

Freshwater Lakes - A potential source for aquaculture activities – A model study on Perumal lake, Cuddalore, Tamil Nadu

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(Received: 20 November, 2004 ; Accepted: 5 July, 2005)

Abstract: The freshwater Perumal lake located at Cuddalore was assessed for its suitability and potential for aquaculture practices. Various hydrobiological parameters determined reveals that the various physicochemical characteristics are within normal range of values. The DO level, BOD and COD values determined in the lake revealed the consequences of community activities and pollution possibilities. The primary productivity data revealed maximum productivity during March which infer that the lake is unaffected by anthropogenic disturbance and community contamination. The bacterial count remained higher during the monsoon periods, which characterize profuse rainfall and storm water discharge into the lake. The microfauna includes zooplankton such as cladocerans, copepods, rotifers and ostracods. Benthos include carps, catfishes, mullets and prawns. The above study revealed that the various parameters in the lake conform to the levels suited for freshwater fish culture and represents a resource for scientific management.

Key words: Hydrobiology, Aquaculture, Pollution, Limnology.

Introduction

Fresh water ecosystems represent an alternate avenue for culture fisheries. In India, not much progress has been made in the last few decades, though freshwater bodies and the potential to culture fish species are plenty. Compared to the vast area of coastal belt available for both capture and culture fisheries (8000km) and aquaculture practices, the freshwater sources such as irrigation tanks in India are mainly contributing for augmenting the crop productivity in agriculture. An enumeration of the local freshwater bodies has revealed that they are distributed in and around the districts of Chennai, Chengalpet, Chidambaram, Kovur, Porur, etc. Limnological studies have been conducted in these freshwater tanks and ponds for the last two decades. The above studies have highlighted not only the hydrological parameters, but also the biotic composition at producer trophic level and higher trophic level and their potential value as sources for augmenting culture activities with reference to fish species and shrimps. Though, these freshwater tanks have been surveyed and their hydrological and biotic components have not been analysed, their proper utilization for aquaculture and management have not been given due consideration and attention by the local authorities as well as the private and public entrepreneurs. The present paper was aimed to project the various hydrobiological parameters, so as to assess the suitability of a model lake for aquaculture purposes. It was also aimed to project the various avenues of pollution activities in and around the model lake and the remedial measures to rejuvenate such sources by purification and their utilitarian values.

Materials and Methods

Hydrological profile:

Model lake: The Perumal lake, spread over an area of 500

acres, selected as a model water body for the present investigation, is a natural perennial lake located near Kullanchawadi, Cuddalore, Tamil Nadu. The bottom of the lake is composed of 40% sand, 20% silt and dead planktonic organisms, fishes and other wind blown materials. Perumal lake is a community lake and constitutes as a major water resource for agriculture and fishing activities. Perumal lake is located at Cuddalore, 210 Km from the laboratory, Chennai. Two stations, station I facing northern side and station II facing southern side were selected for the present study.

Collection of water samples: The present study was carried out over a period of one year from January 1st 1999 to 31st December 1999. Water sampling was carried out in early hr of the morning on a bimonthly basis through out the study period at two stations. Generally 2 litres of water sample in 2.5 litre polythene can is sufficient for most of the physical and chemical examinations.

Sample preservation and estimation: Collected samples were kept in dark at low temperature as it is the best possible preservation. For the estimation of dissolved oxygen content the sample of water was fixed immediately, BOD, the samples were stored at a temperature of 4°C and COD concentrated sulphuric acid was added to bring the pH to about 2 to 3. DO, pH, salinity and free CO₂ were estimated on the same day.

Climatological data: The meteorological data of atmospheric temperature, rainfall and humidity for Cuddalore are presented from the records of the meteorological department, Cuddalore during the observation period of one year (January 1999 to December 1999).

Physical parameters: Physical parameters of water samples estimated include colour, odour, depth, temperature, transparency and turbidity.

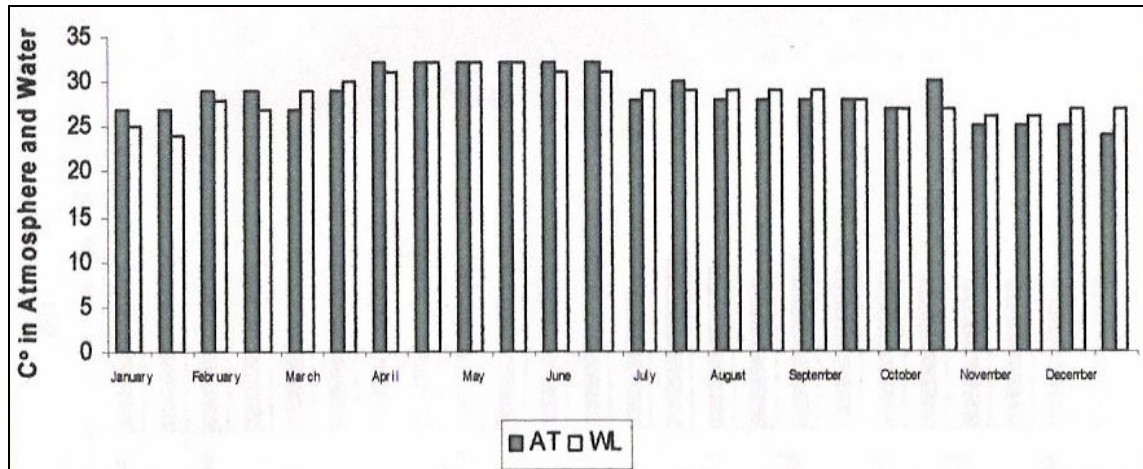


Fig. 1: Climatological parameter viz., temperature during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

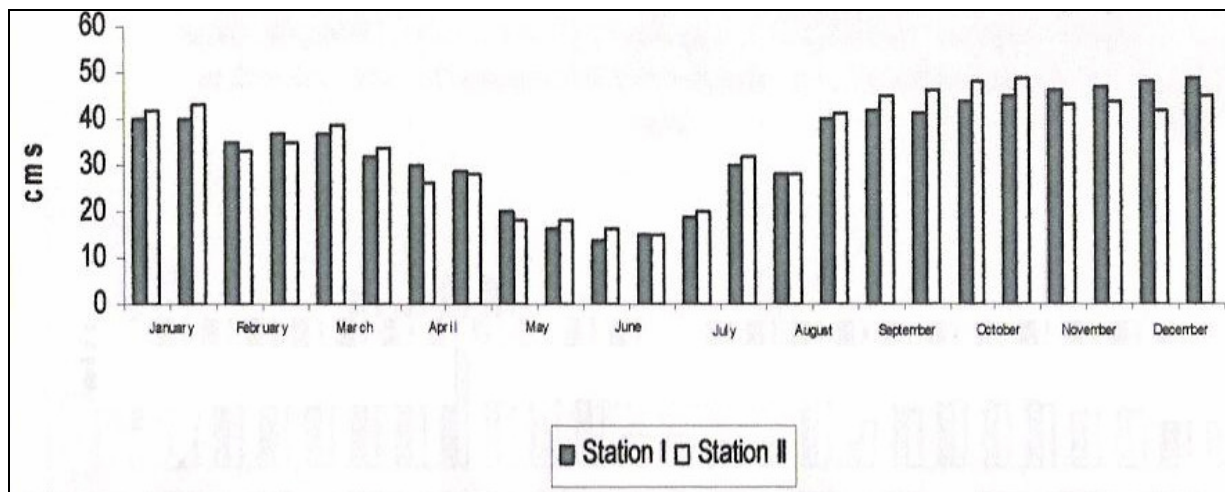


Fig. 2: Physical parameter viz., transparency during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

Total dissolved solids (TDS): TDS is the measure of total contents of both organic and inorganic materials present in the samples. The electrical conductivity of the samples has been measured by conductivity meter 304 of Systronics (P) Ltd.

Chemical parameters determined in the present study include pH, salinity dissolved oxygen Content (DO) and free carbon-dioxide (CO₂) using standard methods (APHA, 1976).

Biotic analysis - Primary productivity: Primary productivity was estimated using 'light and dark bottle method as given in standard methods (APHA, 1976).

Bacteriological studies: At each station, the bacterial density was enumerated using standard plate count and most probable number (MPN) procedure as outlined in standard methods (APHA, 1976). Using a sterile bottle, water samples were collected and bacterial enumeration was carried out within one hour of sample collection.

Planktonic studies: Phyto-and zoo-planktons were sampled by filtering 100 litres of water through plankton net of 32 μ mesh size, concentrating in 100ml and preserving as 4% formalin solution. Identification was done with standard keys (Palmer, 1980) and plankter were enumerated with a sedge-wick rafter counting cell.

Benthos: Using fisherman's net the benthic forms were identified.

Soil analysis: Soil sample analysis was done at Fisheries Department, Research Center, Chetpet, Chennai as per standard methods (APHA, 1981).

Results and Discussion

Hydrological profile – Physicochemical parameters: The range of different physical and chemical parameters are given in the Fig. 2 to 9.

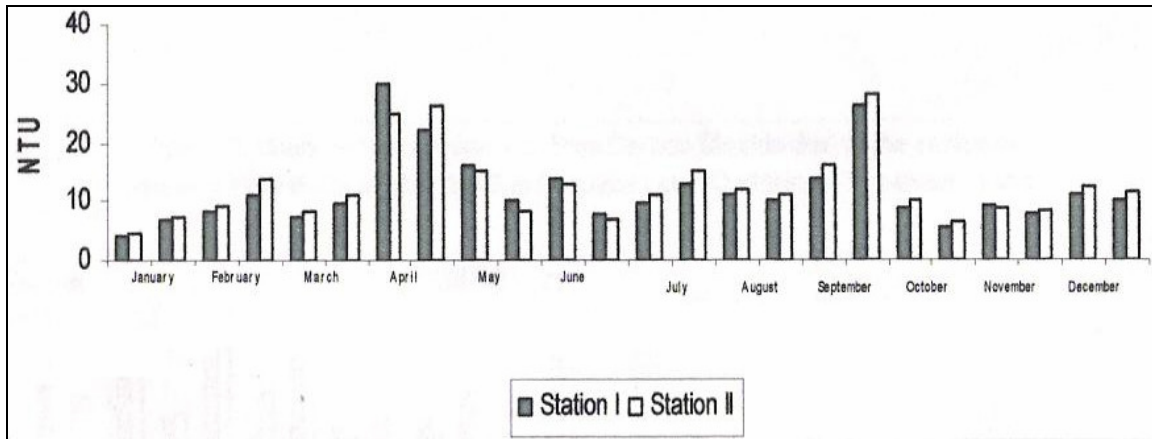


Fig. 3: Physical parameter viz., turbidity during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

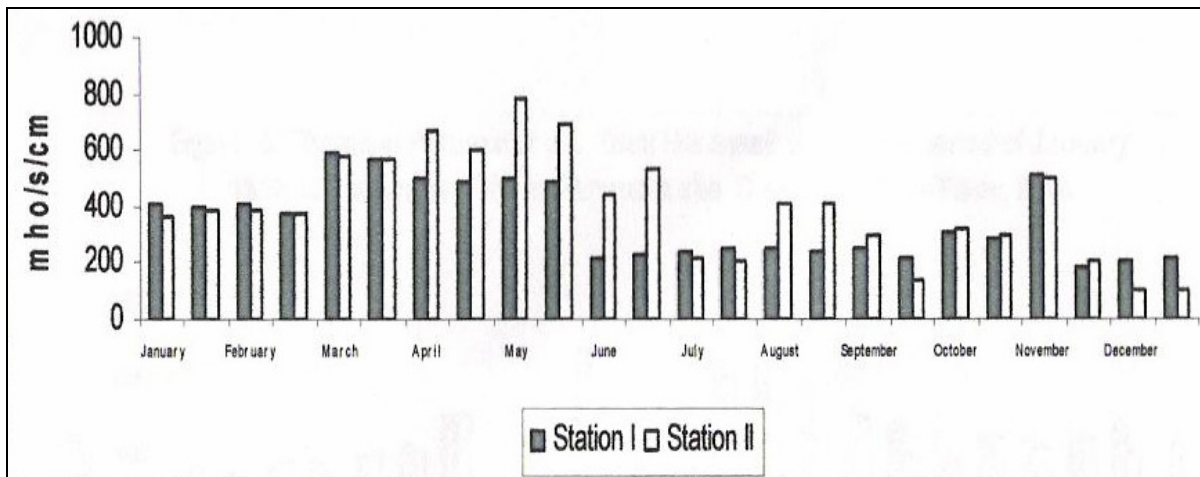


Fig. 4: Physical parameter viz., electrical conductivity during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

Climatological data: Meteorological data for atmospheric temperature, rainfall and humidity of Cuddalore during the observation period of one year (January 1999 to December 1999) are given in the Fig. 1.

Biotic analysis: The primary productivity studies carried out (Fig 11 and 12) revealed both the net productivity values and gross productivity values. The net productivity (NP) values ranged from 140 to 10,225 mg/O₂/m²/day and Gross Productivity (GP) values ranged from 1100 to 12440 at station I. At station II NP ranged from 180 to 814 mg/O₂/m²/day and GP values ranged from 990 to 10220. The monthly samples of water enumerates the presence of bacteria, being highest during the monsoon period (Table 1).

Zooplankter (Table 2): The pelagic micro fauna observed are Cladocerans (*Ceriodaphnia cornuta*; *Daphnia*; *Moina macrura*; *Diaphanosoma excism*), Copepods (*Mesocyclops*), Rotifers (*Brachionus rubens*) and Ostracods (*Naupli* of copepods, *Cypris* sp).

Benthos: The population of the benthos in the Perumal lake includes fishes like *Oreochromis mossambicus*, *Ophiocephalus*, catfish, mullet, *Cyprinus carpio* and freshwater prawn.

Soil analysis: Soil study revealed the following texture of the soil clay (20%), silt (30%) and sand (50%). The soil pH was 8.2%. Soil pH was slightly alkaline in the narrow range of 8.0 to 8.4. Total organic carbon ranged from 1.23 to 3.5%. The other parameters were 21% nitrate, 60% phosphate, 22% potassium and 0.37% sodium.

The present investigation involves the assessment of a model freshwater body (Perumal lake) and its potential towards ecoaquaculture. The above assessment was based on the estimation of various physicochemical characteristics, biotic components and microbial components etc.

The thermal profile as shown in Fig. 1 indicates that the atmospheric and water temperature were higher in the months of April, May and June, initially the surface temperature was

Table – 1: Bacterial enumeration during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
Total Coliform	++	++	++	+++	++	+++	+++	++	++	++	+++	++
Coliform	+	+	+	++	+++	+++	+	++	+++	++	++	++
Streptococci	+	+	++	++	+	+	+	++	+++	+++	+++	++
Escherichia coli	+	+	+	+	+	++	++	++	+	+	+	+
Enterobacter sp.	+++	+++	++	++	++	++	++	+++	++	++	++	++
Aeromonas sp.	+	+	+	+	+	++	++	+	+	+	+	+
Vibrio sp.	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++

+ Present, ++ High, +++ Very High
Total Viable Count (TVC) = 22 X 10⁴ cfu/ml

Table – 2: Zooplankton enumeration during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

Plankton	Jan		Feb		Mar		Apr		May		Jun		Jul		Aug		Sept		Oct		Nov		Dec		
	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	1st	15th	
Cladocera-	+	+	+	+	+	-	+	-	+	+	+++	+++	+++	+++	+++	+++	+	+	+	+	-	-	-	-	
	+	++	++	+	+	-	+	-	+	+	++	+++	+++	+++	+++	++	+	+	+	+	-	-	-	-	
Copepods	+++	+++	++	++	++	++	++	++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+
	++	++	+++	++	++	++	++	++	++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+++	+
Rotifers	-	+	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
	-	-	+	+	+	-	+	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
Ostracods	+	+	-	-	-	+	-	+	-	+	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Others	-	+	+	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	
	+	-	-	-	-	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	+	

+ Present (<100/L), ++ High (>500/L), +++ Very High (>1500/L), - Absent, I Station I, II Station II.

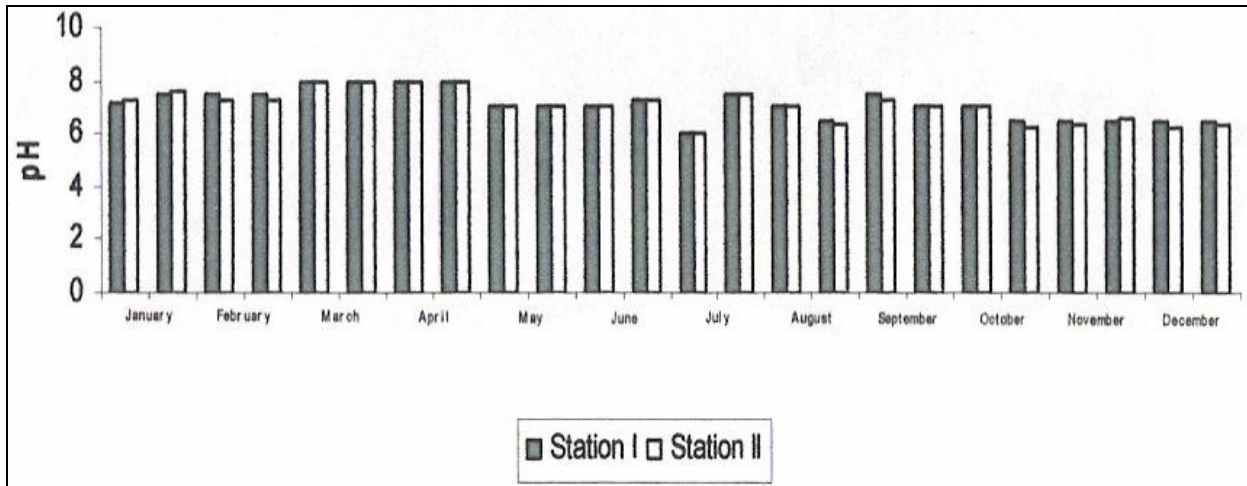


Fig. 5: Chemical parameter viz., pH during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

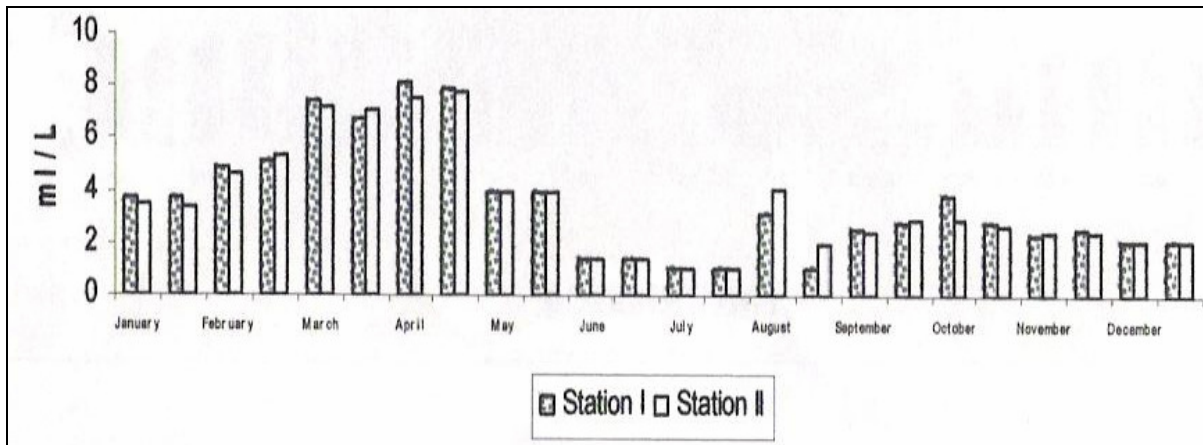


Fig. 6: Chemical parameter viz., dissolved oxygen content during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

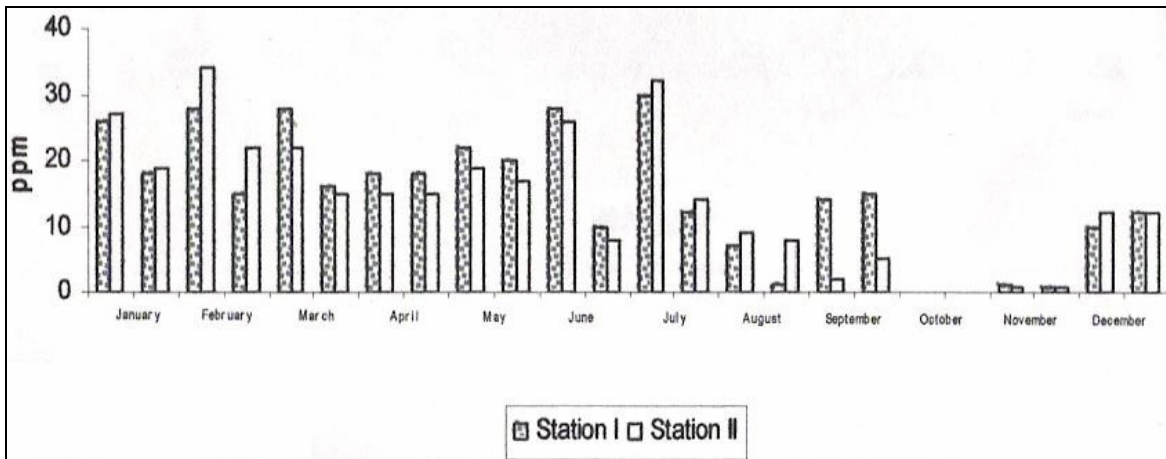


Fig. 7: Chemical parameter viz., free carbon dioxide during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

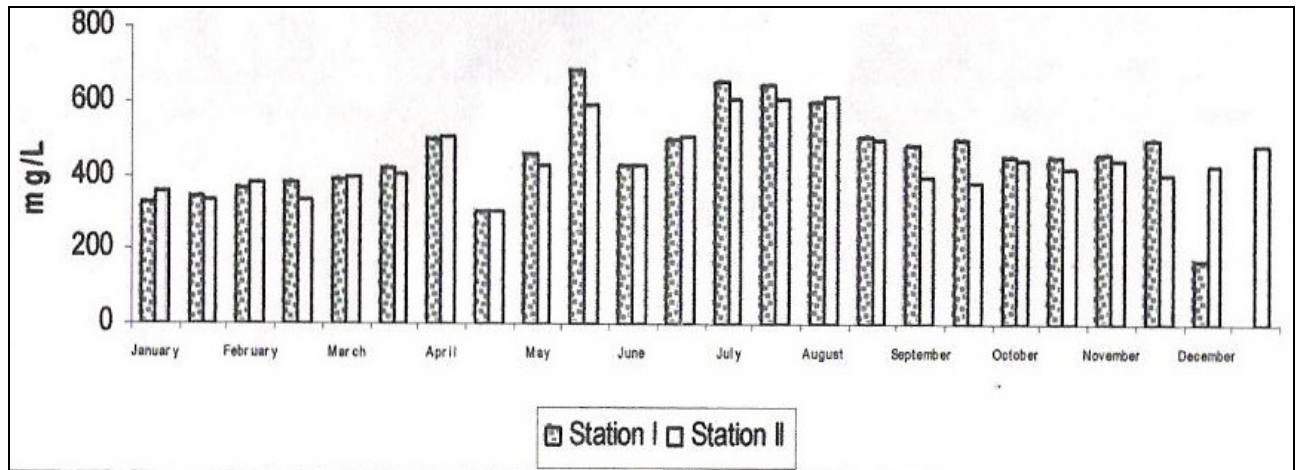


Fig. 8: Chemical parameter viz., total hardness during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

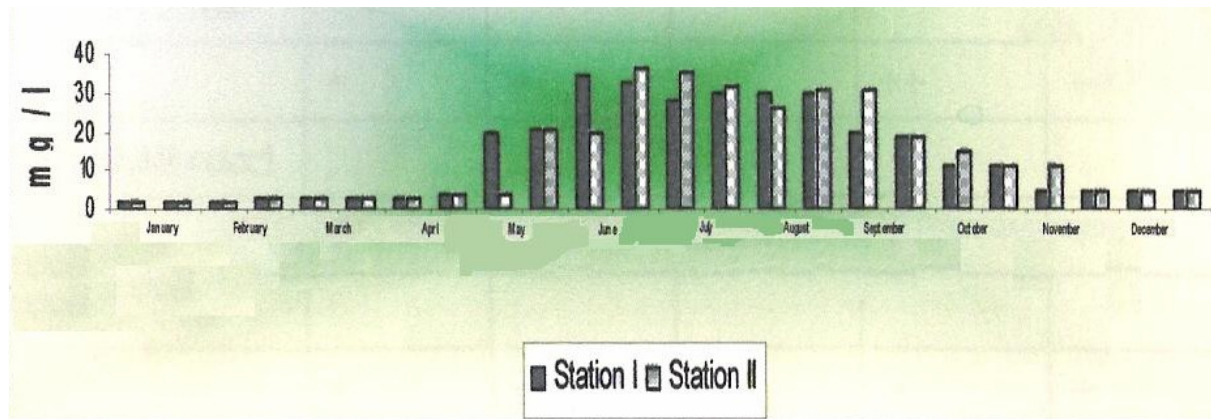


Fig. 9: BOD during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

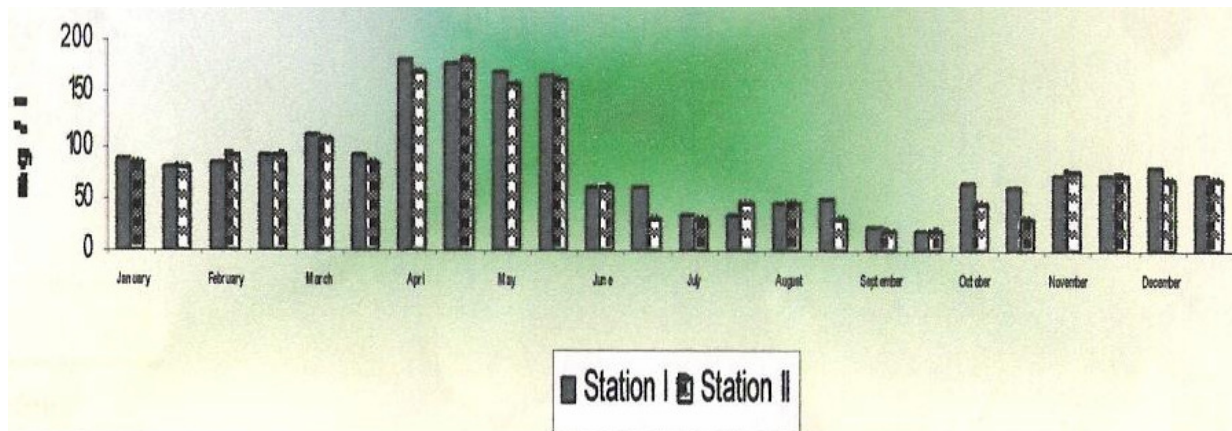


Fig. 10: COD during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India.

higher than that of atmospheric around 6 to 7 am. Temperature was higher in summer while lower in winter. In the present

investigation maximum rainfall was received in the months of July and September and minimum rainfall was received in

August 1999. The maximum rainfall recorded was 22.0mm in July and minimum in August 2.0mm. The physicochemical

parameters of water are important determinants of an aquatic ecosystem although they are greatly influenced and modified by

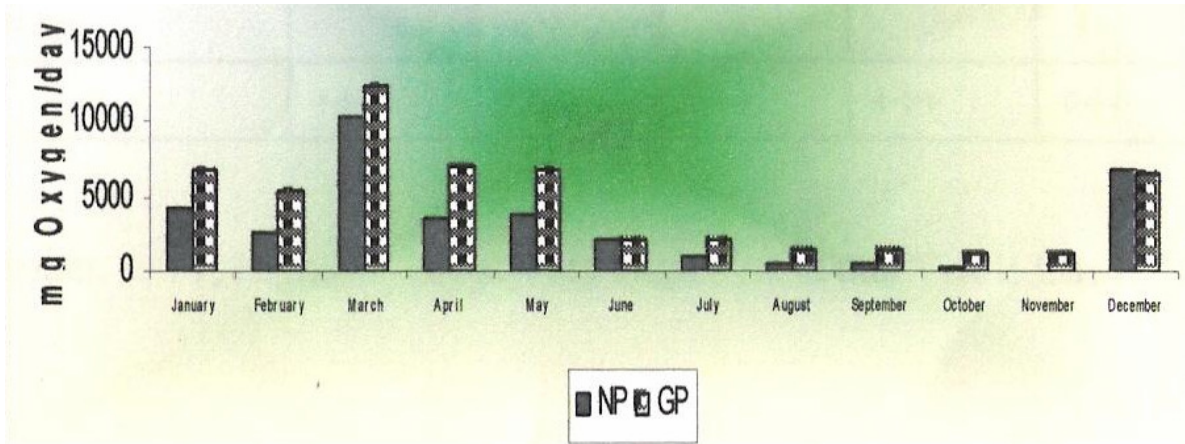


Fig. 11: Net and gross productivity during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India (Station I).

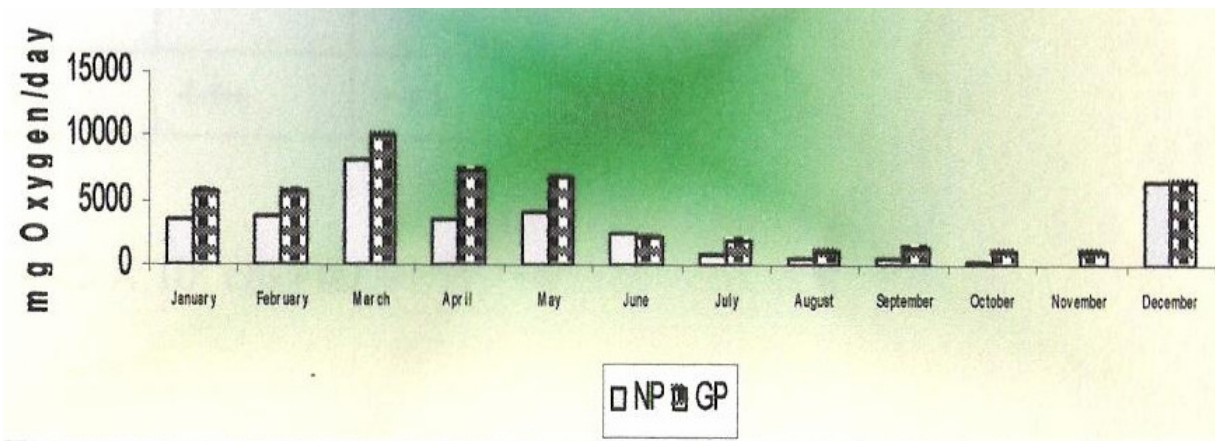


Fig. 12: Net and gross productivity during the period of January 1999 to December 1999 in Perumal lake, Cuddalore, Tamil Nadu, India (Station II).

climate and vegetation (Hutchinson, 1975). In the present investigation maximum humidity was recorded as 99% in July. Suspended materials often limit penetration of light in water. Transparency of water to sunlight can be measured indirectly by measuring the turbidity of water. During the period of investigation a maximum measurement was observed in December at both the stations (49 cm and 45 cm). The transparency values coincide with that of Ganapathi (1953).

The maximum turbidity was noticed during April and September at the sample station respectively. Collection at both the stations revealed that TDS values were within objectionable range (500-1500mg/l).

Conductivity is a numerical expression of the ability of a water sample to carry on electric current. This number depends on the total concentration of the ionized substances, dissolved in the water and the temperature at which the measurement is made. In the present study the ionized

substances showed much variation from 185 to 595 mhos/cm at station I and 105 to 698 mhos/cm at station II.

The low pH value observed during the monsoon months was due to the heavy freshwater inflow into the lake. Water quality of the Perumal lake at the sampling location was neutral to slightly alkaline and falls in the acceptable limits and pH values ranged between 6.5 to 8.0. This indicated that the decomposition of organic matter contributed by inflow waters have not suppressed the pH all along the study area.

Perumal lake has wide variation in DO level (between 1.01 to 8.0) ml/l. Further even in early morning monitoring of water quality, no major deviation in DO level was observed. The low level was noticed in the sites where lushy vegetation and community activities prevailed all the time.

The low level of DO content might be due to the respiratory activity of the fauna and flora of the lake (Odum,

1971). The high level of DO may be attributed to the self purification capacity of flowing water, aquatic plants photosynthetic efficiency and air flow etc. (Hynes, 1970; Singh and Trivedi, 1979). The seasonal changes in the O₂ concentration indicated that the range of fluctuation is moderate. The maximum value was recorded in April 1999 perhaps because of good sunshine and excessive amount of primary production. The low level of DO in water is stressful and benthic organisms may become vulnerable to hypoxia. Such low levels of DO in aquatic ecosystems are common during late summer months (Boyd and Burnett, 1996).

Free CO₂ varied from 0.04 to 28 ppm. Low level of free CO₂ might be either due to its consumption in carbon assimilation or its complete conversion into carbonic acid and ultimately into stable carbonates and bicarbonates.

Alkalinity due to carbonates exists in water system in the form of sodium or calcium compounds (Standard Methods 1976). In the present investigation the total alkalinity ranged from 260 to 600 mg/l. Accumulation of larger quantity of bicarbonates may be due to organic decomposition and depletion in water level.

Total hardness of the Perumal lake represents the total concentration of calcium and magnesium. It is expressed as equivalent to CaCO₃. Total hardness ranged from 168 to 589. Water used for irrigation purpose always contain some of the dissolved constituents (salts) which are the products of weathering and erosion of rocks and dissolution of minerals. The Perumal lake water is used for irrigation. Tidy's test indicates the prevalence of organic pollution. It may be due to sewage or industrial wastes.

BOD indicates the presence of organic load in a water body, the maximum tolerance limit of which is 3ppm for public water. BOD is the amount of oxygen required by the living organisms engaged in the utilization and ultimate destruction or stabilization of the organic matter (Hawkes, 1963). The Royal commission classified the stream having 10mg/l. BOD as bad (Klein, 1957). In the present investigation there was increase in the BOD in May, June, July, August and September at both the stations. The increase may be due to community activities. The high BOD and low DO may indicate the pollution.

COD determination is a measure of the oxygen equivalent of the portion of the organic matter in a sample that is susceptible to oxidation by a strong chemical oxidant. The COD values were higher which might be attributed to the nutrient enrichments, high salinity and sulphate content. In the present study COD values ranged from 34 to 180mg/l at station I and 19 to 180mg/l at station II. COD is an important parameter for stream and industrial waste studies and control of waste treatment plants. In conjunction with the BOD test, the COD test is helpful in indicating toxic condition and the presence of biologically resistant organic substances.

Biotic parameters: In the present investigation, the primary productivity studies were carried at both the stations. The

values of net productivity and gross productivity were estimated. The primary productivity values of the present study have revealed certain high and low values as compared to other freshwater lentic system. Khan and Zutshi (1981) observed the primary productivity in Nilang lake at Kashmir as 375 mg/O₂/m²/day during August. In the present study period the primary productivity showed a maximum productivity as 12440 mg/O₂/m²/day at station II in March 1999 and again a second highest value during March as 10220 mg/O₂/m²/day at station I and 8140 mg/O₂/m²/day at station II.

Bacteriological studies: The occurrence of coliform group, total coliform, faecal coliform, *Escherichia coli*, Enterobacter, Klebsiella, citrobacter and faecal streptococci in aquatic medium has been used as principal ecological indicators of water pollution (Carpenter *et al.*, 1966; Holden, 1970; APHA, 1976; Rodrigue *et al.*, 1977). In the present study, the presence of total coliform, faecal coliform and faecal streptococci, *Escherichia coli*, *Enterobacter* sp., *Aeromonas* sp. and *Vibrio* sp. was established. In the monthly sample collections revealed the occurrence of pollution by the community activities. Generally the water samples showed a highest plate count during the rainy seasons (September to November) as the bacteria are mainly derived from the soil and sewage that gain access to the lake through rain water or storm water. The observations on bacterial species also cautions that the water body is endowed with the species of *Aeromonas* and *Vibrios* an endemic flora which are known to become opportunistic pathogens and could cause fish and shrimp disease. Presence of coliform count in the water sample also point towards pollution of the lake and leads to pathogenic fish diseases.

In the present investigation the zooplankton population was observed throughout the study period though the species composition showed difference over the months.

It is a known fact that the composition of zooplankton vary from lake to lake, depending upon the prevailing hydrological conditions (Davis, 1955). The zooplankton population was comparatively rich in the Perumal lake and was represented by Cladocera, Copepods, Rotifers and Ostracoda.

The soil analysis reveals that it is suitable for aquaculture. The results of hydrological parameters revealed that all the physical, chemical, biological parameters are conforming to the levels suitable for aquaculture activities. In recent years, aquaculture has been found to have a vast potential in providing lively hood security as well as fulfilling the nutritional requirements of the growing population. M.S.Swaminathan Research Foundation at Chennai has envisaged a programme called 'Eco-Aquaculture' whose major concern is to develop a sustainable model in aquaculture. The scopes of the above 'Eco-Aquaculture' include i) unutilisation of local resources, ii) integration of aquaculture components with agricultural activities and iii) development of appropriate production models based on ecological principles etc. (Ramalingam and Ramarani, 2004).

The foundation laid more emphasis on the principles of low external input sustainable aquaculture (LEISA). The foundation has mentioned the freshwater fish as one of major candidate species, suitable for both the mono and poly culture methods of Eco-Aquaculture. The foundation also laid importance to community pond culture in order to enhance the production potential of the ponds. The species of fishes in the above community lake culture include all the major carps such as *Catla catla*, *Labeo rohita* (rohu), *Cirrhina mrigala* (mrigal) and exotic carps such as silver carp, common carp along side with the freshwater prawns. The above survey revealed that the lake is suitable for fish culture and the carps have already been found growing naturally in this lake. Thus it is emphasized that their productivity could be enhanced if they are managed scientifically since the limnological factors are congenial.

With the current estimate and enumeration of about 40,000 community ponds and lakes available throughout Tamil Nadu, the potential of these widespread water bodies in this state towards the promotion of polyculture seem to be immense. In this context, the observations of the present study on the model Perumal lake selected for study reveals 1) The various hydro-ecological parameters measured seemed to conform to the levels, which are best suited for the freshwater fish culture, 2) the observations also reveal that the 'Model lake' represents a self-sustainable water body, and the survey in it revealed that the water system showed high levels of primary productivity ranging from 12820 to 14410 mg/O₂/m²/day, which is unique and common feature in all tropical biotopes and 3) zooplankton population revealed the different species namely copepods, ostracodes, rotifers and cladocerans. Their abundance and availability reveal their importance in fish culture, as they formed the natural feed for the culture species.

However, in recent years, the ornamental fish culture in Cuddalore has been taken in a large scale as a commercial venture in some localities. The culturists have been exploiting the above natural zooplankton feeds available from the natural ponds and lake habitats. The unprecedented harvesting of these zooplankton populations would no doubt deplete the above species and may disrupt the natural food-chain linkage. Such practices may also have adverse consequences leading to the growth of the unwanted and unwarranted biopathogenic microbial populations.

Ponds and lakes are considered as natural ecological resources. The managements of such ponds have become the need of the hour as community activities and other sources of pollution as enumerated in the present study can alter their hydrological characteristics.

1. The community activities such as bathing, cleaning the house hold activities, washing the livestock animals, using them for laboratory purposes will increase the nutrient organic load.

2. Besides depending upon the topography, ponds and lakes have several inlets for filling water during rainy seasons. Storm

water through rains, is not a purified one. Similarly, the runoff water from the adjoining soils is also not without contaminants. Generally such runoff water carry pesticides and fertilizers from the top layers.

3. Location of housing facilities without proper drainage facilities will result in letting out sewage in the open. Sewage being a rich source of organic and inorganic contaminants, when reach the water bodies through the inlets may cause heavy contamination. Moreover sewage is an ideal medium for the endogenous pathogens like viruses, bacteria and microparasites. Coliform bacteria and *E.coli* are very common forms in sewage. When such forms reach the water sources through sewage, it will affect the health of animals and human life.

4. When metallurgical industries were to be established around the water sources, their effluents become a rich source of heavy metal contamination.

The enrichment of ponds and lakes with PO₄ and NO₃ will result in enhancement of weeds and algae. The later bioaccumulate the heavy metals and xenobiotic pesticides. The herbivorous fauna will in turn bioaccumulate the above to a deleterious level. The consumption of such fishes grown in such nearly eutrophicated ponds will cause health disturbances to human. When contaminations are unchecked, the water source may reach derelict stage, whereby the whole ecosystem becomes unfit for either augmentation of fishery culture activities or for human consumption. Considering the need and amount of water supply for the ever expanding human population, and also taking in view of the freshwater budget, these water bodies seem to be the future resources which are in need of strict management and bioremediation activities.

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