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CYANOBACTERIAL BIODIVERSITY FROM DIFFERENT FRESHWATER PONDS OF THANJAVUR, TAMILNADU (INDIA)

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ABSTRACT. *Cyanobacterial biodiversity from different freshwater ponds of Thanjavur, Tamilnadu (India).* Studies on the cyanobacterial biodiversity of 5 different freshwater ponds in and around Thanjavur, Tamilnadu during summer month (June, 2004) has been made and compared their variations among five different ponds. In addition, certain physico-chemical parameters of pond waters such as dissolved oxygen, net productivity, pH, carbonate, bicarbonate, nitrate, nitrite, total phosphorus, inorganic phosphorus etc. were also analyzed and statistically compared with the cyanobacterial diversity. Totally 39 species of 20 genera of cyanobacteria were recorded in all 5 different ponds. Only 6 species of cyanobacteria were identified in Pond 1 (Dabeerkulam), where a massive bloom of *Microcystis aeruginosa* was recorded, which had a significant effect in reducing the other cyanobacterial population. As many as five species namely *Aphanothece microscopica, Synechocystis aquatilis, Merismopedia glauca, Oscillatoria limnetica* and *O. subbrevis* were common in all the ponds surveyed except in Pond 1.

Key words. Biodiversity, ecosystem, cyanobacteria, *Oscillatoria*, *Microcystis.*

RESUMEN. *Biodiversidad de cianobacterias en diferentes charcas de agua dulce de Thanjavur, Tamilnadu (India).* Se ha inventariado, y comparado entre sí, la biodiversidad de cianobacterias de 5 charcas de agua dulce de Thanjavur, Tamilnadu (India); el estudio se llevó a cabo en junio de 2004. En paralelo, también se determinaron los valores de ciertos parámetros físico-químicos que podrían explicar las variaciones en los valores de biodiversidad: oxígeno disuelto, productividad neta, pH, carbonato, bicarbonato, nitrato, nitrito, fósforo total, fósforo inorgánico, etc. Un total de 39 especies de 20 géneros de cianobacterias se identificaron entre las 5 charcas. En la charca 1 (Dabeerkulam) se detectaron 6 especies, pero cuando tuvo lugar una flor de agua de *Microcystis aeruginosa* las restantes especies apenas se pudieron detectar. Cinco especies (*Aphanothece microscopica*, *Synechocystis aquatilis*, *Merismopedia glauca*, *Oscillatoria limnetica* y *O. subbrevis* fueron comunes en todas las charcas con excepción de la número 1.

Palabras clave. Biodiversidad, cianobacterias, ecosistema, *Oscillatoria, Microcystis*.

INTRODUCTION

Cyanobacteria (blue-green algae) are capable of both carbon assimilation and N_2 fixation, thereby enhancing productivity in variety of environments. Apart from fixing atmospheric N_2, they secrete a number of biologically active substances. Tropical conditions such as those in India provide favourable environment for the luxuriant growth of these organisms in the natural ecosystems such as different types of soil, freshwater bodies, oceans, saline backwaters, estuaries, and also hyper saline saltpans (Subbaramaiah, 1972; Srivastava & Odhwani, 1992; Thajuddin & Subramanian, 1992; Thajuddin *et al.* 2002; Rajkumar, 2004 and Chellappa *et al.* 2004).

Cyanobacteria, until recently in oblivion, uncared for and unrecognized, have shot into fame and popularity owing to a host of their innate properties that make them ideal organisms for use in a variety of ways to meet our needs and to promise us a bright future (Thajuddin and Subramanian, 2005). Besides their ecological significance, offer a grate potential tool as an organisms for the biotechnological interest such as mariculture, food, feed, fuel, fertilizer, medicine and combating pollution (De, 1939; Mitsui *et al.* 1981; Venkataraman 1981, Venkataraman, 1983; Kannaiyan, 1985; Borowitzka, 1988; Gustafson *et al.*, 1989; Prabaharan & Subramanian, 1995; Subramanian & Uma, 1996). The present work was carried out to understand the diversity of cyanobacteria from five different freshwater ponds of Thanjavur District, Tamilnadu as an initiative study for exploiting their innate potentials.

MATERIAL AND METHODS

Study area and sampling

Thanjavur is located in the centre-east of Tamil Nadu state, India (Lat. 10°47' N; Long. 79°10' N). Thanjavur district occupies 3,205 sq miles [8,300 sq km] in area in the part of flat, fertile Cauvery Delta region, which is one of the most important rice-growing areas in India. There are several natural and artificial (temple) fresh water ponds are distributed more frequently in and

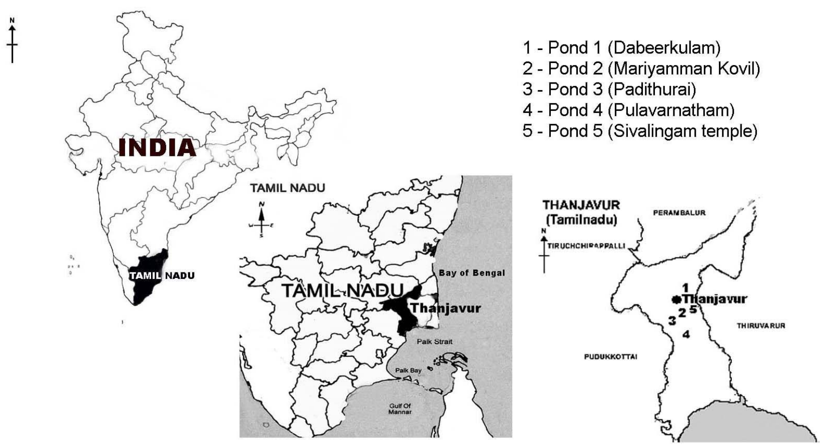

Fig. 1. Map showing the locations of 5 different ponds in Thanjavur. *Localización geográfica de las 5 charcas en Thanjavur.*

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S.No.	Name of the isolates	Sampling Stations				
		Pond 1	Pond 2	Pond 3	Pond 4	Pond 5
1.	*Microcystis aeruginosa* Kütz	+	+	-	-	-
2.	*Aphanothece microscopica* Näg*	-	+	+	+	+
3.	*Chroococcus turgidus* (Kütz.)Näg	-	+	-	+	-
4.	*Chroococcus minutus* (Kütz.)Näg*	-	-	+	+	-
5.	*Gloeocapsa stegophila* (Itzigs.) Rabenh*	-	+	-	-	+
6.	*Gloeothece samoensis* Wille	-	-	+	-	-
7.	*Synechococcus elongatus* Näg	+	-	+	+	-
8.	*Synechocystis aquatilis* Sauv.*	-	+	+	+	+
9.	*Myxosarcina concinna* Printz	-	+	-	+	+
10.	*Dermocarpa leibleinea* (Reinsch)Born.et Thur.	-	-	-	+	-
11.	*Merismopedia glauca* (Ehrenb.) Näg.	-	+	+	+	+
12.	*Spirulina subsalsa* Oerst.ex Gomont	-	-	+	+	-
13.	*Spirulina labyrinthiformis* (Menegh.) Gomont	+	+	+	+	-
14.	*Spirulina meneghiniana* Zanard.	+	-	+	-	-
15.	*Oscillatoria curviceps* Ag.ex Gomont*	-	+	-	-	-
16.	*Oscillatoria subbrevis* Schemidle*	+	+	+	+	+
17.	*Oscillatoria pseudogeminata* Schmid	-	+	+	-	-
18.	*Oscillatoria tenuis* Ag. Ex Gomont	+	+	-	-	-
19.	*Oscillatoria earlei* Gardner	-	-	+	+	+
20.	*Oscillatoria formosa* Bory ex Gomont	-	+	-	-	-
21.	*Oscillatoria brevis* (Kütz.) Gomont	-	+	+	-	-
22.	*Oscillatoria boryana* Bory ex Gomont	-	-	+	-	-
23.	*Oscillatoria limnetica* Lemm.	-	+	+	+	+
24.	*Oscillatoria amphibia* Ag.ex Gomont	-	+	+	-	-
25.	*Phormidium tenue* (Menegh.) Gomont	-	+	+	+	+
26.	*Phormidium corium* (Ag.) Gomont	-	-	+	+	-
27.	*Phormidium fragile* (Menegh.) Gomont	-	+	+	-	-
28.	*Phormidium molle* (Kütz.)Gomont	-	+	-	-	-
29.	*Lyngbya martensiana* Menegh.ex Gomont	-	+	+	-	+
30.	*Lyngbya ceylanica* Wille	-	+	-	+	-
31.	*Lyngbya allorgei* Fremy	-	-	+	-	-
32.	*Lyngbya lutea* (Ag.) Gom.	-	-	+	-	-
33.	*Schizothrix* sp.	-	+	-	-	+
34.	*Calothrix brevissima* West,G.S.	-	-	+	+	-
35.	*Calothrix* sp.	-	+	-	-	-
36.	*Scytonema* sp.	-	+	+	-	+
37.	*Plectonema* sp.	-	+	-	-	+
38.	*Nostoc carneum* Ag. ex Born. et Flah	-	-	+	+	-
39.	*Anabaena* sp.	-	-	+	-	-
	Total number of species/genera	6/4	25/15	26/14	18/13	13/11

Table 1. Diversity of Cyanobacteria in different fresh water ponds of Thanjavur. +: present; -: not recorded. Pond 1: Dabeerkulam; Pond 2; Mariyamman Kovil; Pond 3: Padithurai; Pond 4: Pulavarnatham; Pond 5: Sivalingam temple. *Diversidad de cianobacterias 5 charcas de Thanjavur. +: present; -: not recorded. Charca 1: Dabeerkulam; Charca 2: Mariyamman Kovil; Charca 3: Padithurai; Charca 4: Pulavarnatham; Charca 5: templo de Sivalingam.*

around Thanjavur city with seasonal algal blooms.

Visible and planktonic samples were collected from various freshwater ponds in and around Thanjavur during June 2004, namely Pond 1 (Dabeerkulam), Pond 2 (Mariyamman Kovil), Pond 3 (Padithurai near Mariyamman Kovil), Pond 4 (Pulavarnatham) and Pond 5 (Sivalingam temple) (fig. 1) using forceps, knifes and plankton net (mesh size 42µm). Water samples were also taken from each site for analyzing physico-chemical and biological parameters such as plankton, pH, dissolved oxygen, net productivity, alkalinity, nitrate, nitrite, total phosphorous and inorganic phosphorus and by using standard methods (APHA, 1975).

The collected cyanobacterial samples were transferred to conical flasks with BG 11 medium (Rippka *et al.*, 1979). Cyanobacterial specimens were identified using the publications of Geitler, 1932; Desikachary, 1959 and Starmach, 1966. Photomicrography was taken using Leitz Diaplan photomicrographic unit (Germany). The correlation co-efficient analysis was made between physico-chemical properties of water and total cyanobacterial species.

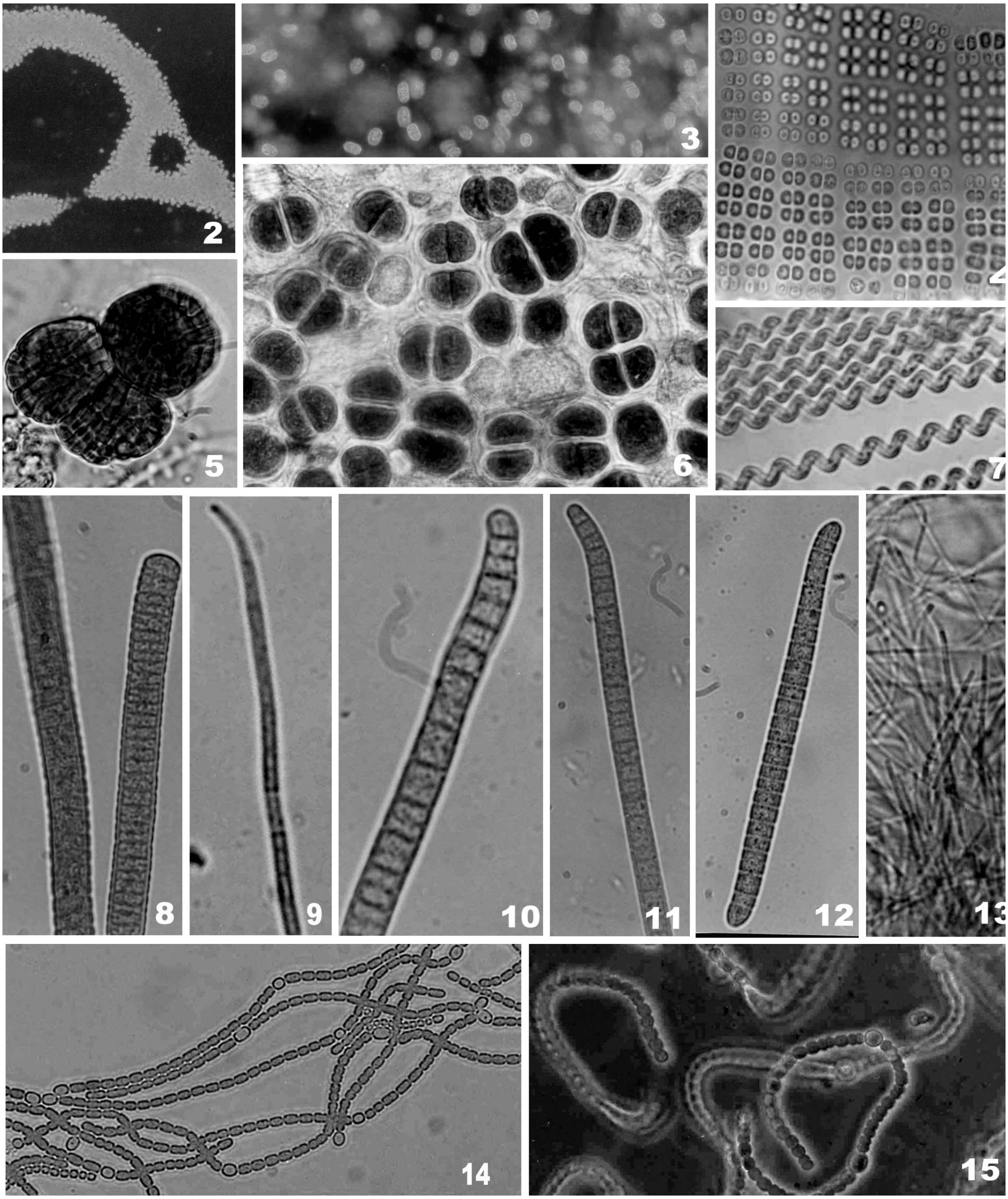
RESULTS

Totally 39 species belongs to 20 genera of cyanobacteria were recorded in all 5 ponds (tab. 1, figs. 2 to 15). Five species of the cyanobacteria viz., *Synechocystis aquatilis, Aphanothece microscopica, Merismopedia glauca, Oscillatoria limnetica***,** and *O. subrevis* were common in all ponds except pond 1, where a massive bloom of *Microcystis aeruginosa* (fig. 2) was recorded. Maximum 26 species of 14 genera were recorded from Pond 3 followed by 25 species belonging from 15 genera, 18 species from 13 genera, 13 species from 11 genera and 6 species from 4 genera in Pond 2, Pond 4, Pond 5 and Pond 1 respectively (tab. 1). As per the diversity and abundance of cyanobacteria, the members of the family Oscillatoriaceae were dominating in most of the ponds surveyed. As many as five species namely *Aphanothece microscopica, Synechocystis aquatilis, Merismopedia glauca, Oscillatoria limnetica* and *O. subbrevis* were common in all the ponds surveyed except in Pond 1.

Physico-chemical analysis of water revealed that the pH range from 6.5 to 7.3, dissolved oxygen from 0.8 to 1.4 mg l^{-1}, net productivity from 0.4 to 0.6 mg $cm^{3-1}l^{-1}$, alkalinity (carbonate from 1.0 to 1.8 mg l^{-1} and bicarbonate from 25.6 to 45.0 mgl^{-1}), nitrate from 5.0 to 9.9 mg l^{-1}, nitrite from 2.6 to 5.5 mg l^{-1}, total phosphorous from 2.6 to 5.7 mg l^{-1} and inorganic phosphorus from 4.2 to 5.5 mg l^{-1} in all the ponds studied (tab. 2). The correlation co-efficient analysis of physico-chemical properties of water samples and total cyanobacterial species revealed that the significant positive correlation between Total Cyanobacterial Species (TCS) and dissolved oxygen ($r=0.9803$; $p<0.01$), TCS and bicarbonate ($r= 0.9928$; $p<0.01$) and TCS and carbonate ($r=0.941$; $p<0.05$) (tab. 3).

DISCUSSION

In any ecosystem, not a single species grows independently and indefinitely, because all the species are interlinked and has cyclic transformation of nutrients. The physicochemical changes in the environment may affect particular species and induce the growth and abundance of other species, which leads to the succession of several species in a course of time. In Pond 1, low diversity of cyanobacteria was attributed to



Figures 2-15 Microphotographs of some cyanobacteria isolated from different fresh water ponds of Thanjavur. 2: *Microcystis aeruginosa;* 3: *Aphanothece microscopica;* 4: *Merismopedia glauca;* 5: *Myxosarcina concinna;* 6: *Chrococcus turgidus;* 7: *Spirulina meneghiniana*; 8: *Oscillatorai subbrevis;* 9: *Oscillatoria earlei;* 10: *Oscillatoria formosa;* 11: *Oscillatoria boryana;*12: *Oscillatoria tenuis*; 13: *Phormidium tenue;* 14: *Anabaena* sp.; 15: *Nostac carneum. Algunas de las cianobacterias aisladas en diferentes charcas de Thanjavur.*

S.No.	Properties	Pond 1	Pond 2	Pond 3	Pond 4	Pond5
1.	pH	7.3	6.5	6.7	6.5	6.8
2.	Dissolved Oxygen (mg l^{-1})	0.8	1.2	1.4	1.2	1.0
3.	Net productivity (mg $cm^{3-1}l^{-1}$)	0.6	0.6	0.4	0.4	0.4
4.	Carbonate (mg l^{-1})	1.0	1.8	1.6	1.4	1.2
5.	Bicarbonate (mg l^{-1})	25.6	39.0	45.0	36.6	33.4
6.	Nitrate (mg l^{-1})	9.9	5.0	9.6	8.7	6.8
7.	Nitrite (mg l^{-1})	3.0	5.5	4.2	4.0	2.6
8.	Total phosphorus (mg l^{-1})	4.4	2.6	5.0	4.9	5.7
9.	Inorganic phosphorus (mg l^{-1})	5.5	4.2	5.4	4.4	4.7

Table 2. Physico-chemical properties of different pond water samples. Pond 1: Dabeerkulam; Pond 2: Mariyamman Kovil; Pond 3: Padithurai; Pond 4: Pulavarnatham; Pond 5: Sivalingam temple. *Propiedades físico-químicas de las diferentes charcas de Thanjavur. Charca 1: Dabeerkulam; Charca 2: Mariyamman Kovil; Charca 3: Padithurai; Charca 4: Pulavarnatham; Charca 5: templo de Sivalingam.*

a massive bloom of *Microcystis aeruginosa***.**

Low amount of dissolved oxygen (0.8 mg l^{-1}) in pond - 1, which had a significant effect in reducing the other cyanobacterial population (tab. 2). The similar type of results has also been reported (Subha & Chandra, 2005; Pingale & Deshmukh, 2005; Rani *et al.,* 2005). Frankelin (1972) reported that *Microcystis* is one of the dominant organisms that is associated with almost permanent blooms in tropical freshwaters that are exposed to constant sunshine, warmth, and nutrients like phosphate, silicate, nitrate, CO_2 and lime. Formation of cyanobacterial blooms in freshwater bodies is essentially due to buoyant nature of these organisms. Buoyancy of cyanobacteria is imported by the gas vacuoles which forms dense growth on the water surface in ponds, reservoirs and lakes and cause serious nuisance because of visual appearance, production of toxins (Carmichael, 1994) and unpleasant odour produced by substances such as geosmin (Juttner, 1987). Jeyaraman (1972) and Qasim (1972) reported that the dominance of cyanobacterial blooms in general, *Trichodesmium* bloom in particular may be due to two reasons: it may be a case of the superiority of the organism competing with the other organisms for the nutrient supply from the environment or it may be an instance where the metabolic products of the dominating species and creating unfavorable condition in the environment for the growth of other organisms.

Murphy *et al.* (1976) and Bailey & Taub (1980) reported that the development of cyanobacterial blooms in any ecosystems, the siderophore mediated iron uptake in believed to be a contributing factor in their ability to dominate other microalage. Where as the other cyanobacterial forms that apparently cannot synthesize siderophore are able to utilize siderophore produced by other bacteria (Ferreira & Straus, 1994). As also reported in other publications addressing the persistence and stability of various organisms in fresh water ecosystems (Duncan & Blinn, 1989; Scarsbrook, 2002; Soininen & Eloranta, 2004), cyanobacteria particularly forms their extreme blooms throughout the main part of the summer.

The crucial role of the physico-chemical parameters in the ecosystem on the

	pH	DO	Net Productivity	Carbonate	Bicarbonate	Nitrate	Nitrite	Inorganic phosphorus	Total Phosphorus	TCS
pH	1									
DO	-0.787	1								
Net Productivity	0.388	-0.480	1							
Carbonate	-0.817	0.832	5.01E	1						
Bicarbonate	-0.764	0.986**	-0.461	0.847	1					
Nitrate	0.532	-0.121	-0.270	-0.559	-0.202	1				
Nitrite	-0.603	0.615	0.339	0.862	0.577	-0.361	1			
Inorganic phosphorus	0.867	-0.391	0.074	-0.641	-0.377	0.777	-0.511	1		
Total Phosphorus	0.209	-0.031	-0.815	-0.547	-0.040	0.595	-0.768	0.425	1	
TCS	-0.806	0.980**	-0.379	0.904*	0.992**	-0.290	0.655	-0.458	-0.150	1

Table 3. Correlation co-efficient analysis of physico-chemical properties of water and total cyanobacteria species; *: Significant at 0.5% level; **: Significant at 0.01% level. *Coeficientes de correlación de las propiedades físico-químicas del agua y el total de especies de cianobacterias. *: significativo al 05%; **: significativo al 0,01%.*

distribution of algal community has been extensively analyzed in tropical and temperate freshwater ecosystems (Lund, 1965; Reynolds, 1984; Köhler, 1994). Chellappa *et al*. (2004) reported the collective dominance by the species of cyanobacteria was due to their capacity to grow in turbid water and low light intensity to maintain buoyancy and the capacity to grow exponentially in wet period in which nitrogenous nutrients were high. The daily water level fluctuations attributed to increase and decrease in phytoplankton species diversity. Pingale & Deshmukh, (2005) identified 87 algal species belonging to 43 genera from Kalsubai-Ratangal, Ahmednagar. Subha & Chandra (2005) studied the algal flora from temple tanks in and around the city of Chennai and reported 17 species of algae belonging to Cyanophyceae, Chlorophyceae, Bacillariophyceae and Euglenophyceae. Of the 39 species of cyanobacteria recorded in the present study, only 5 heterocystous cyanobacteria such as *Calothric brevissima, Calothrix* sp., *Scytonema* sp., *Anabaena* sp. and *Nostoc carneum* were recorded. Hoyslew & Pearson, (1979) and Oren & Shilo, (1979) reported that the high levels of sulfide content, and anaerobic conditions was believed to exclude the heterocystous forms. High levels of nitrogen source in the environment is also eliminating heterocystous forms, since nitrogen free media is commonly used for the isolation and purification of heterocystous cyanobacteria.

The significant positive correlation between the cyanobacterial diversity and micronutrients (zinc and nitrite) was observed and also reported by Govindasamy & Azaraiah (1999). In the present study the significant positive correlation was observed between the Total Cyanobacterial Species (TCS) and dissolved oxygen ($r=0.9803$; $p<0.01$), TCS and bicarbonate ($r= 0.9928$; $p<0.01$) and TCS and carbonate ($r=0.941$; $p<0.05$). Hence the present study concluded inspite of the fact that the cyanobacteria are ubiquitous, their population dynamics are often influenced by the available nutrients and the physico-chemical conditions of the ecosystem.

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