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PJBS

ISSN 1028-8880

Pakistan Journal of Biological Sciences

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Biological Sciences 10 (6): 868-873, 2007
ISSN 1028-8880

A Preliminary Observation on Water Quality and Plankton of an Earthen Fish Pond in Bangladesh: Recommendations for Future Studies

[1,2]Md. Yeamin Hossain, [1]Saleha Jasmine, [1]Abu Hanif Md. Ibrahim,
[3]Zoarder Faruque Ahmed, [2]Jun Ohtomi, [2]Bernerd Fulanda,
[4]Momtaz Begum, [5]Abdullahil Mamun, [6]Mohamed A.H. El-Kady and [3]Md. Abdul Wahab
[1]Department of Fisheries, Faculty of Agriculture, University of Rajshahi, Rajshahi-6205, Bangladesh
[2]Laboratory of Aquatic Resource Science, Faculty of Fisheries,
Kagoshima University, 4-50-20 Shimoarata, Kagoshima 890-0056, Japan
[3]Department of Fisheries Management, Faculty of Fisheries,
Bangladesh Agricultural University, Mymensingh-2202, Bangladesh
[4]Bangladesh Fisheries Research Institute, Brackishwater station, Paikgacha, Khulna-9280, Bangladesh
[5]Fishery Officer, Agro Industrial Trust, Dhaka, Bangladesh
[6]Laboratory of Marine Biotechnology, Faculty of Fisheries, Kagoshima University,
4-50-20 Shimoarata, Kagoshima 890-0056, Japan

Abstract: The present study provides a characterization of water quality and plankton samples in earthen fish pond in Rajshahi, Bangladesh. Sampling was done over a period of six months, running from October, 2004 through March, 2005. All the water quality parameters were within the optimal ranges for plankton productivity. Temperatures varied from 19.75 to 27.25°C; transparency, 24.75-29.50 cm; pH, 6.62-7.85; Dissolved Oxygen (DO), 3.87-5.85 mg L^{-1}; free CO_2 5.25-7.25 mg L^{-1} and bicarbonate (HCO_3) alkalinity, 81.25-147.5 mg L^{-1}. Analyses of plankton samples recorded a total of 5 classes phytoplankton viz.; Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae, Euglenophyceae and 2 classes of zooplankton; Crustacea and Rotifera. The phytoplankton population was comprised of 17 genera belonging to Cyanophyceae (5 classes, 34.47%), Bacillariophyceae (3, 13.87%), Cyanophyceae (3, 34.48%), Euglenophyceae (3, 10.68%) and 1 to Dinophyceae (6.50%). The zooplankton population consisted of 10 genera belonging to Rotifera (4, 40.13%) and Crustacea (6, 59.87%). Phytoplankton and zooplankton abundance varied from 60800 to 239400 units/1 and 7620 to12160 units/1, respectively. It is concluded that the phytoplankton groups provide the main support for earthen pond aquaculture in the pond compared to zooplankton classes. The information provides for more research to compare water quality and pond plankton characteristics in earthen aquaculture systems with and without fish stocking. Further studies on the seasonal changes of water quality parameters and its effects on plankton production in the fish ponds and all year extended monitoring is recommended in future studies.

Key words: Water quality, Plankton, Earthen fish pond, Bangladesh

INTRODUCTION

Water quality, i.e., the physico-chemical and biological characteristics of water, plays a big role in plankton productivity as well as the biology of the cultured organisms and final yields. Water quality determines the species optimal for culture under different environments (Dhawan and Karu, 2002). The overall productivity of a water body can easily be deduced from its primary productivity, which forms the backbone of the aquatic food chains (Ahmed and Singh, 1989). The plankton community is comprised of the primary producers or phytoplankton and zooplankton; the secondary producers (Battish, 1992). The phytoplankton population represents the biological wealth of a water body, constituting a vital link in the food chain. The zooplankton forms the principal surce of food for fish within the water body (Prasad and Singh, 2003). Both the qualitative and quantitative abundance of plankton in a fish pond are of great importance in managing the successful aquaculture operations, as they vary from location to location and pond to pond within the same

Corresponding Author: Md. Yeamin Hossain, Laboratory of Aquatic Resource Science, Faculty of Fisheries, Kagoshima University, 4-50-20 Shimoarata, Kagoshima 890-0056, Japan
Tel: +81-99-286-4152 Fax: +81-99-286-4133

location even within similar ecological conditions (Boyd, 1982). The physico-chemical attributes of a water body are principle determinants of fish growth rates and development (Jhingran, 1991). Climate has a major influence on water quality and consequently, the biodiversity within the water bodies (Boyd and Tucker, 1998). Good water quality in fish or shrimp ponds is essential for survival and adequate growth (Burford, 1997).

Little or no studies on water quality and plankton in ponds within Rajshahi region of Bangladesh have been done, though similar experiments have been in fish ponds from the Indian sub-continent (Bose and Philops, 1994; Wahab *et al*., 1994; Hossain *et al*., 2006). Therefore, this research reports on preliminary analyses of the water quality parameters and plankton composition and abundance, with some recommendations for further studies in the earthen fish ponds within the Rajshahi region, Bangladesh.

MATERIALS AND METHODS

The experimental pond and physico-chemical parameters: The experiment was carried out over a period of 6 months, ranging from October, 2004 through March, 2005 on rectangular earthen fish pond of area 120 sqare decimal and average water depth of 1.2 m in Rajshahi University Campus, Bangaldesh. The pond was stocked with exotic and indigeous fishes. Lime was applied before the start of the experiments and cow manure, urea and triple super phosphate fertilizers used to enhance plankton productivity. The experimental pond was free from any shading and adequate sunlight through out the day. Water quality parameters and sampling for plankton analyses was done once a week between 09.00-11.00 h from specific points of the pond at a depth of 20 cm below the surface. A mercury thermometer was used to measure both water and air temperature (°C), while Transparency (cm) was measured with a secchi disc of 20 cm diameter. Digital electronic meters (Model YSI-58, USA and Jenway Model-3020) were used to measure dissolved oxygen (DO) (mg L^{-1}) and pH on site, respectively while Total alkalinity (mg L^{-1}) and free carbondioxide (CO_2) (mg L^{-1}) were determined titrimetrically in the laboratory on collected water samples, according to the standard procedures and methods define in APHA (1992).

Plankton sampling and analyses: Sampling of pond water for plankton analyses was done on ten-liter water samples sampled from different areas and depths of the pond and filtered through a 25 μ mesh plankton net. Preservation of the samples before analyses was done by addition of 5% buffered formalin in small plastic bottles, before analyses on a Sedgewick-Rafter counting cell, under a compound binocular microscope (SWIFT M 4000-D).

Analyses involved transfer of 1 mL sub-sample from each of the samples to the Sedgewick-Rafter counter and counting of cells within 10 squares of the cells, chosen randomly. The cell counts were used for compute the cell density using the Striling (1985) formula where the plankton density is estimated by-

$$N = (A\times1000\times C)/(V\times F\times L)$$

Where,

N = No. of plankton cells or units per litre of original water.
A = Total No. of plankton counted.
C = Volume of final concentrate of the samples in ml.
V = Volume of a field in cubic mm.
F = No. of fields counted.
L = Volume of original water in liters.

The plankton were then identified up to the genus level and enumerated by the following (APHA, 1992; Bellinger, 1992). The mean number of plankton was recorded and expressed numerically per litre of water of the pond.

Statistical analysis: The statistical analysis of different physico-chemical and plankton parameters were carried out by using one-way ANOVA and any difference at 5% level of significance using the statistical package of Statgraphics Version 7, while the Microsoft exell® 2002 was used to plots graphs for decimination of the results. The results of the plankton density were expressed as mean±SD.

RESULTS

Physico-chemical parameters: During the study period, water temperatures varied from 30°C at the initial period of the study to lows of 18°C in January with related decrease in Secchi disk depth from 29.59 cm in October to 24.75 cm in February (Table 1). Although temperatures were within the suitable range for plankton production among the months, but the variations were significantly differences ($p<0.05$). Water depths also decreased from 136.9 cm at the start of the experiment in October to 85.5 cm in March and was found to vary significantly ($p<0.05$) among the months during the experimental period. The lowest and highest pH levels were recorded in March and December, at 6.0 and 8.2, respectively. At the start of the experiment, DO levels were generally low, at 3.0 mg L^{-1} in October,

Table 1: Mean±SD values of water quality parameters of freshwater man-made earthen fish ponds of Bangladesh

	WT	AT	Depths	Transparency		DO	CO_2	TA
Months	°C		cm		pH	(mg L^{-1})		
October	28.00±1.91	29.00±1.82	138±2.58	29±1.73	7.25±0.76	3.88±0.63	6.00±4.08	145±25.16
November	23.00±1.29	25.50±1.29	127±5.06	27±1.71	7.40±0.53	4.17±0.17	7.25±5.12	81±8.54
December	21.00±1.41	21.50±2.64	120±5.25	28±1.71	7.85±0.34	5.17±0.23	6.75±5.12	140±11.57
January	19.00±0.81	18.50±1.29	104±3.74	27±0.96	7.25±0.45	5.85±0.31	6.30±3.00	96±7.36
February	19.75±0.50	22.00±0.81	94±3.30	25±1.71	7.05±0.68	5.17±0.31	5.25±3.60	147±15.54
March	22.00±1.41	24.00±1.41	89±2.93	25±1.15	6.62±0.49	5.47±0.51	5.47±3.52	120±18.43

WT, Water Temperature; AT, Air Temperature; DO, Dissolved Oxygen; CO_2, Carbon Dioxide; TA, Total Alkalinity

Table 2: Monthly abundance and composition (%) of phytoplankton and zooplankton (cells L^{-1}) of the pond

	2004			2005			
Plankton groups	October	November	December	January	February	March	(%)
Phytoplankton							
Navicula sp.	22800	9000	11400	1200	1200	18600	61.20
Nitzschia sp.	5400		4200	1700	9600		19.90
Pinnularia sp.	3000	5400	2400		8400	600	18.90
Bacillariophyceae	**31200**	**14400**	**18000**	**2900**	**19200**	**29200**	**100**
Chlorella sp.	1200	1800	600	2400		2400	3.22
Cosmarium sp.	10200		16800	2700	27600	11400	26.33
Spirogyra sp.	2400	37400	4800	3600	24600	44400	44.92
Ulothrix sp.	600	1200	4200		27600		12.88
Volvox sp.		1800	3000	10200	1200	16800	12.65
Chlorophyceae	**14400**	**42200**	**29400**	**18900**	**81000**	**7500**	**100**
Anabaena sp.	6600	11400	3600	17400	55200	94200	36.11
Mycocystis sp.		10800	4200	2400	4800	14400	14.04
Nostoc sp.	16800	2400		17400	4800	1200	16.34
Oscillatoria sp.	600		2200	4200	16800	27600	19.71
Rivulatoria sp.	12000	1160		2400	19800	600	13.80
Cyanophyceae	**36000**	**25760**	**10000**	**43800**	**10400**	**43800**	**100**
Peridinium sp.	25200	18000	-	1200	600	4200	100
Dinophyceae	**25200**	**18000**	-	**1200**	**600**	**4200**	**100**
Euglena sp.	14400	7200	1600		17400	600	51.00
Phacus sp.	4200	5400		3000	19800		40.10
Trachelomonas sp.	1200	600	1800	2400		1200	8.90
Euglenophyceae	**19800**	**13200**	**3400**	**5400**	**37200**	**1800**	**100**
Zooplankton							
Daphnia sp.	2400	1400		1200	600	1100	21.83
Moina sp.	600		1400	2100	1200	800	12.16
Cyclops sp.	1200	2400	1400	800	600	960	15.90
Diaptomus sp.		1200	600	1400		900	12.16
Diaphonosoma sp.		800	760	1200	1200	1400	19.87
Mesocyclops sp.	1200	1200	1100		600		18.09
Crustacea	**5400**	**7000**	**5260**	**6500**	**4200**	**5160**	**100**
Asplanchna sp.	2400	600	800	900		700	23.87
Brachionus sp.	1400	2100	600		1200	800	26.97
Keratella sp.		1200	960	600	1400	1200	23.70
Notholca sp.	1600	1260		900	1200	800	25.46
Rotifera	**5400**	**5160**	**2360**	**2400**	**3800**	**3500**	**100**

increasing to 6.1 mg L^{-1} in January. However, free CO_2 showed a downward trend during the study, from 7.5 measured in November to 5.2 in February. The variations in pH, DO and CO_2 in the experimental ponds were similar and within the productive range during study period, although bicarbonate alkalinity which increased from 70 to 165.0 mg L^{-1} and was found to vary significantly ($p<0.05$) among the months during the same study period.

Plankton: The plankton population was identified up to genus level and re-grouped into the various classes or groups as shown in Table 2. Monthly variations of total phytoplankton and zooplankton in the fish ponds of Bangladesh during October, 2004 to March, 2005 are shown in Fig. 1 and 2, respectively. The phytoplankton population was comprised of 17 genera of which falling into five major groups; Bacillariophyceae, Chlorophyceae, Cyanophyceae, Dinophyceae and Euglenophyceae. Within these groups, Chlorophyceae was the most dominant at 34.48% followed by Cyanophyceae at 34.46%; Bacollariophyceae, 13.87%); Eulenophyceae, 10.68% and Dinophyceae, 6.50%. Comparison of percentage among different phytoplankton groups of the

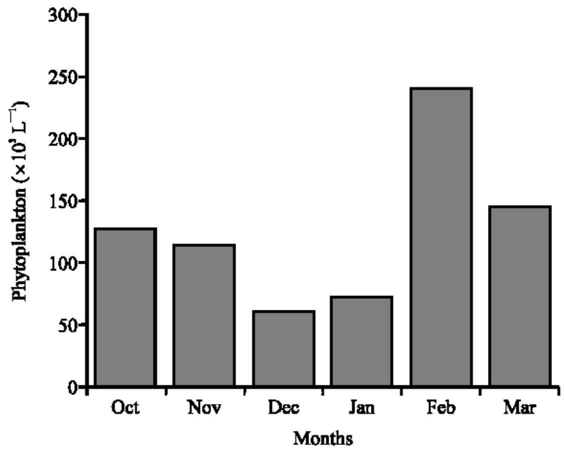

Fig. 1: Monthly variations of total phytoplankton in the fish pond of Bangladesh

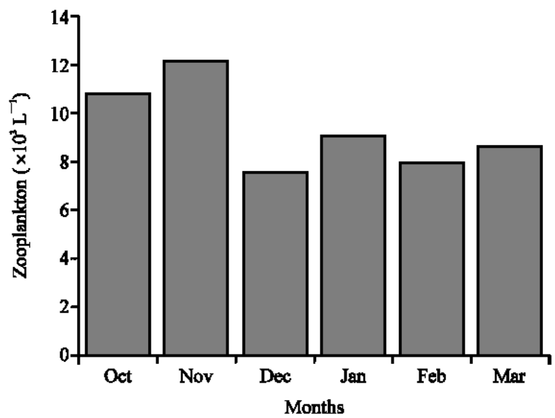

Fig. 2: Monthly variations of total zooplankton in the fish pond of Bangladesh

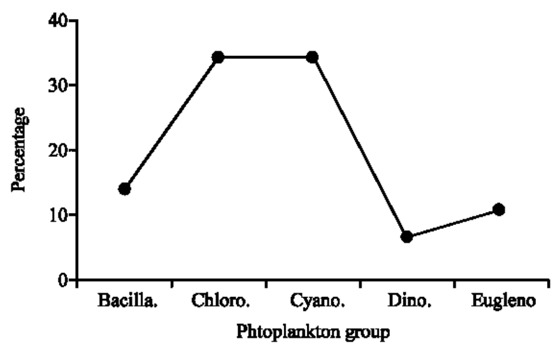

Fig. 3: Comparison of percentage among different phytoplankton groups of the fish pond

fish pond during October, 2004 to March, 2005 is shown in Fig. 3. The zooplankton population consisted of 10 genera, with 4 belonging to Rotifera (40.13%) and 6 to Crustacea (59.87%). Total phytoplankton population were significantly higher ($p<0.05$) in the month of February followed by March, October, November, December and January. On contrast, in case of zooplankton abundance, total zooplankton was significantly ($p<0.05$) higher in the month of November followed by October, December, January, February and March.

DISCUSSION

Water quality parameter and plankton density: During the study period, variations in water temperature are attributed to weather conditions and statistical tests showed significant differences ($p<0.05$) in temperatures over the months. The observed temperatures are within the optimal ranges for (18.3-37.8°C) for production of plankton in tropical ponds (Jhingran, 1991; Begum *et al*., 2003). However Boyd (1982) recommends optimal temperatures for fish culture, in the range of 26.06-31.97°C, if fish growth and consequently yields are to be optimized. Similarly, secchi disk depths recorded (24-30 cm) showed no significant difference, implying that plankton abundance and productivity levels were similar through out all months during the study period. Reid and Wood (1979) reported that the transparency of water depends on several factors such as silting, plankton density, suspended organic matter, latitude, season and the angle and intensity of incident light. Measurements of both air and water temperature showed similar trends and this may be attributed to the small size of ponds, with water temperatures responding fast to any changes in air temperature as observed in Table 1. Similar resultings are reported by Welch (1952) who add that water temperatures in small ponds shows similar variations as the atmospheric temperatures. A similar correlation was also observed between temperature and plankton abundance with hotter months recording higher plankton abundance. However Sreenivasan (1964) further reported that peaks of plankton abundance occur at different periods in different years. It should also be noted that temperature alone may not account for variations in plankton densities as other factors such as high pH, alkalinity, carbon dioxide and nutrients are also responsible for the organic production (Pulle and Khan, 2003).

The variations in monthly densities of total phyto- and zooplankton are therefore attributed to wide range of physico-chemical parameters including as temperature, dissolved oxygen, carbon dioxide and total alkalinity. The dominance in plankton species during the various months of the study period was observably attributed to variations in the optimal conditions for the particular species. Phytoplankton and zooplankton abundance varied from 60800 to 239400 cells L^{-1} and 7620 to 12160 cells L^{-1}, respectively in the pond and the mean abundance of phytoplankton was significantly higher ($p<0.05$) than zooplankton during the study period. The results of the present study showed that acceptable ranges of water quality parameters influence the growth of both phyto- and zooplankton groups. Margalef (1964) also reported that the phytoplankton population in nutrient rich waters is more diverse than those in nutrient deficient waters. Verma and Shukla (1970) recorded 30 genera of phytoplankton from Kamala Nehru Tank, Muzaffarnagar, India. Similarly, Hossain *et al.* (2006) recorded 38 genera of phytoplankton and 13 genera of zooplankton during a three month study period in earthen fish ponds within the Mymensingh region, Bangladesh.

In the study, Chlorophyceae dominated the phytoplankton groups, followed by Cyanophyceae, Bacillariophyceae, Euglenophyceae and Dinophyceae in the pond. This is attributed to favorable water quality attributes, particularly high levels of total alkalinity recorded during the study. Similar findings where high phytoplankton density is recorded are also reported by Seenayya (1971). The effects of fertilizer application and frequent water change to avoid development of anoxic pockets within the pond are also to account for these high levels of plankton productivity observed in the pond. Hossain *et al.* (2006) also reports high densities of plankton while working on fish ponds within the Mymensingh region, Bangladesh Mainly 2 groups of zooplankton Rotifera and Crustacea were identified in present study.

The results of the present study showed that optimal water quality attributes especially in relation to total alkalinity has a strong positive influences the growth of phytoplankton and zooplankton groups in earthen fish pond. A detailed description of the dynamics of plankton within the pond hasn't been given in this study since the samples only cover a period of 6 months. Hence there is a need to carry out successive studies to look at the dynamics of the plankton groups within the earthen ponds sampled over several years in order to fully characterize the variations both due to water quality and variability in climatic conditions. This information is useful for the future research as a foundation study towards characterization of these dynamics within the ponds of the Rajshahi, Bangladesh.

ACKNOWLEDGMENTS

The authors wish to acknowledge the Chairman, Department of Fisheries, University of Rajshahi, Bangaldesh for the financial supports to carry out this research. This research is the part of Thesis for A.H.M. Ibrahim, Masters student of the University of Rajshahi, Bangaldesh. Also the authors would like to express the acknowledgments to the Editor-in-Chief, PJBS and anonymous referees for their useful comments.

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