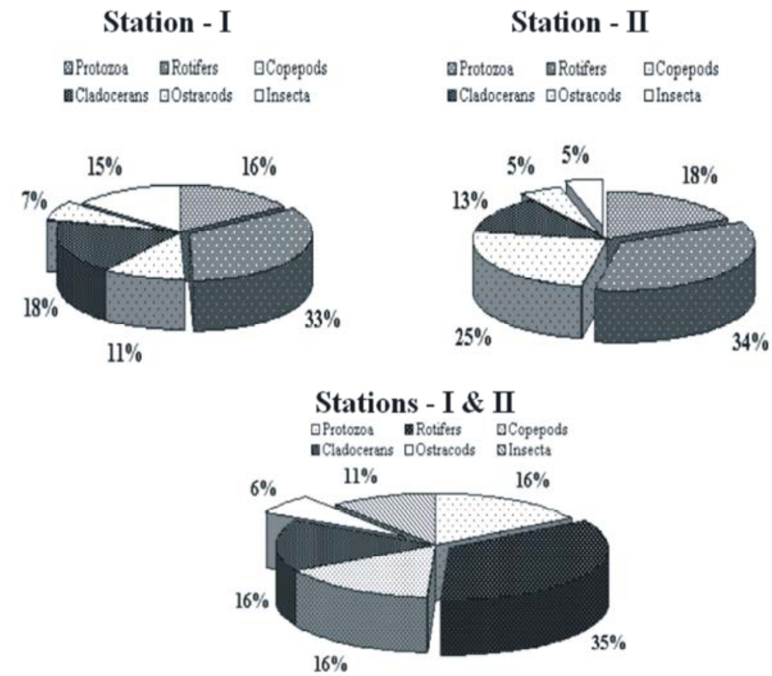

Fig. 2: Percentage composition of different zooplankton groups in Vellore Moat water (stations I and II).

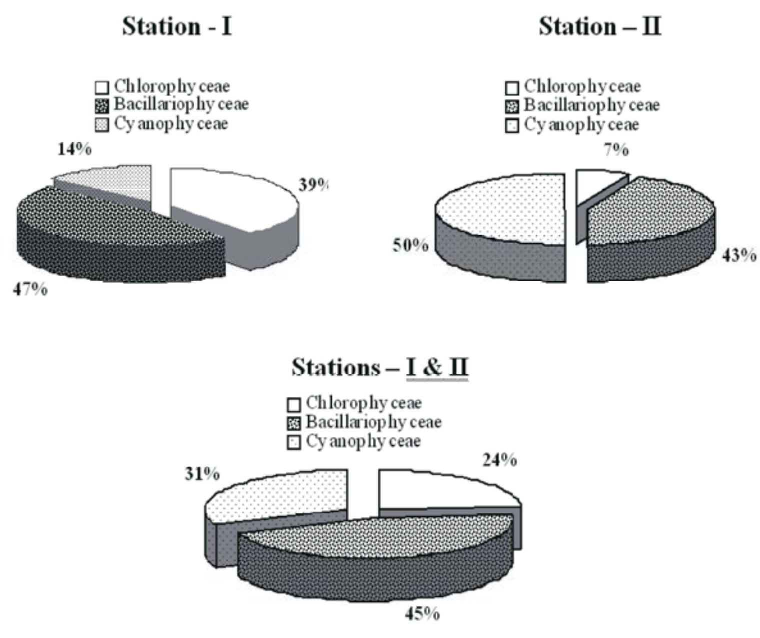

Fig. 3: Percentage composition of different phytoplankton groups in Vellore Moat water (stations I and II).

secondary and tertiary producers. The zooplankton mainly comprise of Protozoa, Rotifers, Copepods, Cladocerans, Ostracods and Insecta. Rotifers were the largest contribution in term of density (33%) followed by Cladocerans (18%), Protozoa (16%), Copepods (11%), Ostrocods (7%) and Insects (15%) at station II. At station I, density was Rotifers (34%), Copepods (25%), Protozoa (18%), Cladocerans (13%) and each (5%) of Ostracods and Insecta. At both the stations, Rotifers (35%) Copepod, Cladocerans and Protozoa shared each 16%, Insecta (11%) and Ostracods (6%) during the present study (Fig. 2).

Three groups of phytoplankton were recorded viz., Chlorophyceae, Bacillariophyceae and Cyanophyceae.

While, Bacillariophyceae was the largest contribution in term of density (47%) among phytoplankton followed by Chlorophyceae (39%) and Cyanophyceae (14%) in the order of abundance at station I and at station II Cyanophyceae (50%), Bacillariophyceae (43%) and Chlorophyceae (7%). At both the stations *Bacillariophyceae* (45%), *Chlorophyceae* (31%) and *Cyanophyceae* (24%) were shared their contributions during the present study period (Fig. 3). The wide distribution, spatial abundance of phytoplankton and zooplankton diversity because of abstraction structures being under direct control of the user, ground water and rain water has become to stay as a preferred sources for meeting the water demands for various user sector. It is visible because human interference has become endangered resources in many parts of Tamil Nadu especially in Vellore Moat, water reservoir once contaminated or polluted cannot be restore to its present state.

Enrichment factors, used as the tool of quantification of contamination, were compared for water samples with respect to natural and local background concentration values. Moreover, concentrations of the nutrients and other physical variables varied from place to place. So it is concluded from the present study that the Moat water of Vellore fort rapidly getting higher physico-chemical and biological variables. So these results clearly indicated the local hydrography, monthly, seasonally and spatial variability which cannot be neglected in studies of the occurrence of dissolved nutrients, plankton diversity and productivity in Moat waters. Thus Boating zone of Moat water possesses relatively more nutrients than the Entrance zone. Attention should be made immediately to Boating zone region which will be contaminate loss of valuable Moat water resources due to high eutrophication.

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