The Scientific Temper
July, 2010; No.1: pp177-186

Academy of Innovative Research
Email: pntripathiphd@hotmail.com

EFFECT OF PHYSICO-CHEMICAL CHARACTERISTICS ON CYANOBACTERIAL DIVERSITY IN THREE FISH CULTURE PONDS OF MEERUT REGION

Prashant Saxena[1] , Kapil Kumar[2], P. V. Malik[3] and Jyoti Saxena*
I.I.M.T College, Meerut
Dept. of Zoology, Meerut College , Meerut
Sanjay Ghadhi P.G. College, Sarorpur, Meerut
*Translam Institute of Pharma Education and Research, Meerut
Email: amitprashant259@gmail.com , shiwachkapil@gmail.com

ABSTRACT

Cyanobacteria provide an extraordinarily wide-ranging contribution to human affairs in everyday life. Both the beneficial and detrimental features of Cyanobacteria are of considerable significance as they are important primary producers and their general nutritive values is high. The occurrence of a particular genus and species of Cyanobacteria around the world is apparently affected by regional differences in water chemistry and climatic conditions. The ponds, taken into consideration for the present study are located in District Meerut. All of these ponds are very important for commercial point of view. Interference of local people, as they bath, wash their clothes and utilise the water for agriculture and other purposes, leads to fluctuations of physico-chemical characteristics which affect the growth and diversity of Cyanobacteria.

Key words- Cyanobacteria, Meerut region, Physico-chemical characteristics.

INTRODUCTION

India being the fourth largest producer of fish is playing an important role in global fisheries. With current production of over 2.4 mmt from aquaculture, the country also occupies second position in the world after China, (CIFA, 2007). India has a great variety of topographical and climatic conditions. As a result the fresh water flora and fauna fluctuate to great extent. Odum (1971) reported that water and biota of an aquatic ecosystem are inseparable and complementary to each other.The present study has been conducted for two consecutive years (from July 2004 to June 2006) on three fish culture ponds located at Nanpur, Shahjahanpur and Kithore in Meerut district. These ponds were surveyed frequently to obtain data. All the sampling sites are natural, evergreen and muddy ponds. These ponds were visited monthly to analyse physico-chemical parameters, cyanobacterial diversity and to collect different fish species found in these ponds.

MATERIAL AND METHODS

The physico-chemical characteristics of the water were measured monthly at selected sampling sites. The collection and analysis of water was conducted after following Trivedy and Goel (1984) and APHA AWWA WEF (1995). The physico-chemical parameters are as follows

Water Temperature (°C): The temperature of water was recorded on the sampling site during forenoon (8:00-11:00 AM) with a 0-50°C thermometer.

Hydrogen ion Concentration (pH): pH of pond water was recorded with accuracy of 0.1 unit at the site immediately after the collection of samples, using a portable pocket-type pH meter (Hanna make).

Turbidity (NTU): For turbidity measurement, the water samples were taken in a clean sampling bottle, brought to the laboratory and measured by the digital turbidity meter (model 331 E) in NTU (Nephlometer Turbidity Unit). The mean value of turbidity in each month was recorded.

Dissolved Oxygen (ppm): Dissolved oxygen was measured at the site without any delay after collecting the sample. Wrinkler's method was applied to measure the DO.

Free Carbon-di-oxide (ppm): The analysis of free CO_2 was made independently after the sampling by using phenolphthalein as indicator and N/44 NaOH solution as titrant. The amount of free CO_2 was calculated in ppm.

Alkalinity (ppm): Water sample was taken in a conical flask and two drops of phenolphthalein indicator were added into the sample. As the phenolphthalein alkalinity was disappear, methyl orange indicator was added to the fresh water. The titration was continued by N/50 Sulphuric acid to convert all the bicarbonates (HCO_3) into CO_2 and water. The complete neutralization of the alkalinity in the sample was indicated by the change in colour from yellow to orange at the end point. The total methyl orange alkalinity, carbonate and bicarbonate, were calculated in ppm by multiplying used volume of N/50 H_2SO_4 (ml) by 10.

Biological Oxygen Demand (BOD): The BOD determination involves the measurement of differences in oxygen concentration in the sample before and after incubating it for 5 days. Following formula was applied for the calculation of BOD of the water samples-

BOD mg/L = (D_i-D_5) * dilution factor

Where, D_i = Initial DO in the sample

D_5 = DO after 5 days of incubation.

Nitrate-Nitrogen: Nitrate reacts with phenol disulphonic acid to form nitro acid complex, which gives yellow colour with strong alkali salt. Absorbance at 410 nm was taken with the help of spectrophotometer and the result was compared with the standard value.

Total Phosphate: 25 ml of collected water sample was taken in 100 ml conical flask and evaporated up to dryness. The residue was cooled and 1 ml of perchloric acid was added into it. Flask was heated , till the residue becomes colourless. The temperature was increased to evaporate the perchloric acid. Afterwards, one drop of phenolphthalein indicator and distilled water were added to it. It was titrated with 8% NaOH solution. Slight pink colour appears. With this treatment, all forms of phosphate are converted into ortho-phosphate.

Now, 1 ml ammonium molybdate solution and three drops of Stannous chloride solution were added to it. Blue colour was appeared. The readings were taken with the help of spectrophotometer at 690 nm and the result was compared with the standard value.

Diversity of cyanobacteria: The diversity of cyanobacteria was studied at selected fish culture ponds. The samples of cyanobacterial blooms were collected from each sampling site every month and transported to the laboratory for further study, *viz.* their identification. The species were separated by morphotypes to which a numerical code is already assigned. Each morphotype was identified up to genus level. The cyanobacteria were identified and classified after following Rippka *et al.* (1979). Qualitative and quantitative study of the cyanobacterial population was done. Cell counting and differentiation were performed microscopically, with the help of counting chamber.

Statistical analysis : The mean values of multiple observations of the experimental designs were calculated with their standard deviations to reach on meaningful conclusions. For correlation study, bi-variant Pearson correlation coefficient was calculated by using statistical software SPSS version 10.0.

RESULT:

The qualitative as well as quantitative study of cyanobacterial diversity was undertaken for the period of two years (from July 2004 to June 2006) in all the ponds, to understand about the cyanobacterial species and their impact on other biological organisms present in the ponds.

The monthly occurrence of cyanobacterial population in aquatic environments of all three ponds was determined and their density per liter of water was recorded and tabulated in tables-1 to 3, respectively. The cyanobacterial community in Nanpur, Shahjahanpur and Kithore fish ponds was mainly represented by six dominant cyanobacterial genera, *viz. Anabaena*, *Nostoc*, *Spirulina, Microcystis*, *Oscillatoria* and *Phormidium* (Tables-1 to 3).

In Nanpur fish pond, the cyanobacterial abundance was observed during winter months (January-February) with a peak density (68.00 ±5.20 Nos./liter during February 2005 and 54.33 ±3.42 Nos./liter during January 2006). The cyanobacterial population gradually declined towards the summer months and was minimum in the month of May (24.67 ±1.64 Nos./liter in the year 2005 and 19.00 ±2.18 Nos./liter in the year 2006) (Table-1). *Oscillatoria* was the most dominant genus throughout the study period in Nanpur fish pond followed by *Spirulina* (Table-1). The population of *Oscillatoria* was found maximum in winter months (20.33 ±3.06 Nos./liter in February 2005 and 12.67 ±2.08 Nos./liter in January 2006), while *Spirulina* was found maximum during December 2004 (15.00 ±1.73 Nos./liter) and January 2006 (13.33 ±2.89 Nos./liter) respectively.

It was revealed by the analysis of Pearson correlation coefficient that in Nanpur fish pond, cyanobacterial density showed positive correlations with DO (r=0.604, P<0.01, n=24), nitrate-nitrogen (r=0.911, P<0.001, n=24), total phosphate (r=0.532, P<0.01, n=24) and chlorophyll-a content (r=0.971, P<0.001, n=24). On the other hand, the cyanobacterial density showed significant negative correlations with temperature (r=-0.695, P<0.001, n=24), pH (r=-0.405, P<0.05, n=24), turbidity (r=-0.475, P<0.05, n=24) and BOD (r=-0.619, P<0.01, n=24) however it was negatively correlated with temperature (r=-0.527, P<0.01, n=24), free CO_2 (r=-0.429, P<0.05, n=24) and BOD (r=-0.589, P<0.01, n=24).

Similarly in Shahjahanpur fish pond, cyanobacteria were observed abundant with a peak density in December (51.00 ±3.20 Nos./liter in the year 2005) and March (56.67 ±3.09 Nos./liter in the year 2006). These populations decreased towards summer and monsoon months showing a similar trend in annual variation of cyanobacterial population as Nanpur fish pond. The minimum density of cyanobacteria in Shahjahanpur fish pond was noted as 40.67 ±2.29 Nos./liter in April 2005 and 41.33 ±1.75 Nos./liter in May 2006 (Table-2). In Shahjahanpur also, *Oscillatoria* was found as the most dominant genus throughout the study period followed by *Spirulina* (Table-2). The population of *Oscillatoria* was found maximum in late winter months (14.33 ±5.51 Nos./liter in February 2005 and 13.00 ±3.46 Nos./liter in March 2006), while *Spirulina* was found maximum during November 2004 (13.33 ±2.89 Nos./liter) and January 2006 (13.33 ±1.15 Nos./liter) respectively.

In Shahjahanpur fish pond also, cyanobacterial density was positively correlated with nitrate-nitrogen (r=0.944, P<0.001, n=24), total phosphate (r=0.866, P<0.001, n=24) and chlorophyll-a content (r=0.890, P<0.001, n=24). The cyanobacterial density showed significant negative correlations with temperature (r=-0.541, P<0.01, n=24) and turbidity (r=-0.436, P<0.05, n=24) only.

In Kithore fish pond, the cyanobacterial abundance was observed during winter months (December-February) with a peak density of 65.33 ±5.21 Nos./liter during February 2005 and 55.67 ±3.21 Nos./liter during January 2006. A gradual decrease in cyanobacterial community was observed after winter months and it was found minimum in the month of May (28.00 ±1.94 Nos./liter) in the year 2005 (Table-3). However, during the year 2006, the minimum population of cyanobacteria was observed in the month of March (25.00 ±2.66 Nos./liter). Similar trend was observed with the populations of *Oscillatoria* and *Spirulina*. The maximum density was of *Oscillatoria* (20.33 ±3.06 Nos./liter in February 2005 and 12.67 ±2.08 Nos./liter in January 2006),

TABLE-1: DISTRIBUTION OF CYANOBACTERIAL POPULATION IN NANPUR FISH POND DURING TWO CONSECUTIVE YEARS (JULY 2004 – JUNE 2006)

Months	Cyanobacterial Genera												Total Cyanobacteria ±S.D.
	Anabaena		*Nostoc*		*Phormidium*		*Microcystis*		*Oscillatoria*		*Spirulina*		
	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	
Jul. 04	5.00	1.00	5.67	1.53	5.67	0.58	4.33	1.53	8.33	1.53	7.33	0.58	36.33 ±1.73
Aug. 04	7.33	1.15	5.67	0.58	3.67	0.58	6.33	0.58	7.33	0.58	8.33	0.58	38.67 ±1.65
Sep. 04	3.33	0.58	4.33	1.53	3.33	0.58	6.33	1.15	4.67	1.15	9.33	1.53	31.33 ±2.37
Oct. 04	7.67	0.58	7.67	0.58	4.67	0.58	10.33	1.15	5.33	0.58	10.67	0.58	46.33 ±2.40
Nov. 04	6.33	0.58	4.67	0.58	6.67	0.58	5.33	0.58	9.67	0.58	11.33	0.58	44.00 ±2.50
Dec. 04	7.33	1.15	6.67	1.15	9.67	0.58	11.00	1.73	14.67	1.53	15.00	1.73	64.33 ±3.53
Jan. 05	7.67	0.58	9.67	1.15	8.33	1.15	9.67	1.53	15.33	1.53	7.00	1.00	57.67 ±2.99
Feb. 05	6.67	0.58	13.33	1.15	11.67	0.58	10.67	1.53	20.33	3.06	5.33	1.15	68.00 ±5.20
Mar. 05	4.67	1.15	5.0	1.73	6.33	1.15	3.67	0.58	14.00	2.65	5.00	1.73	38.67 ±3.82
Apr. 05	7.67	0.58	6.33	0.58	5.00	1.73	3.67	0.58	3.67	0.58	4.67	1.15	31.00 ±1.69
May 05	3.67	0.58	2.67	1.53	4.33	0.58	5.33	1.15	6.33	0.58	2.33	0.58	24.67 ±1.64
Jun. 05	6.67	1.53	3.33	0.58	1.33	0.58	5.00	1.00	7.00	2.65	5.00	2.00	28.33 ±2.40
Jul. 05	6.33	1.15	6.67	0.58	9.67	1.15	8.30	0.58	7.33	1.53	3.33	0.58	41.63 ±2.10
Aug. 05	6.00	0	5.33	2.08	10.00	1.00	9.00	1.73	8.33	1.15	4.00	1.00	42.67 ±2.47
Sep. 05	7.67	0.58	6.33	2.08	8.67	0.58	5.67	2.52	5.33	2.08	4.00	1.00	37.67 ±2.11
Oct. 05	2.67	0.58	4.00	3.00	9.67	1.15	7.00	2.65	7.00	2.00	8.67	1.53	39.00 ±3.03
Nov. 05	5.33	1.15	7.33	1.15	4.67	2.08	6.00	1.00	8.67	0.58	5.33	2.08	37.33 ±1.86
Dec. 05	4.00	1.00	9.00	2.00	7.33	1.15	7.00	1.00	4.67	2.08	2.67	0.58	34.67 ±2.53
Jan. 06	5.33	0.58	7.00	1.00	8.67	2.08	7.33	1.53	12.67	2.08	13.33	2.89	54.33 ±3.42
Feb. 06	3.67	0.58	4.33	0.58	8.67	0.58	7.67	0.58	10.00	1.00	10.67	1.15	45.00 ±2.81
Mar. 06	5.67	0.58	4.67	1.15	5.33	3.51	4.67	1.53	1.67	1.53	1.33	2.31	23.33 ±2.45
Apr. 06	5.33	0.58	3.67	2.52	6.67	3.06	8.67	0.58	2.67	2.52	5.33	2.08	32.33 ±2.68
May 06	2.33	0.58	1.33	1.53	2.67	1.53	2.33	2.08	6.67	0.58	3.67	2.08	19.00 ±2.18
Jun. 06	5.33	0.58	5.67	2.31	1.67	2.08	0.67	1.15	7.67	0.58	3.00	1.00	24.00 ±2.79

* Data presented here is the mean of three observations.

TABLE-2: DISTRIBUTION OF CYANOBACTERIAL POPULATION IN SHAHJAHANPUR FISH POND DURING TWO CONSECUTIVE YEARS (JULY 2004 – JUNE 2006)

Months	Cyanobacterial Genera												Total Cyanobacteria ±S.D.
	Anabaena		*Nostoc*		*Phormidium*		*Microcystis*		*Oscillatoria*		*Spirulina*		
	Mean	**±S.D.**	**Mean**	**±S.D.**	**Mean**	**±S.D.**	**Mean**	**±S.D.**	**Mean**	**±S.D.**	**Mean**	**±S.D.**	
Jul. 04	7.33	0.58	6.67	1.53	8.33	0.58	7.00	1.73	10.00	2.00	8.67	0.58	48.00 ±1.61
Aug. 04	6.00	2.65	6.00	2.65	8.00	1.73	8.67	2.08	9.67	3.79	6.67	2.08	45.00 ±2.60
Sep. 04	4.33	2.08	4.67	0.58	6.00	1.00	8.67	1.53	8.67	0.58	9.67	4.93	42.00 ±2.91
Oct. 04	7.00	2.00	7.33	1.53	7.33	1.15	10.00	1.00	8.00	1.00	10.33	1.53	50.00 ±1.81
Nov. 04	5.67	2.08	7.00	1.73	5.00	0	8.33	3.51	8.33	2.89	13.33	2.89	47.67 ±3.47
Dec. 04	7.67	1.53	6.00	1.73	5.33	0.58	9.33	2.31	10.33	4.51	12.33	1.53	51.00 ±3.20
Jan. 05	6.00	2.65	7.67	0.58	5.33	3.06	9.00	2.00	12.33	2.52	6.67	1.53	47.00 ±3.03
Feb. 05	6.33	0.58	7.67	3.79	5.67	1.15	8.67	3.51	14.33	5.51	7.67	1.15	50.33 ±3.94
Mar. 05	7.33	1.15	7.33	2.08	7.33	1.15	7.33	4.04	11.33	3.21	7.33	1.15	48.00 ±2.54
Apr. 05	4.67	2.52	7.00	2.00	5.67	1.15	9.00	2.65	6.67	2.52	7.67	1.53	40.67 ±2.29
May 05	7.00	1.73	7.00	1.73	5.67	0.58	6.67	2.31	11.00	3.61	7.33	0.58	44.67 ±2.43
Jun. 05	6.00	2.00	6.00	2.00	8.67	2.52	7.67	3.21	7.00	2.65	8.33	1.15	43.67 ±2.24
Jul. 05	4.33	2.08	8.67	0.58	8.33	0.58	8.30	4.93	8.67	4.73	8.00	2.65	46.30 ±3.12
Aug. 05	5.00	1.00	7.33	1.15	9.67	2.89	8.67	3.21	7.33	2.52	8.33	0.58	46.33 ±2.35
Sep. 05	5.33	0.58	6.00	1.73	8.00	1.73	8.33	0.58	8.67	2.08	9.67	3.79	46.00 ±2.33
Oct. 05	5.67	1.53	5.67	0.58	7.00	3.46	9.67	2.08	9.67	2.08	8.33	1.53	46.00 ±2.45
Nov. 05	7.00	1.73	8.00	0	6.67	1.53	8.00	3.61	8.00	1.00	8.33	0.58	46.00 ±1.64
Dec. 05	5.00	1.73	7.67	1.53	10.00	3.46	10.33	1.53	7.33	2.08	10.00	0	50.33 ±2.59
Jan. 06	2.33	1.53	6.33	1.53	6.67	2.08	8.67	4.73	12.33	1.53	13.33	1.15	49.67 ±4.35
Feb. 06	5.33	0.58	6.67	2.31	6.33	1.53	10.67	3.21	9.67	0.58	9.00	0	47.67 ±2.48
Mar. 06	8.33	0.58	6.67	2.08	9.00	4.58	9.33	0.58	13.00	3.46	10.33	3.06	56.67 ±3.09
Apr. 06	7.33	0.58	8.67	0.58	9.67	2.08	7.33	1.53	9.67	2.52	7.33	0.58	50.00 ±1.68
May 06	6.33	2.31	7.33	1.15	7.67	1.53	6.33	2.31	7.67	0.58	6.00	2.65	41.33 ±1.75
Jun. 06	6.00	1.00	6.00	1.73	7.00	2.00	8.33	0.58	9.67	2.08	9.67	1.15	46.67 ±2.05

* Data presented here is the mean of three observations.

TABLE-3: DISTRIBUTION OF CYANOBACTERIAL POPULATION IN KITHORE FISH POND DURING TWO CONSECUTIVE YEARS (JULY 2004 – JUNE 2006)

Months	Cyanobacterial Genera												Total Cyanobacteria ±S.D.
	Anabaena		*Nostoc*		*Phormidium*		*Microcystis*		*Oscillatoria*		*Spirulina*		
	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	Mean	±S.D.	
Jul. 04	7.00	0	5.33	1.53	5.67	0.58	4.33	1.53	8.33	1.53	7.33	0.58	38.00 ±1.68
Aug. 04	6.00	1.73	6.33	1.53	3.67	0.58	6.33	0.58	7.33	0.58	8.33	0.58	38.00 ±1.71
Sep. 04	8.00	1.00	7.00	1.00	3.33	0.58	6.33	1.15	4.67	1.15	9.33	0.53	38. 67 ±2.25
Oct. 04	8.00	1.00	8.33	1.15	4.67	0.58	10.33	1.15	5.33	0.58	10.67	0.58	47.33 ±2.45
Nov. 04	6.33	2.31	5.00	0	6.67	0.58	5.33	0.58	9.67	0.58	11.33	0.58	44.33 ±2.55
Dec. 04	8.00	1.00	6.67	0.58	9.67	0.58	11.00	1.73	14.67	1.53	15.00	1.73	65.00 ±3.40
Jan. 05	7.33	0.58	7.67	1.53	8.33	1.15	9.67	1.53	15.33	1.53	7.00	1.00	55.33 ±3.14
Feb. 05	8.33	0.58	9.00	4.58	11.67	0.58	10.67	1.53	20.33	3.06	5.33	1.15	65.33 ±5.21
Mar. 05	5.00	0	5.33	2.52	6.33	1.15	3.67	0.58	14.00	2.65	5.00	1.73	39.33 ±3.81
Apr. 05	6.00	0	6.67	0.58	5.00	1.73	3.67	0.58	3.67	0.58	4.67	1.15	29.67 ±1.39
May 05	5.67	1.15	4.00	3.61	4.33	0.58	5.33	1.15	6.33	0.58	2.33	0.58	28.00 ±1.94
Jun. 05	6.67	1.53	4.67	2.08	1.33	0.58	5.00	1.00	7.00	2.65	5.00	2.00	29.67 ±2.41
Jul. 05	6.00	1.00	7.67	1.15	9.67	1.15	8.30	0.58	7.33	1.53	3.33	0.58	42.30 ±2.17
Aug. 05	8.33	0.58	4.67	1.53	10.00	1.00	9.00	1.73	8.33	1.15	4.00	1.00	44.33 ±2.52
Sep. 05	6.67	0.58	6.00	1.73	8.67	0.58	5.67	2.52	5.33	2.08	4.00	1.00	36.33 ±1.98
Oct. 05	5.00	0	6.67	2.52	9.67	1.15	7.00	2.65	7.00	2.00	8.67	1.53	44.00 ±2.20
Nov. 05	8.67	0.58	6.33	1.53	4.67	2.08	6.00	1.00	8.67	0.58	5.33	2.08	39.67 ±2.00
Dec. 05	5.00	0	9.00	2.00	7.33	1.15	7.00	1.00	4.67	2.08	2.67	0.58	35.67 ±2.41
Jan. 06	6.33	0.58	7.33	1.15	8.67	2.08	7.33	1.53	12.67	2.08	13.33	2.89	55.67 ±3.21
Feb. 06	6.00	1.73	4.33	0.58	8.67	0.58	7.67	0.58	10.00	1.00	10.67	1.15	47.33 ±2.42
Mar. 06	6.00	0	6.00	2.00	5.33	3.51	4.67	1.53	1.67	1.53	1.33	2.31	25.00 ±2.66
Apr. 06	6.00	1.73	4.33	3.51	6.67	3.06	8.67	0.58	2.67	2.52	5.33	2.08	33.67 ±2.81
May 06	7.00	1.00	3.33	2.08	2.67	1.53	2.33	2.08	6.67	0.58	3.67	2.08	25.67 ±2.37
Jun. 06	8.00	1.00	5.00	2.00	1.67	2.08	0.67	0.58	7.67	0.58	3.00	1.00	26.00 ±3.11

* Data presented here is the mean of three observations.

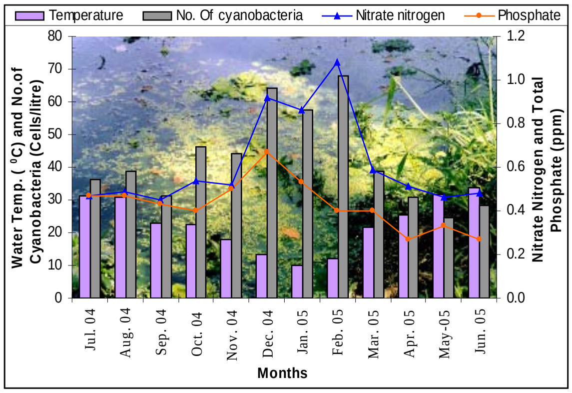

Fig.-1: Effect of water temperature, Nitrate-nitrogen and Total Phosphate on the Cyanobacterial density in Nanpur fish pond during July 2004 to June 2005.

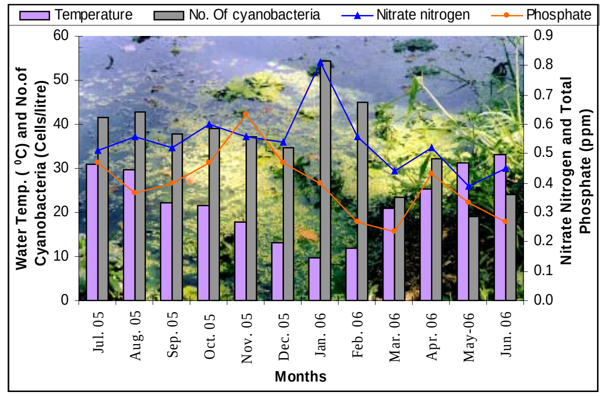

Fig.-2: Effect of water temperature, Nitrate-nitrogen and Total Phosphate on the Cyanobacterial density in Nanpur fish pond during July 2005 to June 2006.

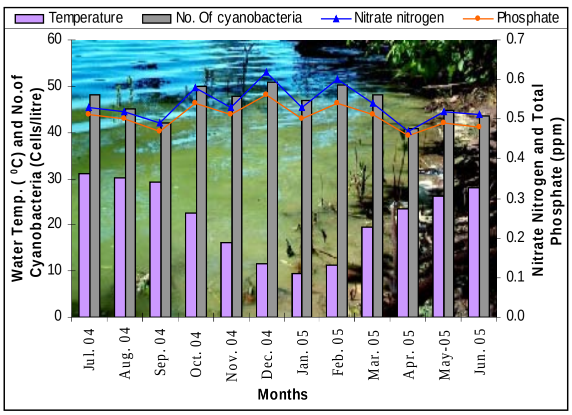

Fig.-3: Effect of water temperature, Nitrate-nitrogen and Total Phosphate on the Cyanobacterial density in Shahjahanpur fish pond during July 2004 to June 2005

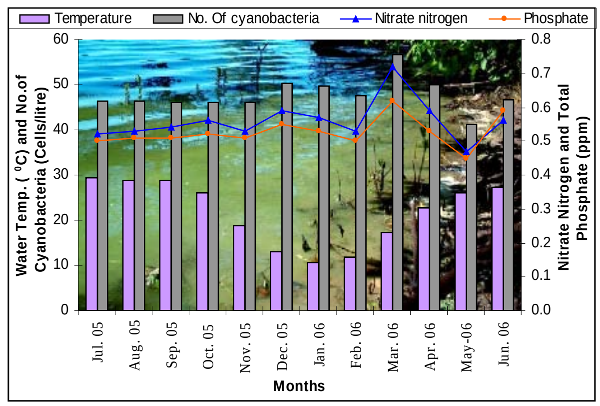

Fig.-4: Effect of water temperature, Nitrate-nitrogen and Total Phosphate on the Cyanobacterial density in Shahjahanpur fish pond during July 2005 to June 2006.

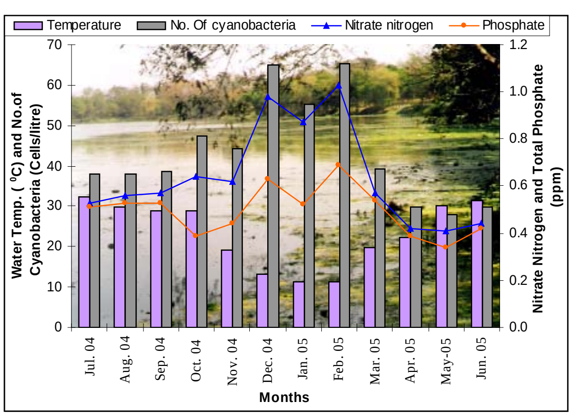

Fig.-5: Effect of water temperature, Nitrate-nitrogen and Total Phosphate on the Cyanobacterial density in Kithore fish pond during July 2004 to June 2005.

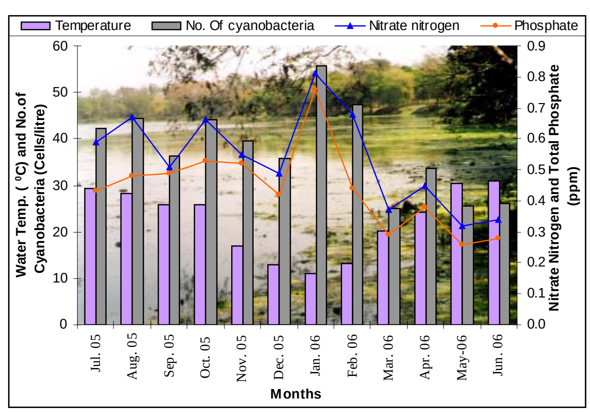

Fig.-6: Effect of water temperature, Nitrate-nitrogen and Total Phosphate on the Cyanobacterial density in Kithore fish pond during July 2005 to June 2006.

followed by *Spirulina* (15.00 ±1.73 Nos./liter in December 2004 and 13.33 ±2.89 Nos./liter in January 2006).

Moreover, in Kithore fish pond, cyanobacterial density was positively correlated with DO (r=0.473, P<0.05, n=24), nitrate-nitrogen (r=0.990, P<0.001, n=24), total phosphate (r=0.813, P<0.001, n=24) and chlorophyll-a content (r=0.968, P<0.001, n=24). While it showed significant negative correlations with temperature (r=-0.637, P<0.001, n=24), total alkalinity (r=-0.425, P<0.05, n=24) and BOD (r=-0.621, P<0.01, n=24).

To understand the possible role of environmental factors on cyanobacterial density of different ponds, Pearson correlation coefficient was analyzed and compared. It was observed that among various physico-chemical parameters; water temperature, nitrate-nitrogen and total phosphate are the major factors that determine the density and diversity of cyanobacteria in ponds. This impact has shown in the figs.-1 to 6, for Nanpur, Shahjahanpur and Kithore fish ponds respectively.

As the water temperature decreased towards winter months, the density of cyanobacteria was increased in all the three ponds. After winter months, the temperature rose gradually and it acted as a limiting factor for cyanobacterial density. As a result, cyanobacterial density decreased towards summer months in all the ponds (Figs.-1 to 6). However, nitrate-nitrogen and total phosphate were found directly proportional to the density of cyanobacteria. The cyanobacterial density was found fluctuated according to the fluctuations in both the parameters in all the ponds (Figs.-1 to 6).

DISCUSSION:

Since the physicochemical characteristics of a water body exert a great effect on its biota, hence the parameters of paramount importance, like water temperature, turbidity, pH, free CO_2, DO, total alkalinity, nitrate, phosphate and BOD of three different ponds *viz.* Nanpur, Shahjahanpur and Kithore were studied continuously from July 2004 to June 2006 during the present study.

Temperature is one of the important physical factors, which regulate the quality of ecosystem. In the present study, the temperature of all the ponds was found to exert a negative impact on the cyanobacterial density (r=-0.695, P<0.001; r=-0.541, P<0.01 and r=-0.637, P<0.001 for Nanpur, Shahjahanpur and Kithore fish ponds respectively). It clearly indicates that during winter months, when the temperature of water was quite low, the cyanobacterial density and diversity reached to its maximum. While in summers, cyanobacteria were decreased due to the high temperature and bloom-formation occurred.

Welch (1952) reported that the smaller the water body, quickly it reacts with the change in atmosphere, which is well evident in light of the present study. It is also well known that the temperature directly affects the solubility of gases, mainly CO_2 and oxygen (Srivastava, 1956; Kajak, 1961; Vasisht and Bhandal, 1978). The results of the present study also support this fact.

According to Roberts *et al.* (1940), pH values between 5 and 8.5 are suitable for freshwater fauna. The pH of water is greatly influenced by the concentration of CO_2, an acidic compound. Phytoplanktons and other aquatic vegetations remove CO_2 from the water during photosynthesis, as a result of which, pH of a water body rises. Present investigation also supports this fact. The pH was found slightly alkaline in nature. It ranged from 7.50 ±0.26 to 8.60 ±0.30 in Nanpur fish pond, 7.17 ±0.75 to 8.90 ±0.80 in Shahjahanpur fish pond and 7.53 ±0.21 to 8.70 ±0.96 in Kithore fish pond. The pH showed a negative relation with free CO_2, but the significant correlation was only established in Nanpur fish pond (r=-0.471, P<0.02).

Because cyanobacterial blooms often develop in eutrophic water bodies, it was originally assumed that they required high phosphorus and nitrogen concentrations. Experimental data have shown that the affinity of many cyanobacteria for nitrogen or phosphorus is higher than for many other photosynthetic organisms. This means that they can dominate over other phytoplankton organisms under conditions of phosphorus or nitrogen limitation. In addition to their high nutrient affinity, cyanobacteria have a substantial storage capacity for phosphorus. They can store enough phosphorus to perform two to four cell divisions, which corresponds to a 4-32 fold increase in biomass. However, if total phosphate rather than only dissolved phosphate is considered, high concentrations indirectly support cyanobacteria because they provide a high carrying capacity for phytoplankton.

The results of seasonal variation in cyanobacterial population suggest that the favourable period for primary production is from August to February, when nutrient accumulation from freshwater run-off due to monsoon rainfall is higher. Some studies were concerned with addition of fertilizers and its effect on the Cyanobacteria in fish ponds (Boyd, 1982) and others related to water quality control (Tebbutt, 1999). Singh (1960) in his study on the phytoplankton of inland water of Uttar Pradesh in India recorded primary peak of phytoplankton in the months of September-October.

In present investigation, low amount of dissolved oxygen in all the ponds had a significant effect in reducing the cyanobacterial population. Therefore, a positive relationship was established between the DO and cyanobacterial density. Similar types of results have also been reported by various workers (Subha & Chandra, 2005; Pingale & Deshmukh, 2005; Rani *et al.,* 2005).

During the present study, free CO_2 did not show any definite trend and no relationship could be established between free CO_2 and dissolved oxygen. This view is supported by several workers (Munawar, 1970; Khan and Siddiqui, 1971; Mandal and Hakim, 1975; Mehra, 1976; Khan *et al.*, 1978; Zutshi and Khan, 1988). The free CO_2 in Nanpur fish pond ranged between 3.10 ±0.20 ppm to 4.53 ±0.25 ppm, while it was fluctuated from 3.43 ±0.21 ppm to 5.53 ±0.74 ppm and 2.97 ±0.32 ppm to 4.77 ±0.21 ppm in Shahjahanpur and Kithore fish ponds, respectively.

The significant positive correlation between the cyanobacterial diversity and micronutrients (zinc and nitrite) was observed by Govindasamy & Azaraiah (1999). In the present study, the significant positive correlation of cyanobacterial density was observed with total phosphate (r=0.532, P<0.01; r=0.866, P<0.001 and r=0.813, P<0.001 in Nanpur, Shahjahanpur and Kithore fish ponds respectively) and nitrate-nitrogen (r=0.911, P<0.001; r=0.944, P<0.001 and r=0.990, P<0.001 in Nanpur, Shahjahanpur and Kithore fish ponds respectively). Hence the present study concluded in spite of the fact that the cyanobacteria are universal, their population dynamics are greatly influenced by the available nutrients and the physico-chemical conditions of the ecosystem.

Biological oxygen demand (BOD) affects the metabolism of aquatic organisms. BOD was found fluctuating from 12.33 ±1.15 ppm to 96.00 ±8.00 ppm, 12.33 ±2.08 ppm to 95.00 ±8.19 ppm and 14.00 ±3.61 ppm to 88.33 ±2.52 ppm in Nanpur, Shahjahanpur and Kithore fish ponds respectively. According to Ray *et al.* (1966) and Tandon and Singh (1972), BOD lowers down due to the sewage addition in ponds. The BOD was observed maximum in summer months and decreased to a minimum in winters in all the ponds. Similar trend was observed in BOD fluctuation during whole study. Welch (1952) reported positive correlation between BOD and DO, however BOD has shown a negative correlation with DO in the present study (r=-0.510, P<0.02; r=-0.517, P<0.01 and r=-0.762, P<0.001 in Nanpur, Shahjahanpur and Kithore fish ponds respectively).

In the present study, a positive relationship was found between the concentration of nitrate nitrogen and DO, thus the present observation did not support the view of Munawar (1970).

Phosphates act as limiting factor in enhancement of aquatic productivity and more amounts of inorganic phosphate can be attributed from the surrounding areas as observed by Michael (1969), Mehra (1976) and Zutshi and Vass (1978) in the water of Dal Lake. These observations strongly support the findings recorded in the present study.

REFERENCES:

APHA AWWA WEF (1995). Standard methods for the examination of water and waste water. *American*

Public Health Association, *American Water Works Association and Water Environment Federation,* Washington, D.C. 20005.

Bartram, J.; Carmichael, W.W.; Chorus, I.; Jones, G. and Skulberg, M.O. (1999). Introduction. In: *Toxic Cyanobacteria in Water: A Guide to their public health consequences, monitoring and management*, W.H.O.: 1-5.

Boyd, C.E. (1982). *Water Quality Management for Pond Fish Culture*. Elsevier Scientific Publishing Company, Amsterdam, Oxford, New York: 318 pp.

CIFA (2007). *Vision 2025: CIFA Perspective Plan* (eds., N. Sarangi, J.K. Jena, P.K. Sahoo & B.K. Das), Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar, India: 1-64.

Govindasamy, C. and Azariah, J. (1999). Seasonal variation of heavy metals in coastal water of the Coromandel Coast, Bay of Bengal, India, *Indian J. Mar. Sci.* 28: 249-256.

Kajak, J.D. (1961). Profundal benthic fauna in lakes Taily and Grajewko. *Ekd. Polska Ser. A* 9: 343-353.

Khan, A.A. and Siddiqui, A.Q. (1971). Primary production in a tropical fish pond at Aligarh, India. *Hydrobiologia* 37: 447-456.

Khan, A.A.; Siddiqui, A.Q.; Musharraf, A. and Hameed, T. (1978). Physical and biological characteristics of a pond Chantal. *Zool. Res.*, Aligarh 2: 1-13.

Mandal, B.K. and Hakim, A. (1975). Ecological studies on a tropical fish pond. I. Certain physicochemical factors. *Indian J. Zootomy* 16: 37-42.

Mehra, N.K. (1976). Limnological studies in the Lake Bhalaswa, a shallow tropical lake in Delhi. *J. Natcon* 12 (2): 211-216.

Michael, R.G. (1969). Seasonal trend in physicochemical factors and plankton of freshwater fish pond and their role in fish culture. *Hydrobiologia* 33: 144-160.

Munawar, M. (1970). Limnology studies on freshwater ponds of Hyderabad, India. I. The biotope. *Hydrobiologia* 35:127-162.

Odum, E.P. (1971). *Fundamentals of ecology*. W.B. Saunders Co., Philadelphia.

Pingale, S.D. and Deshmukh, B.S. (2005). Some fresh water algae from Amphitheatre of Wilson Dam. *Indian Hydrobiol.* 7: 97-100.

Rani, G.K.; Indhumathy and Revathi, K.S. (2005). Water characterization and freshwater algae of Chitlapakkam. *Indian Hydrobiol.* 7: 143-146.

Ray, P.S.; Singh, S.B. and Sehgal, K.L. (1966). A study of some aspects of ecology of the rivers, Ganga and Yamuna at Allahabad (U.P.) in 1958-59. Proc. *Nat. Acad. Sci.*, India, Sec. B 36 (3): 235-272.

Rippka, R.J.; Deruelles, J.; Waterbury, J.B.; Herdman, M. and Stanier, R.Y. (1979). Generic assignments, strain histories and properties of pure cultures of cyanobacteria. *J. Gen. Microbiol.* 111: 1-61.

Roberts, C.H.; Grindley, J. and Williams, E.H. (1940). Chemical methods for the study of river pollution. HMSO Fishery Investigations series I, Ministry of Agriculture & Fisheries, London 4 (2): 182 pp.

Singh, V.P. (1960). Phytoplankton ecology of the inland waters of Uttar Pradesh. *Proc. Symp. Algal.* ICAR, New Delhi: 243-271.

Srivastava, V.K. (1956). Studies on the freshwater bottom fauna of North India, quantitative fluctuation and qualitative comparison of benthic fauna in a lake in Lucknow. *Proc. Nat. Acad. Sci. Sect. B* 25: 406-416.

Staley, J.T.; Bryant, M.P.; Pfennig, N. and Holt, J.G. (1989). *Bergey's Manual of Systematic Bacteriology.* Vol. 3, Williams & Wilkins, Baltimore.

Subha, T.S. and Chandra, S. (2005). Temple tanks, their status and algal biodiversity. *Indian Hydrobiol.* 7: 123-127.

Tandon, K.K. and Singh, H. (1972). Effect of certain physicochemical factors on the plankton of Nangal Lake. *Proc. Indian Acad. Sci.* 76: 15-25.

Tebbutt, T.H.Y. (1999). Principles of Water Quality Control. Butterworth Heineman Publishing Ltd.: 280 pp.

Trivedy, R.K. and Goel, P.K. (1984). Chemical and biological methods for water pollution studies. *Environmental Publications*: 247.

Vasisht, H.S. and Bhandal, R.S. (1978). Seasonal variation of benthic fauna in some North Indian lakes and ponds. *Indian J. Ecol.* 6 (2): 33-37.

Welch, P.S. (1952). *Limnology*. McGraw Hill Book Co. Inc., New York: 405-442.

Zutshi, D.P. and Vass, K.K. (1978). Limnological studies on Dal Lake, Chemical Features. *Indian J. Ecol. 5* (1): 90-97.

Zutshi, D.P. and Khan, A.V. (1988). Eutrophic gradient in the Dal Lake, Kashmir. *Indian J. Environ. Hlth.* 30 (4): 348-354.