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ISSN : 0254-8704
http : //www.geocities.com/j_environ_biol/

J. Environ. Biol.
29(6), 859-862 (2008)
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Growth and periodicity of cyanobacterial bloom in a polluted pond of Agra city

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(Received: June 15, 2006; Revised received: February 20, 2007; Accepted: March 28, 2007)

Abstract: *Periodical changes in physico-chemical properties and cyanophycean bloom in a pond of Agra city during the year 2005 and 2006 were studied. It was recorded that the pond water was polluted throughout the study period and this was closely associated with Cyanobacterial bloom. During summer (March to June), the pond water was highly polluted, as it was rich in various nutrients and phosphates in particular. The pH of pond water was high with low DO and this was associated with the highest peak of water bloom. On the other hand, during winter (November to January), the bloom was at its lowest. The quantity of various nutrients in the pond water was low and the pH was also low but DO was high. Bloom consisted of eighteen members of Cyanophyceae of which Oscillatoria limosa, O. formosa, O. splendida, Anabeana iyengarii, Microcystis arruginosa and Nostoc muscorum were observed throughout the year. On the other hand, Oscillatoria agardhi, and O. tenuis were found only in winters, while O.annae in rainy season only. Similarly, Oscillatoria brevis, Anabaena flos-aquae, Aphanizomenon sp. and Lyngybea birgei were found in abundance in summer.*

Key words: *Cyanobacterial bloom, Pond*
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Introduction

Cyanobacteria or blue-green algae comprise a unique group of organism, which is world wide in distribution. They grow in a wide variety of habitats such as fresh water system, soil and hot springs. cyanobacteria are also abundant in eutrophic lakes and paddy fields and these form water blooms. Increased eutrophication from domestic effluent, sewage and agricultural fertilizer run-off promotes the growth of cyanophycean bloom. They impart colour, odour and unpleasant taste to water and makes water non-potable. They also cause some hazardous water borne diseases. The blooms some times are so intense that by drinking bloom affected water, sheep and cattle fail to survive due to naturally produced poison by the algal cells of certain cyanobacteria. These toxins are usually released in to water when the cells rupture or die (Bagchi, 1996). The toxic and poisonous effects of cyanobacteria on animals and human beings have been reviewed by Tyagi *et al.* (2000), Tarar and Bodkhe (2001). Present investigation was undertaken to study the extent of bloom formation associated with polluted state of the pond located on Master Plan Road, Agra.

Materials and Methods

Study area: The city of Agra is situated in the upper Gangetic plain on the right bank of Yamuna river at 27° 12 N' latitude and 78° 4 E' longitude. It occupies the mid west corner of Uttar Pradesh. It is tropical with summer season extending from March to June, rainy season from July to October and winter season November to February. Water samples were collected during morning hours in between 9 to 11 am. The sampling frequency was once in a month. The maximum temperature in April to May ranges between 35-48°C and minimum between 7-25°C during December to February (Tiwari and Chauhan, 2004). Present investigation was undertaken in a pond located on Master Plan Road near New Lajpat Kunj colony adjacent to District Jail and R.B.S. College, Agra (Fig. 1). The size of the pond is 140 X 80 m. A small agricultural field is situated towards the southwest side of the pool. The main crops grown here are jawar and maize during kharif season, and barley and wheat in rabi season. The water is highly contaminated due to addition of domestic wastes from the nearby New Lajpat Kunj colony, which inhabits nearly about twenty thousand inhabitants. A dairy and one dying factory are also situated on the northeast side of the pond. The important pollutants added to the pond water include dairy waste, dyes, pesticides, herbicides, sewage and soap water.

Water samples and algal blooms were collected from four different sites located in north, south, east, west of the pond in sterilized 250 ml plastic bottles during different months of the year. The collected samples were brought to the laboratory and preserved in 4% formalin. Temperature of water was measured by thermometer. Salinometer (digital salinity tester) was used to measure the salinity of water. For the estimation of oxygen water collected in BOD bottles and fixed at the sampling spot. Free carbon dioxide, dissolved oxygen, total hardness, total alkalinity, nitrates and phosphate were estimated by standard method by APHA (2005). Identification of different taxa was done with the help of standard Monograph by Desikachary (1959). The metal concentration Fe, Zn, Ni, Cu and Cd were analyzed by a flame atomic absorption spectrophotometer (Perkin Elmer, 5000).

Results and Discussion

Physico-chemical properties of pond water during summer, rainy and winter seasons are presented in Table 1. During summer (March-June), pond water was highly polluted due to the presence of higher quantity of various nutrients *eg.* $CaCO_3$ (415.0 mg l^{-1}) Mg (11.5 mg l^{-1}), Zn (0.03 mg l^{-1}), Cu (0.005 mg l^{-1}), Fe (0.02 mg l^{-1}), and orthophosphates in particular were present in higher quantity. On account of higher quantity of CO_2 (135.0) and high pH (8.0), pond

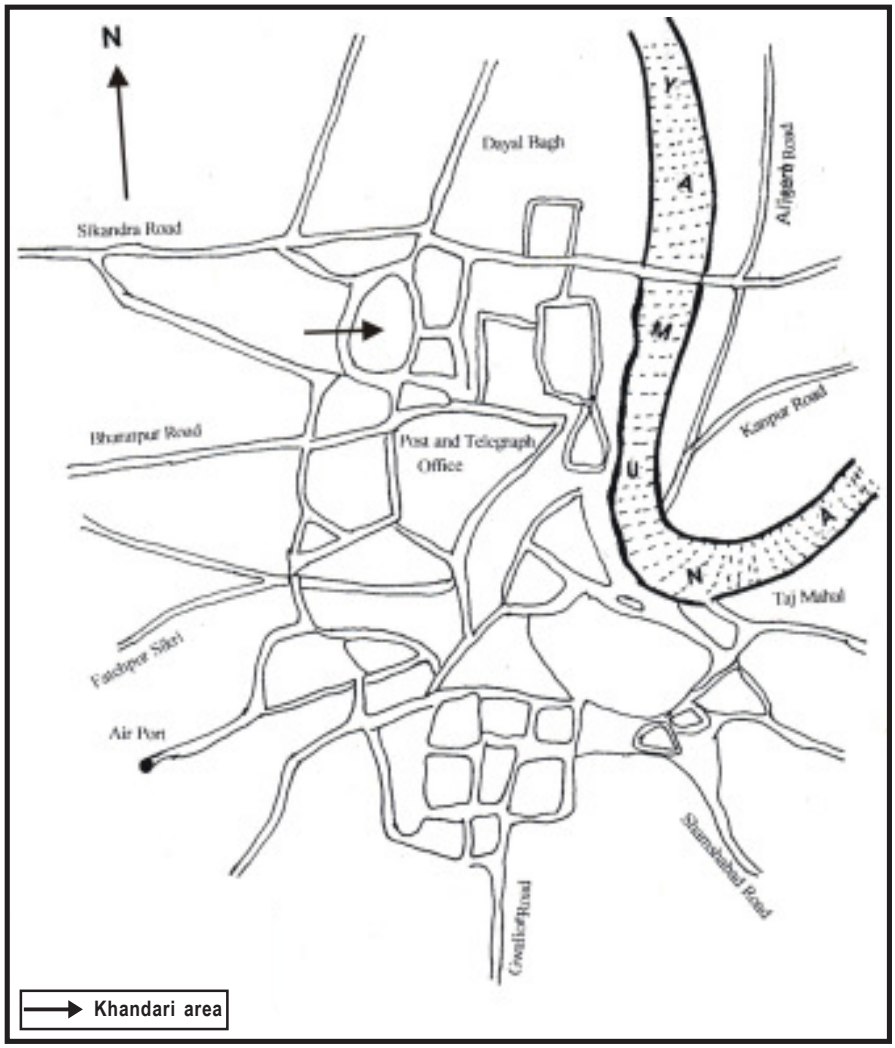

Fig. 1: Map of Agra showing algal collection site

Table - 1: Seasonal variation in the physico-chemical characters of pond water during the year 2005 - 06

Parameters	Summers 2005-2006*	Rainy 2005-2006*	Winters 2005-2006*
Temperature (°C)	33.6	28.0	28.6
pH	8.0	7.9	5.7
Colour	Brown-black	Dark brown	Greenish-brown
DO	0.9	0.7	1.6
Free CO_2	135.0	86.0	64.0
Total hardness	324.0	270.0	310.0
Phosphate	2.74	1.64	1.49
Chloride	108.0	94.0	100.0
Total alkalinity	415.0	400.0	320.0
Nitrate	5.9	2.0	3.5
Ferric	0.02	0.05	0.07
Zinc	0.03	0.08	0.011
Nickel	0.01	0.04	0.06
Copper	0.005	0.012	0.018
Cadmium	0.01	0.05	0.06

All values are in mg l^{-1} except temperature, colour and pH, * Average value of two consecutive years, Number of sample = 5

Table - 2: List of blue-green algae encountered from pond water during the year 2005-06

Name of the algal forms	Summers (March-June)		Rains (July-September)		Winters (October-February)	
	2005	2006	2005	2006	2005	2006
Oscillatoria princeps	+++	+++	++	+++	-	-
O. agardhi	-	±	-	++	++	-
O. obscura	+++	+++	±	±	-	±
O. acuta	±		-		±	±
O. annae	-	+	+	+	+	±
O. chalybea	+++	++	-	-	-	-
O. tenuis	-	-	-	-	+	+
O. splendida	+	+	+	++	+	+
O. formosa	++	+++	++	++	+	+
O. limosa	++	++	+	+	+	±
O. brevis	+++	+++	±	-	-	-
Microcystis arruginosa	+++	+++	+	++	+	-
Anabaena iyengarii	+++	+++	++	++	+	+
Anabaena flos-aquae	+++	++	-	-	-	±
Aphanizomenon	+++	++	±	+	-	-
Nostoc muscorum	+++	++	+	++	+	+
Lyngybea birgei	+++	++	±	±	-	-
Phormedium luridium	+++	±	+	±	-	±

+ = Present, – = Absent, ± = Rare, +++ = Most abundant, ++ = Abundant

water was highly alkaline while; the quantity of DO was significantly low. On the other hand, during winters, the quantity of various nutrients, CO_2 (64.0 mg l^{-1} and pH (5.7) decreased significantly but DO (1.6 mg l^{-1}) increased. Water temperature was also found to fluctuate throughout the study period. In the dye factory silicate is used in dying process. It is employed for bleaching of grey cloths and is washed after printing. The water used in bleaching process is slightly acidic, but after washing it becomes alkaline. The significant changes in pH during winters (5.7) to rainy season (7.8) were mainly attributed to dilution of pond water during rainy season as well as due to slower utilization of phosphates by phytoplanktons in winters. Addition of agricultural runoff from nearby field and sewage from the colony also makes the water acidic. Findings of Sachidanandamurthy and Yajurvedi (2006) and Garg *et al.* (2006) support present observations. They have studied physico-chemical parameters of an aquaculture bodies in Mysore city and Ramsagar Reservoir, Datia respectively. According to them, due to the entry of agricultural runoff and occasional flow of sewage into the water bodies enhance turbidity, BOD, phosphate and nitrate in few months above desirable limits, which increases in phytoplankton growth in the lake.

It was interesting to note that the periodicity of Cyanobacteria, which forms water bloom, changed with the changes in physico-chemical nature of pond water. Higher pollution load in pond water during summers due to the presence of higher quantity of various nutrients, CO_2, high pH and low DO and increase in temperature resulted in the increase of water bloom. However, subsequent reduction in pollution load and temperature in winters resulted in both qualitative and quantitative reduction in water bloom formed by blue-green algae. It was interesting to note that water bloom was higher at the northern site where water comes from residential areas. This may be due to discharge of water containing various detergents. Sharma *et al.* (2004) have studied the comparative effects of two household detergents on algal communities in oligotrophic and eutrophic microcosms. They have recorded higher algal species richness (20-40%) and their density (20-90%) and ± -diversity (5-20%) in the detergent treatments. More or less similar trend was observed in the algal communities of the eutrophic microcosm after receiving (one time) different levels (10, 20 and 30%) of phosphorous by adding phosphorous containing detergent surf excel. Chlorophytes exhibited percentage reduction whereas an opposite trend was observed with cyanobacteria. During the course of present investigation, a total number of 18 blue-green algal species were collected from the pond, which participates in forming bloom (Table 2). The maximum peak of *Oscillatoria princeps, O. chalybea, O. brevis, O. obscura, Nodularia, Phormedium, Anabaena flos-aquae, Lyngbya* and *Aphanizomenon* were observed in summers (March-June) when temperature was at its peak. *Microcystis aeruginosa* was found as a permanent bloom throughout the study period and in maximum in summer and rainy seasons, but decreased in winters. On the other hand, *Oscillatoria agardhi, O. acuta, O. annae* and *O. tenuis* were comman water bloom algae during winters. It was interesting to observe a dense bloom of *Oscillatoria limosa, O. formosa, O. splendida, Anabaena iyengarii* and *Nostoc muscorum* at different sites of pond throughout the year.

Tarar and Bodkhe (2001), Samantaray *et al.* (2002), Tas and Gonulol (2007), Sridhar *et al.* (2006), Kwang Guk *et al.* (2003) and Tiwari and Chauhan (2006a, b) have also emphasized that higher concentration of various nutrients and low dissolved oxygen play an important role in inducing cyanophycean bloom. Ghosh *et*

al. (2006) have reported that *Microcystis* dominate blooms of freshwater resources from eastern Madhya Pradesh. Recently, Vishnoi and Srivastava (2006), have reported the algal taxa from alkaline pond of Gura Vishnoiyan near Jodhpur, Rajasthan. The physico-chemical parameters change throughout the year, which shows a diverse pattern of distribution of algal flora. They have recorded as many as 36 cyanophycean members as compared to only 10 species of Chlorophyceae. Johnson (2006) has studied algal flora of Banjara and Nadimi lakes and found that both the lakes are eutrophic and are dominated by cyanophycean and Bacillariophycean members. According to these workers, the species and strains of *Anabeana, Aphanizomenon, Microcystis, Nodularia, Nostoc, Anabaena* and *Oscillatoria* are the common toxic bloom algae in eutrophic and hyper eutrophic water bodies all over the world. Presence of certain species of cyanobacteria *eg. Aphanizomenon, Oscillatoria, princeps, O. formosa* and *Anabaena* in water create serverl problems in the management of aquatic environment as they produce highly toxic substances. Mahadev and Hosmani (2004, 2005) have studied the community structure of cyanophyceae in two polluted lakes of Mysore city. They have found that cyanophyceae are highly tolerant organisms and prefer to grow at higher temperature and in slightly alkaline conditions. The lakes of Mysore city receive city sewage regularly and are heavily polluted. The algal diversity can be used as biomonitor of organic pollution.

Thus, from the forgoing observations and those of others presented in support, it is clear that summers and polluted water are most favourable for the formation of bloom. Presence of cyanophycean species in water bodies is a pollution indicator and makes water poisonous and non-potable for both human beings and animals.

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