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Research Article

Limnological Studies of Kodaikanal Lake (Dindugal District), in Special Reference to Phytoplankton Diversity

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ABSTRACT

The present paper deals with the assessment of water quality and phytoplankton diversity of Kodaikanal lake. The lake was monitored for a period of one year (October 2008 to September 2009). In the present investigation a total of 75 species of algae were reported in which 43 species belongs to Chlorophyta, 14 species to Cyanophyta, 13 species to Bacillariophyta, 2 species to Euglenophyta, 2 species to Pyrrophyta and one species to Chrysophyta. The phytoplankton was found to be abundant during southwest monsoon, declined during summer and again increased during winter season. The most pollution tolerant species were *Ankistrodesmus, Scenedesmus, Closterium, Microcystis, Crucigenia, Chroococcus, Merismopedia, Synedra* and *Fragillaria*. Higher pH values (7.5± 0.01), low oxygen level (4.2 mg/l), maximum BOD levels (18.46± 0.35 mg/l) were observed during summer season. Algal blooms of *Navicula cuspidata* and *Microcystis aeruginosa* were reported during March.

Key Words: Phytoplankton, assessment, abundance, species diversity.

INTRODUCTION

Lakes, rivers and reservoirs are most important water resources and used for several purposes. Kodaikanal is one of the most important tourist place, which is situated in Tamil Nadu, India between 10º 13'50" N and 77º28'07"E at an altitude of about 2285 meters and covers an area of 21.45km^2 including a man made lake which spreads out in a star shaped body covering 25 hectares of area. The lake is used for boating, fishing and other human activities. It receives sewage, agricultural run off and contaminated water sources from the neighboring lands. Almost in all the months the water looks green by the abundant growth of algae. Algae are the most abundant predominant members in all fresh water environments and the water quality is assessed by the physico-chemical and biological parameters. Much work has been carried out throughout India regarding the diversity and water quality (Gowd and Kotaih, 2000; Shastri and Pendse, 2001; Shanthi *et al.,* 2002; Sharma and Lyngdon, 2003; Sankaran, 2005; Rajkumar *et al.,* 2006; Gose and Pingale, 2007; Murugan, 2008; Jawale and Patil, 2009 and Manimegalai *et al.,* 2010). The present investigation is focused to assess the water quality of Kodaikanal lake with special reference to phytoplankton diversity.

MATERIALS AND METHODS

a. Physico-chemical parameters

Water samples were collected monthly for the analysis of pH (pH meter), temperature (0º Celsius thermometer), dissolved oxygen and BOD (Wrinkler's titration method), Calcium, Magnesium, Nitrate, Phosphate, Sulphate and Chloride (APHA, 1998).

b. Phytoplankton Analysis

Water samples from the lake was collected between 7 – 9 A.M using phytoplankton net (No.25) and fixed in 4% formaldehyde, with the help of relevant literatures they were identified (Desikachary, 1959; Philipose, 1962; Fritsch, 1977; Prescott, 1978 and Anand, 1980).

RESULT AND DISCUSSION

The results on the seasonal variation of pH, temperature, DO, BOD, NO_3, PO_4, Ca, Cl and Mg are reported in the Table.1. The temperature ranged from a minimum mean of 13.75± 0.35 during winter season to the maximum of 17.57± 1.07 during summer. In February the temperature remained low (13.5ºC) and reached maximum of 18.5ºC during May. Temperature plays a major role in determining the diversity, productivity and periodicity of algae (Sedamkar and Angadi, 2003). Similar variation in water temperature was noticed by the earlier workers in lakes (Iwona and Lowri, 2003; Kumavat and Jawale, 2004; Sharma and Sharang, 2004; Rajkumar *et al.*, 2006).

PH is one of the most important single factor which influences aquatic production. In the present study pH value of the lake remains alkaline throughout the study period and it was from 6.1 in September to 7.8 in May. The mean values were minimum in winter

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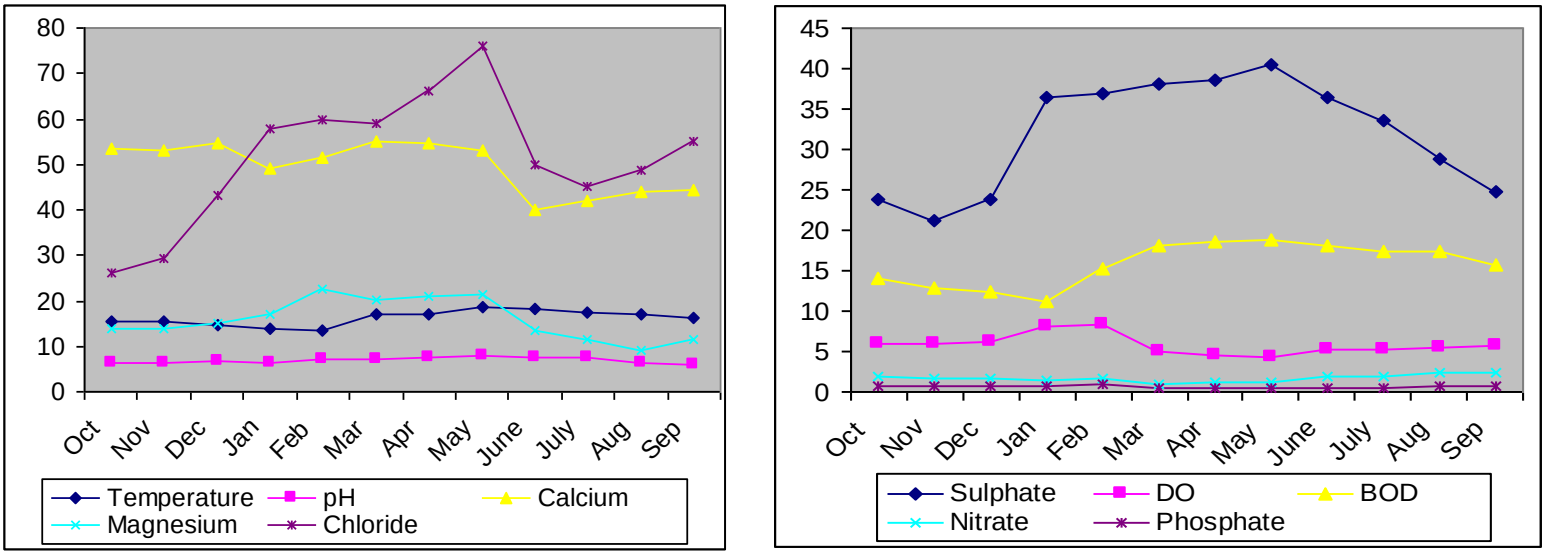

a **b**

Figure 1: (a & b): Monthly variations of indicated physico-chemical parameters of Kodaikanal lake during the study period (Oct 2008 to Sep 2009)

Table 1: Physico-chemical parameters of Kodaikanal lake water during the study period (October 2008 to September 2009)

Parameters	N.E.M	Winter	Summer	S.W.M
Temperature (C°)	15.3 ± 0.43	13.75 ± 0.35	17.57 ± 1.07	17.3 ± 0.77
pH	6.37 ± 0.2	6.8 ± 0.28	7.5 ± 0.3	6.92 ± 0.75
Calcium (mg/l)	53.7 ± 0.96	50.4 ± 1.70	54.23 ± 0.91	42.57 ± 2.01
Magnesium (mg/l)	14.26 ± 0.64	19.8 ± 3.68	20.86 ± 0.60	11.4 ± 1.76
Chloride (mg/l)	32.83 ± 8.97	59.0 ± 1.41	64.0 ± 13.11	54.48 ± 10.72
Sulphate (mg/l)	22.86 ± 1.53	36.6 ± 0.28	39.0 ± 1.32	30.95 ± 5.16
DO (mg/l)	6.03 ± 0.15	8.2 ± 0.14	4.57 ± 0.35	5.40 ± 0.21
BOD (mg/l)	13.13 ± 0.77	13.25 ± 2.89	18.46 ± 0.35	17.17 ± 1.06
Nitrate (mg/l)	1.72 ± 0.12	1.52 ± 0.08	1.05 ± 0.17	2.14 ± 0.29
Phosphate (mg/l)	0.67 ± 0.06	0.82 ± 0.03	0.41 ± 0.04	0.57 ± 0.06

N.E.M – Northeast monsoon; S.W.M – Southwest monsoon

Table 2: Algae recorded in the study area (Oct 2008 to Sep 2009)

Name of the Algae	N.E.M	Winter	Summer	S.W.M
Chlorophyta				
**Ankistrodesmus falcatus* (Corda) Ralfs	++	+	-	++
A. convolutes Corda	+	-	-	++
A. spiralis (Turn.) Lemm.	+	-	-	+
Bulbochaete sp	+	-	-	++
Closterium kuetzingii Breb.	+	-	-	+
C. littorale Gay.	-	+	+	++
**C. parvulum* Nag.	+	-	+	++
Coloeochaete sp	-	-	-	++
Cosmarium obsoletum (Hant.) Rein.	++	-	-	+
C. moniliforme (Turpin) Ralfs	-	+	-	+++
**Crucigenia tetrapedia* Kirchner	+	+	-	++
Dactylococcopsis fascicularis Lemm.	+	-	-	+
Desmidium bengalicum W.B. Turner	+	-	-	++
Dictyosphaerium sp	+	-	-	+
Gleocystis sp	++	-	-	+
Hyalotheca sp		+	-	+
**Kirchneriella lunaris* (Kirchner) Moeb.	+	-	+	++
Micrasterias sp	++	+	+	+++
Netrium digitus (Ehr.) Itz. And Roth	-	-	-	++
Oedogonium sp	-	+	-	+
Pandorina sp	+	-	-	+
Pediastrum tetras (Ehr.) Ralfs	++	+	++	+++
P.duplex Meyen	++	-	-	+++
P. ovatum (Ehr.) A. Braun	+	-	-	++
**P.simplex* Meyen	-	-	-	+
Pleurotaenium ehrenbergii (Breb.)de Bary	++	+	-	++
P. trabecula (Her.) Naeg.	++	-	-	+
**Scenedesmus quadricauda* (Turpin) Breb.	+	+	++	+++
S. bijugatus (Turp.) Kutz.	-	-	-	++
S. dimorphus Kutz.	+	+	+	+++
S. muzzanensis Huber - Pestalozzi	++	-	-	+
S. obliquus (Turp.) Kutz.	-	+	-	+++
S. perforatus Lemm.	++	-	+	++
Spirogyra sp	-	-	-	+
Straurastrum aequum W.B.Turner	+	+	+	+++
S. convolutum (Corda) Rabenh	-	+	-	+++
S. egregium West and G.S. West	-	-	-	++
S. pinnatum Turner	+	-	-	+++
S. recurvatum Turner	-	-	+	++

S. santhalianum W.B. Turner	++	-	-	+
Terallantos sp	-	-	+	++
Tetraedron gracile (Reinsch) Hang.	++	+	-	++
T. limneticum Borge	-	-	+	+
Cyanophyta				
Anabaena sp	++	+	++	-
Aphanocapsa sp	-	-	++	-
Calothrix sp	+	+	++	-
**Chroococcus tenax* (Kirch.) Hieron	-	-	+++	+
**Merismopedia elegans* A. Br.	++	-	++	-
M. glauca (*P. trabecula* (Ehrenb.) Nag.	-	-	+	-
**Microcystis aeruginosa* Kutz.	++	-	+++	-
Microcystis sp	++	+	++	-
**Oscillatoria subbrevis* Kutz.	-	-	+	-
Spirulina sp	+	-	+	-
Synechococcus elongates Nag.	++	-	+++	-
Synechocystis aquatilis Sauv.	++	-	++	-
Synecocystis crassa Woronich	++	+	++	-
Bacillariophyta				
Amphora ovalis Kuetz.	+	+	+++	++
Aulacoseira granulata (Ehr.) Simonsen	-	+	+++	+
Cyclotella meneghiniana Kutz.	-	+	++	++
Cymbella sp	+	-	++	-
Eunotia lunaris (Ehr.) Grun.	++	-	-	-
**Fragillaria* sp	-	-	++	-
Gomphonema lanceolatum Ehr.	+	+	++	+
Melosira granulata Ehr. Ralfs	+	-	++	-
**Navicula cuspidata* Kutz.	+	-	+++	-
Nitzchia sp	-	+	++	+
Pinnularia graciloides Hust.	-	-	++	+
**Synedra ulna* (Nitz.) Ehr.	-	-	++	++
Tabellaria fenestrate (Lyngb.) Kutz.	+	-	+++	-
Euglenophyta				
**Phacus* sp	+	-	+++	++
**Trachelomonas* sp	+	-	++	+
Pyrrophyta				
Ceratium sp	+++	+	+	++
Peridinium sp	+++	+	+	++
Chrysophyta				
Dinobryon sp	+	+++	++	-

N.E.M – Northeast monsoon; S.W.M – Southwest monsoon
*+++ = Abundant; ++ = Dominant; + = Rare; - Absent; * - Pollution indicator*

(13.75± 0.35) and maximum (17.57 ± 1.07) in summer. PH is an important parameter in water body since most of the aquatic organisms are adapted to an average pH and do not withstand abrupt changes (Mini *et al.*, 2003). Variation of pH reflects the exchange of nutrients between sediment and water. The maximum PH 7.8 in the present study coincides with the observation of Pandey *et al.*, (2004), Mane and Deshmukh, (2008) and Manimegalai et al., (2010).

Calcium and Magnesium was the dominant cations in the aquatic ecosystem. Calcium concentration was minimum of 40mg/l to the maximum of 54.9mg/l and the magnesium concentration of the present study is ranged from 9.2mg/l to 22.4mg/l. During December and February months Calcium and Magnesium concentrations reached maximum, it may be due to the high temperatures, low water level and additional amount of detergents added by human bathing, washing and by domestic waste into the waters. The present observation is in line with the reports of Kumar *et al.*, (2006). The Chlorides occurs naturally in all types of water and waste water forming a major inorganic anion. In the present study the values ranged from a minimum of 32.83± 9.91 during northeast monsoon to the maximum of 64± 13.11 during summer seasons. In this lake sewage waste was mixed and is responsible for the increasing chloride content and it determines the water quality. In several fresh water ecosystem hardness of water increased due to washing of cloths, agricultural run off and automobile cleaning (Mohanta and Potra, 2000; Mishra *et al.*, 2005). The amount of phosphate during the sampling period was from 0.38mg/l (March) to 0.85mg/l (February) with the mean value of 0.82 ± 0.035. The increased PO_4 was mainly by flood washing and mixing of fertilizers from near by the agricultural land and it was also reported by Sharma and Shrang (2004). Phosphate is a major nutrient regarding the growth and production of phytoplankton and its concentration can be used to predict the total biomass of phytoplankton (Jacob *et al.*, 2008). Increased PO_4 concentration also produced eutrophication and bloom formation (Khan and Siddique, 1974). In February the percentage contribution of phytoplankton reached maximum (64.89%) which is related to the phosphate concentration of the lake.

The dissolved oxygen concentration of the lake reached maximum of 8.3mg/l during January and remained low in May (4.2mg/l). This may be due to the discharge of huge quantities of waste water accompanied by increasing inorganic matter and the results are inconsistency with the earlier reports of Sanap *et al.*, (2008). Oxygen can be used as a pulse of the aquatic ecosystem. The increased BOD level in the lake (18.8mg/l) indicates the degradation of organic matters by the microbes thereby reducing the oxygen content in the lake and the same was previously observed by Trivedi and Goel (1990) in the Veli lake.

A total of 75 species of phytoplankton were identified from the lake. Among them 23 genera 43 species belonged to Chlorophyta, 9 genera with 14 species to Cyanophyta, 13 genera with 13 species to Bacillariophyta, 2 species to Euglenophyta, 2 species to Pyrrophyta and only one species to Chrysophyta (Table.2) were reported. The higher concentration of effluents and low water level in the lake, indirectly increases the phosphate and nitrates concentrations there by increasing the growth of phytoplankton. Algae like *Ankistrodesmus falcatus,Scenedesmus, Closterium, Crucigenia tetrapedia, Kirchneriella lunaris, Pediastrum simplex, Chroococcus, Merismopedia, Oscillatoria, Navicula, Fragillaria, Synedra, Phacas* and *Trachelomonas* were reported as pollution indicators. Six algal groups were observed and the occurence of distribution is in the decreasing order Chlorophyta> Cyanophyta> Bacillariophyta > Euglenophyta / Pyrrophyta and Chrysophyta.

Chlorophyta was represented by maximum number of genus and the algae like *Scenedesmus, Cosmarium, Pediastrum, Straurastrum* and *Microsterias* were the dominant forms collected throughout the study period. The second dominant group was Cyanophyta in which species of *Microcystis, Synechococcus* and *Chroococcus* were dominant forms. Among Bacillariophyta *Aulacoseira, Navicula, Pinnularia* and *Tabellaria* were the dominant forms collected from the lake.

Phacus is the common species of Euglenophyta collected almost in all the months. The Chrysophyta and Pyrrophyta members were observed frequently. The phytoplankton members were maximum in summer season and the lake looks dark green. During summer the temperature, pH and light intensity were high resulting in higher biomass of green algae. Murugesan and Sivasubramanian (2008) has also reported the enhanced growth of chlorophyta especially the Volvocales members during summer in Porur lake.

From the study it can be concluded that Kodaikanal Lake is polluted and luxuriously blessed with chlorophycean members.

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