

## Assessing the Phytoplankton Population of Hard Water Ponds in Eastern Kolkata, India

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Received 3 November 2016 ; Accepted 5 December 2016 ; Published online 23 December 2016

**Abstract** A year round study was carried out to investigate the phytoplankton diversity of three hard water ponds in Eastern Kolkata from July 2014 to June 2015. During this investigation four groups of phytoplankton such as Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae were recorded and among them Chlorophyceae was the dominant group. Phytoplankton population ranged from 3834.34 to 7692.67 no./l were recorded in different months in three ponds. The hardness of three water bodies ranged from  $211 \pm 3.05$  to  $478 \pm 2.00$  mg/l. The nutrient content including phosphate phosphorus and nitrate-nitrogen were varied from  $0.14 \pm 0.020$  to  $1.46 \pm 0.03$  mg/l and  $0.12 \pm 0.03$  to  $0.86 \pm 0.00$  mg/l in three ponds. Other parameters like DO content varied from  $2.27 \pm 0.23$  to  $6.4 \pm 0.20$  mg/l, TS varied from  $450.75 \pm 1.29$  to  $2333 \pm 2.64$  mg/l, TDS varied from  $428.32 \pm 0.388$  to  $2272.2 \pm 0.346$  mg/l GPP varied from  $45.96 \pm 0.83$  to  $153.67 \pm 2.96$  mg  $\text{Cm}^{-3}\text{hr}^{-1}$  and NPP varied from  $30.833 \pm 0.381$  to  $142.75 \pm 2.25$  mg  $\text{Cm}^{-3}\text{hr}^{-1}$ . The Pearson correlation revealed that the total phytoplankton population was significantly variance ( $p \leq 0.05$ ) in all the months and ponds studied.

**Keywords** Hard water body, Hydrological parameters, Phytoplankton.

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### Introduction

Phytoplankton, an integral component of aquatic food webs which are grazed by zooplankton and constitute an important link in energy flow [1]. Variation in phytoplankton community composition depends on the availability of nutrients, temperature, light intensity and other limnological factors and it forms the basic link in the food chain of an aquatic ecosystem and virtually all the dynamic features of lakes such as color, clarity, trophic state, zooplankton and fish production depend to a large extent on the phytoplankton. Phytoplankton are important indicators of the ecological status of a water body and their composition and dynamics play an important role in biodiversity and energy flow in lake ecosystem. The quality and quantity of phytoplankton and their seasonal successional patterns have been successfully utilized to assess the quality of water [2]. Among the chemical parameters of water hardness has been given less importance in many studies but its effect in fish production and fish food organism needs detailed attention. Therefore present study draws an attention to the relative impact of water quality parameter in particularly hardness on phytoplankton community in hard water body.

### Materials and Methods

#### Study site

The study area was located in East Kolkata in South 24 Parganas (Latitude  $22^{\circ} 28' 35''$  N,  $22^{\circ} 28' 47''$  N, 22



Fig. 1. Map of the study area.

$28^{\circ}48''$  N and longitude  $88^{\circ}23'5''$  E,  $88^{\circ}24'5''$  E,  $88^{\circ}24'3''$  E) where hard water pond is a serious problem (Fig. 1). It comes under costal alluvial soil zone where the surface water is slightly saline and rainwater is the major source of water. Three ponds were selected for the experimental purpose. Pond-1 (Panchasayar Lake) is situated behind Ambuja complex, is misused by local people by dumping statue after puja festival and people are used for various purposes such as bathing with soap, utensil and cloth washing. Pond 2 and 3 were situated in the Faculty of Fishery Sciences, West Bengal University of Animal and Fishery Sciences at Chakgaria campus having fishery activities. The average area of three ponds was  $18000\text{ m}^2$ ,  $2928\text{ m}^2$  and  $4680\text{ m}^2$  respectively. The water as well as plankton samples were collected once a month over a period of one year (July 2014 to June 2015).

#### Physico-chemical analysis

Water samples for the estimation of dissolved oxygen (DO) were collected directly in BOD bottles, and were fixed immediately according to the standard protocol. Other parameters such as temperature (by using dial thermometer), transparency (by using Secchi disc), free  $\text{CO}_2$  [3] and pH (Pocket Digital pH Meter) were recorded at the time of sample collection. For analysis of the remaining parameters (such as DO, total dissolved solid or TDS, hardness, alkalinity, phosphate, nitrate and conductivity), surface water

samples were collected in clean 11 bottles. All the parameters were analyzed in laboratory, within 4–6 h of collection and whenever overnight storage was required, samples were stored at  $4^{\circ}\text{C}$  to minimize microbial activity. The procedures were adopted according to the standard methods for the examination of water and wastewater [3] for analysis of all the physicochemical parameters except nitrates and productivity. Nitrates were analyzed according to EPA approved Brucine Method [4]. The total primary productivity (gross and net primary productivity) was determined by light and dark bottle method [5].

#### Phytoplankton analysis

Phytoplankton were collected at monthly interval by filtering 10 liters of water by plankton net (made up of  $60\ \mu$  meshed nylon bolting silk cloth framed with metal). Immediately after collection, the plankton were preserved in 4% formalin. The counting of phytoplankton were done according to direct census method [6]. A Sedgwick rafter plankton counting cell which is divided into 100 equal squares made to hold 1 ml of sample. Phytoplankton present in 10 squares in the vertical row and 10 squares in the horizontal row were randomly counted and identified and results were expressed in no/l.

#### Statistical analysis

The data generated from the investigation were

**Table 1.** Range of water quality parameters (mean  $\pm$  SD) in different ponds during experimental period.

Water parameters	P-1	P-2	P-3
pH	6.52 $\pm$ 0.01-7.50 $\pm$ 0.01	7.05 $\pm$ 0.02-7.53 $\pm$ 0.06	6.81 $\pm$ 0.01-7.67 $\pm$ 0.01
Water temperature (°C)	19.13 $\pm$ 0.05-33.27 $\pm$ 0.11	18.87 $\pm$ 0.05-33.67 $\pm$ 0.15	19.73 $\pm$ 0.05-33.13 $\pm$ 0.05
DO (mg/l)	2.27 $\pm$ 0.23-5.53 $\pm$ 0.11	2.4 $\pm$ 0.20-5.63 $\pm$ 0.15	2.27 $\pm$ 0.16-6.4 $\pm$ 0.20
Alkalinity (mg/l)	114 $\pm$ 2.0-189.67 $\pm$ 3.51	131 $\pm$ 1.0-261.67 $\pm$ 1.52	121.67 $\pm$ 1.52-263.33 $\pm$ 2.08
Hardness (mg/l)	211 $\pm$ 3.05-280 $\pm$ 1.0	234 $\pm$ 2.64-478 $\pm$ 2.0	217 $\pm$ 3.05-454 $\pm$ 1.15
Transparency (cm)	15.43 $\pm$ 0.01-44.37 $\pm$ 0.20	14.83 $\pm$ 0.05-37.1 $\pm$ 0.10	13.49 $\pm$ 0.01-33.20 $\pm$ 0.17
Conductivity ( $\mu$ Simen)	1476 $\pm$ 2.64-1912.33 $\pm$ 1.52	1631.67 $\pm$ 2.08-2451.67 $\pm$ 4.04	1857 $\pm$ 1.73-3302.33 $\pm$ 1.52
TS (mg/l)	450.75 $\pm$ 1.29-1277 $\pm$ 5.19	1043.33 $\pm$ 3.05-2073.67 $\pm$ 3.21	985.92 $\pm$ 4.44-2333 $\pm$ 2.64
TDS (mg/l)	428.3167 $\pm$ 0.38-1152.85 $\pm$ 1.03	981.48 $\pm$ 0.41-1950.92 $\pm$ 1.01	825.32 $\pm$ 0.26-2272.2 $\pm$ 0.34
Free CO <sub>2</sub> (mg/l)	10.07 $\pm$ 2.00-24.87 $\pm$ 1.02	14.67 $\pm$ 2.30-24.07 $\pm$ 0.11	13.63 $\pm$ 0.63-24.8 $\pm$ 1.05
Phosphate (mg/l)	0.14 $\pm$ 0.02-0.89 $\pm$ 0.011	0.36 $\pm$ 0.015-0.75 $\pm$ 0.015	0.17 $\pm$ 0.011-1.46 $\pm$ 0.025
Nitrate (mg/l)	0.12 $\pm$ 0.02-0.50 $\pm$ 0.01	0.14 $\pm$ 0.01-0.80 $\pm$ 0.03	0.15 $\pm$ 0-0.86 $\pm$ 0.00
GPP (mg/l)	60.08 $\pm$ 5.12-91.92 $\pm$ 2.67	45.96 $\pm$ 0.83-149.29 $\pm$ 3.98	91.17 $\pm$ 1.15-153.67 $\pm$ 2.96
NPP (mg/l)	30.83 $\pm$ 0.38-112.63 $\pm$ 2.62	48.67 $\pm$ 2.98-142.75 $\pm$ 2.50	32.42 $\pm$ 2.46-132.75 $\pm$ 2.88

tested for significance of variance among the different study areas during different months of the year through two factors (ANOVA) analysis of variance based on randomized complete block design. Statistical differences were considered significant when  $p \leq 0.05$ . Pearson's correlation analysis was conducted to determine the relationship between physico-chemical parameters with the plankton population in different months.

## Results and Discussion

### Physico-chemical analysis

The physico-chemical parameters of treatment water during experiment period have been shown in Table 1. The temperature ranged from 18.87 $\pm$ 0.05 °C to 33.67  $\pm$  0.15 °C was suitable for the development of the planktonic organisms [7]. The maximum DO was during the winter and minimum during the summer season. This present findings justify the earlier findings [8, 9]. Seasonally, the pH was maximum during summer and minimum during winter and similar re-

sults were reported by Dutta and Patra [9] which might be due to the low level of water and high photosynthesis of micro-macro organisms resulting in high production of free CO<sub>2</sub> which make the water a little alkaline. The total hardness value was maximum during summer and minimum in winter season in pond 2 and 3 and similar findings had been observed by Harney et al. [10]. The higher values of total hardness in summer could be due to higher temperature which increases the concentrations of salts by excessive evaporation. Kaur and Sharma [11] reported that generally during summer maximum hardness was observed because increase in hardness value during summer could be attributed to the decrease in water volume and increased rate of evaporation. Seasonally, the total alkalinity was maximum in monsoon and minimum in summer. Similar findings had been reported by Harney et al. [10] who also observed that the total alkalinity was minimum in summer and maximum in monsoon in Pindavani pond. The maximum TDS was recorded in May (summer) in the pond 3 and this may be due to heavy rainfall and minimum TDS in the month of April (summer) in the pond 1.

**Table 2.** Quantitative analysis of phytoplankton (no./l) during the study period.

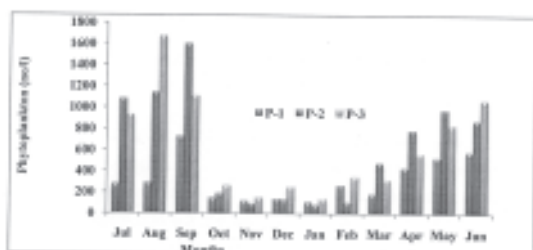
Plankton Month	Chlorophyceae			Bacillariophyceae			Euglenophyceae		
	P-1	P-2	P-3	P-1	P-2	P-3	P-1	P-2	P-3
Jul 2014	70.0	686.0	378.0	65.3	0.0	172.6	144.6	396.6	382.6
Aug	289.3	1143.3	954.0	0.0	0.0	102.6	0.0	0.0	476.0
Sep	507.3	1283.3	807.3	0.0	0.0	303.3	224.0	322.0	0.0
Oct	102.6	32.6	51.3	18.6	93.3	74.6	28.0	66.0	140.0
Nov	84.0	56.0	107.3	0.0	37.3	0.0	0.0	0.0	0.0
Dec	56.0	51.3	88.6	51.3	84.0	168.0	32.6	0.0	0.0
Jan 2015	70.0	32.6	70.0	42.0	0.0	70.0	0.0	0.0	0.0
Feb	228.6	51.3	186.6	0.0	0.0	163.3	0.0	0.0	0.0
Mar	112.0	60.6	322.0	0.0	93.3	0.0	74.6	326.6	0.0
Apr	303.3	121.3	65.3	74.6	168.0	93.3	56.0	499.3	410.6
May	303.3	177.3	79.3	0.0	210.0	0.0	228.6	597.3	760.6
Jun	368.6	98.0	140.0	0.0	224.0	93.3	219.3	560.0	840.0

**Table 2.** Continued.

Plankton Month	Cyanophyceae			P-1	Total P-2	P-3
	P-1	P-2	P-3			
Jul 2014	0.0	0.0	0.0	280.0	1082.6	933.3
Aug	0.0	0.0	144.6	289.3	1143.3	1677.3
Sep	0.0	0.0	0.0	731.3	1605.3	1110.6
Oct	0.0	0.0	0.0	149.3	192.0	266.0
Nov	37.3	0.0	46.6	121.3	93.3	154.0
Dec	0.0	0.0	0.0	140.0	135.3	256.6
Jan 2015	0.0	51.3	0.0	112.0	84.0	140.0
Feb	42.0	56.0	0.0	270.6	107.3	350.0
Mar	0.0	0.0	0.0	186.6	480.6	322.0
Apr	0.0	0.0	0.0	434.0	788.6	569.3
May	0.0	0.0	0.0	532.0	984.6	840.0
Jun	0.0	0.0	0.0	588.0	882.0	1073.3

Manjare et al. [12] reported the minimum TDS value in April from Kolhapur district Maharashtra. But in the present study the TDS value was very high and it might be due to organic matter, salts, silts, cations and debris. Seasonally, phosphate phosphorus was high during summer and monsoon and low during winter in pond 2 and similar results were observed by Harney et al. [10]. The high nitrate content was found in July, August and June months and minimum value was found in November and December and almost similar results were also obtained by Manjare et al. [12]. In the present investigation, seasonally free CO<sub>2</sub> was maximum in summer and minimum during winter and similar findings were reported by Gonjari and Patil [13] from Thillaividangan in South Arcot district and Triputi reservoir near Satra, Maharashtra. The present study revealed that the seasonally conductivity was

maximum in summer followed by winter and monsoon which is in agreement with the report of Rajgopal et al. [14] who recorded the high value of EC during June (summer) whereas low during September and this might be due to high temperature, less solubility and high degradation of organic substances. The present investigation revealed that the transparency was maximum during winter season followed by monsoon and summer season where, Sivalingam et al. [15] found the high transparency value during winter. Seasonally, the maximum GPP and NPP were found in the summer and monsoon and minimum in the winter. This might be due to rising temperature which accelerates the nutrient release from the sediment through microbial decomposition, high population of phytoplankton (photosynthetic activity) and these findings was similar to the findings of Chakravarty [16].



**Fig. 2.** Average monthly variation of total phytoplankton (no./l) in three ponds during the study period.

### Phytoplankton analysis

During the study periods four groups of phytoplankton (Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae) were recorded from all three ponds (Table 2). According to Bhatnagar and Devi [17] the total phytoplankton population in three ponds was less to moderate due to high hardness. In the present investigation 84 to 1605.33 no/l of phytoplankton were recorded in  $211 \pm 3.05$  to  $478 \pm 2.0$  mg/l hardness where, Nowrouzi and Valavi [18] found the 5983 no/l of phytoplankton in Kaftar lake and they recorded the hardness was ranged from 117.2 to 288 mg/l. The minimum phytoplankton/l was 112, 84 and 140 in pond 1, 2 and 3 in January whereas ; the maximum phytoplankton number was 731.33, 1605.33 and 1110.66 in pond 1, 2 and 3 in September (Fig. 2). But Karthi et al. [19] found that the maximum phytoplankton population during February and minimum phytoplankton during different months including December, April and August from Vaduvur lake, Tamilnadu. Minimum number of phytoplankton in June and maximum number in March were reported by Ghosh et al.

[20] from Santragachi lake, West Bengal. During the present study Chlorophyceae represented by *Lyngbya*, *Chlorella*, *Spyrogyra*, *Ulothrix*, *Klebsormidium*, *Closterium*, *Zygnema*, *Scenedesmus*, *Clamydomonas*, *Hydrodictyon*, *Proolus*, *Mougeotia*, *Oedogonium*, *Ankisteri* ; Euglenophyceae represented by *Euglena* and *Phacus* ; Bacillariophyceae represented by *Synedra*, *Tabillaria*, *Asterionella*, *Nitzschia* and *Mellosira* ; Cyanophyceae represented by *Oscillatoria*, *Nodularia*, *Aphanizomenon*. Chlorophyceae was the dominant group among phytoplankton followed by Euglenophyceae, Bacillariophyceae and Cyanophyceae where, Sugunan and Bhattachariya [21] reported that Chlorophyceae was dominant component of phytoplankton in beels of Assam.

Chlorophyceae population was maximum in June, September and August and the minimum value of Chlorophyceae was observed during December, January and October in pond 1, 2 and 3. The Bacillariophyceae population was maximum in April, May and September. Euglenophyceae population was maximum in May in all ponds. The Cyanophyceae population was very minimum in all the ponds. The minimum number of Bacillariophyceae was in October, November and January in pond 1, 2 and 3. The Euglenophyceae population was minimum in October in all ponds. Karthi et al. [19] reported that the maximum number of Chlorophyceae was found in the month of February and minimum was in December and maximum Bacillariophyceae was found in the December and minimum in the April. Pandey et al. [22] also found that the maximum density of Chlorophyceae was found in May and minimum density in December but maximum density of Bacillariophyceae found in May and June and minimum in December. They also found the maximum density of Euglenophyceae was

**Table 3.** Analysis of variances (ANOVA) of total phytoplankton in three ponds during the study period.

ANOVA						
Source of variation	SS	df	MS	F	P-value	F crit
Ponds	803315.1	2	401657.5	6.745776	0.005191	3.443357
Months	4682948	11	425722.5	7.149944	4.96E-05	2.258518
Error	1309926	22	59542.08			
Total	6796188	35				

in October and minimum in June from swamp of Purnia, Bihar. During the present study, the Pearson correlation revealed that the total phytoplankton population was significantly variance ( $p \leq 0.05$ ) in all the months and ponds (Table 3).

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