Dhaka Univ. J. Biol. Sci. **20**(1): 31-39, 2011 (January)

PHYSICO-CHEMICAL ASPECTS OF *CHANDBILL* OXBOW LAKE OF MEHERPUR, BANGLADESH*

A.K.M. NAZRUL KABIR AND M. NIAMUL NASER[1]

Advanced Fisheries Research Laboratory (AFRL), Department of Zoology, University of Dhaka, Dhaka-1000, Bangladesh

Key words: Physico-chemical aspects, Oxbow lake, Meherpur

Abstract

Some physico-chemical parameters of *Chandbill Baor*, a natural oxbow lake of Meherpur district were studied from September 2006 to August 2007. Air temperature of the study area varied from 18.10 to 32.10°C ($\bar{x}$ ± SE : 27.73 ± 1.22°C). The Water temperature (17.10 to 32.10°C; $\bar{x}$ ± SE: 28.24 ± 1.32°C), Secchi disc depth (8.89 to 53.34 cm; $\bar{x}$ ± SE : 26.19 ± 4.29 cm), water depth (132.08 to 307.34 cm; $\bar{x}$ ± SE : 183.93 ± 13.88 cm); total alkalinity (51.3 to 85.5 mg/l; $\bar{x}$ ± SE : 68.4 ± 3.64 mg/l), total hardness (85.5 to 188.10 mg/l; $\bar{x}$ ± SE : 125.81 ± 9.38 mg/l), dissolved oxygen (5.0 to 12.0 mg/l; $\bar{x}$ ± SE: 8.42 ± 0.62 mg/l), free CO_2 (5.0 to 30.0 mg/l; $\bar{x}$ ± SE : 14.58 ± 2.64 mg/l), pH (8.0 to 10; $\bar{x}$ ± SE : 8.54 ± 0.19), ammonia-nitrogen (0.3 to 0.7 mg/l; $\bar{x}$ ± SE: 0.46 ± 0.04 mg/l) in the '*Baor*' water were found to be suitable for survival of aquatic fauna. Nitrite-nitrogen was absent in the '*Baor*' throughout the year. Positive correlations were observed in between air and water temperature (r = 0.978); free CO_2 and Secchi depth (r = 0.839), free CO_2 and water depth (r = 0.714); water depth and Secchi depth (r = 0.903); total hardness and total alkalinity (r = 0.861) and pH with DO (r = 0.661). However, inverse relations were observed among ammonia-nitrogen with water depth (r = –0.727); ammonia-nitrogen with Secchi disc depth (r = –0.840); dissolved oxygen with free CO_2 (r = –0.636); pH with Secchi disc depth (r = –0.581) and pH with free CO_2 (r = –0.825). The productivity of the lake was found to be medium and could be improved to higher level. Alkaline pH (8.54 ± 0.19) was supposed to be helpful for proper growth and development of fishes and aquatic organisms. This is the first limnological report from a natural '*Baor*' (Oxbow lake) of Meherpur district, Bangladesh.

Introduction

Baor or oxbow lake formed naturally when river-banks constrict across the neck of dead river leaving a crescent like closed waterbodies. The naturally formed *Baor* of Bangladesh are situated in the south-western part of the country and mostly in Jessore, Kustia, Meherpur, Jheniadah, Rajbari and Faridpur districts. At present the total production of fish from the *Baor* was estimated to be 4,778 Metric tones from an area of 5,488 Ha in Bangladesh.(1) *Baor* fisheries include major carps, minor carps, predatory (*Zeol*) fishes, shrimps and small indigenous fish species. The physical and chemical

*A Part of the Ph.D. dissertation of first author (AKMNK). [1]Corresponding author: <mnnaser@univdhaka.edu>.

factors of the water body play a great role in the production.[2-4] Fishes like many aquatic organisms are totally dependent on good water quality for their life support. Poor water quality can cause of massive fish death and is often the major factor contributing to fish diseases.[4] Physico-chemical conditions do not remain constant throughout the year and any change of physico-chemical factors of water may affect the growth, development and maturity of fish.[5] The management of oxbow lakes of Bangladesh has immense importance to support and conservation of the aquatic life in the water bodies. To employ scientific management of the *Baor* a detailed investigation and understanding of physico-chemical conditions of water become the foremost task. There is no published limnological data of *Baor* of Meherpur district but some important work on the limnology of the rivers,[6-9] lakes,[10-15] and ponds[16-19] of Bangladesh have been done. The present work was undertaken to investigate the some important physico-chemical factors of the *Chandbill Baor*, a natural oxbow lake of Meherpur district, Bangladesh.

Material and Methods

Chandbill baor is located very close to Kajla river, at village Chandbill of Amjhupi union, Sadar upazilla, Meherpur district (Fig. 1). Three stations (A,B and C) were selected for sampling. The *Baor* is more or less rectangular in shape with an area of 37.90 ha and it is surrounded by paddy fields. The depth of the *Baor* varied from 132.08 to 307.34 cm.

Fig. 1. Satellite Image showing the sampling sites (A, B and C) of the study area at *Chandbill Baor*, Meherpur district, Bangladesh (Ref. Google Map, accessed 14 Jan., 2006).

The soil of the *Baor* is clay loamy to sandy loamy with mixed up of organic debris. The villagers use the *Baor* for bathing, washing, fishing and irrigating paddy field during dry season. The *Baor* is rich in fish fauna and 10 - 12 fishermen engaged in catching indigenous fishes daily in the *Baor*. Presently local '*Matshyajibi Samity*' manage the *Baor* and introduce indigenous and exotic carps following semi-intensive culture method. A fish landing centre has constructed close to *Chandbill Baor* for quick transportation of harvested fishes.

Monthly water samples were collected from approximately 10 - 15 cm below the surface level of water at 100 - 200 cm depth ranges using wooden boat during the study period from September, 2006 to August, 2007. Collection of water was restricted within the reference area (A, B and C shown in Plate 1) of the *Baor*. The bottle was allowed to sink up to the desired depth and its mouth was opened and filled up and the cap locked underwater before taken out of water. Caution was taken to avoid any air bubble in side the bottle. Immediately after collection the water samples were analyzed. Chemical parameters of water such as DO, free CO_2, hardness, alkalinity, pH, ammonia-nitrogen and nitrite-nitrogen of the *Baor* were measured monthly by using HACH water testing kit (Model FF-1A, USA). Water and air temperatures were recorded using mercury thermometer. Water depth was measured with the help of graduated centimeter scale. Transparency was measured by using a Secchi disc of 20 cm in diameter. Statistical analysis was done following methods described by Zar[20]. The mean ($\bar{x}$) is associated with standard error (± SE) value. Correlation was calculated by using SPSS® (Version 11.5, 2007. Systat, Inc. USA), a computer based program for Windows®.

Results and Discussion

Monthly fluctuations, annual range and mean values ($\bar{x}$) and standard error (± SE) of different physico-chemical factors and relationships among the factors are presented in Tables 1 and 2.

Monthly variation of air temperature ranged from 18.1 to 32.1°C ($\bar{x}$ ± SE : 27.73 ± 1.22 °C). Highest air temperature (32.1°C) was recorded in June, 2007 and the lowest (18.1°C) in January, 2007. The fluctuation of water temperature varied from 17.1 to 32.1°C ($\bar{x}$ ± SE: 28.24 ± 1.32°C). The maximum water temperature (32.1°C) was recorded in May, 2007 and minimum (17.1°C) in January, 2007. The water temperature values showed close relationship with the air temperature. Water temperature showed almost an increasing and decreasing trend with air temperature. Similar results were also observed by Roy.[21] It also showed significant strong positive correlation with the air temperature ($r = 0.979$, $p < 0.01$) (Table 2). A similar correlation between air and water temperature was also reported by Chowdhury and Mozumdar[12] and Patra and Azadi.[8] In the winter months water temperature was lower while in summer months it was higher. Dewan[15] observed such variations in BAU Campus Lake.

Table 1. The monthly fluctuation of different physico-chemical parameters with range and mean ($\overline{X}$)values (± SE) of *Chandbill Baor*, Meherpur district, Bangladesh.

Parameters	2006				2007								Range	Mean± SE
	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apl.	May	Jun.	Jul.	Aug.		
Air temp. (°C)	29.7	31.3	27.1	20.8	18.1	26.2	28.7	28.5	30	32.1	30.1	30.2	18.1 - 32.1	27.73 ± 4.24
Water temp. (°C)	31.1	32.1	28.2	21.5	17.1	27.4	30.1	27.3	31.8	32	30.2	30.1	17.1 - 32.1	28.24 ± 4.60
Secchi disc depth (cm)	25.4	44.45	48.22	27.94	22.86	15.24	20.32	12.7	8.89	12.7	20.32	53.34	8.89 - 53.34	26.20 ± 14.90
Water depth (cm)	198.12	231.14	205.71	182.88	170.18	154.94	160.02	160.02	137.16	132.08	167.6	307.34	132.08 - 307.34	183.93 ± 48.10
Total alkalinity (mg/l)	85.5	68.4	85.5	85.5	68.4	68.4	68.4	51.3	68.4	68.4	51.3	51.3	51.3 - 85.5	68.40 ± 12.62
Ammonia nitrogen (mg/l)	0.4	0.3	0.3	0.3	0.4	0.6	0.4	0.6	0.6	0.7	0.6	0.3	0.3 - 0.7	0.46 ± 0.15
Free CO_2 (mg/l)	20	20	30	20	10	5	5	10	0	10	20	25.0	5 - 30	14.58 ± 9.16
DO (mg/l)	6	9	7	9	10	11	10	8	12	6	5	8.0	5 -12	8.41 ± 2.12
Nitrite-N (mg/l)	0	0	0	0	0	0	0	0	0	0	0	0	0 - 0	0.00 ± 00
pH	8	8.5	8	8	8	9	9.5	9	10	8.5	8	8.0	8 - 10	8.54 ± 0.0.69
Total hardness (mg/l)	188.1	119.7	171	153.9	136.8	136.8	102.6	102.6	102.6	102.6	102.6	85.5	85.5 - 188.1	125.81 ± 32.50

The water depth of the *Baor* varied from 132.08 to 307.34 cm ($\bar{x}$ ± SE: 183.93 ± 13.88 cm) with maximum in August, 2007 and minimum in June, 2007. The increasing trend of water depth was related to the Monsoon. Similar observation was made by Michael[22] and Dewan[15] from a tropical water bodies and Bangladesh respectively. Water depth may also be related to other factors. In the present study water depth showed positive correlation with Secchi depth ($r = 0.903$, $p < 0.01$) and free CO_2 ($r = 0.714$, $p < 0.01$) and inverse correlation with ammonia nitrogen ($r = –0.727$, $p < 0.01$) values of the *Baor* water (Table 2).

Table 2. Relationships among the physico-chemical factors of '*Chandbill Baor*', Meherpur district, Bangladesh.

Parameters	Correlation (r)
Water temperature with air temperature	0.978**
Water depth with Secchi disc depth	0.903**
Water depth with free CO_2	0.714**
Water depth with ammonia nitrogen	-0.727**
Secchi disc depth with free CO_2	0.839**
Secchi disc depth with ammonia nitrogen	-0.840**
Secchi disc depth with pH	-0.581*
pH with dissolved oxygen	0.661*
pH with free CO_2	-0.825**
Free CO_2 with dissolved oxygen	-0.636*
Free CO_2 with ammonia nitrogen	-0.640*
Total alkalinity with total hardness	0.861**

*Significant at 5% level. ** Significant at 1% level.

Secchi depth: The Secchi depth or transparency was found to be fluctuated from maximum of 53.34 cm in August, 2007 to a minimum of 8.89 cm in May, 2007 ($\bar{x}$ ± SE : 26.19 ± 4.29 cm). Similar observation was made by Chowdhury and Zaman.[7] Water transparency is generally related to plankton abundance and the range of transparency between 15 and 40 cm was found to be suitable for fish culture.[23] In the present investigation the Secchi depth showed strong positive correlation with water depth ($r = 0.903$, $p < 0.01$) and free CO_2 ($r = 0.839$, $p < 0.01$). It also showed inverse correlation with ammonia nitrogen ($r = –0.804$, $p < 0.01$) and pH ($r = –0.581$, $p < 0.05$) of the water (Table 2). The higher value of transparency might be due to the less number of plankton and suspended materials present in the water which needed further study.

The pH of water always found to be alkaline in nature and it varied between 8.0 and 10.0 ($\bar{x}$ ± SE : 8.54 ± 0.19). Similar result was also reported by Islam *et al*.[24] The highest value of pH (10.0) was recorded in May, 2007 and the lowest (8.0) in September, 2006 and

November, 2006 to January, 2007, July, 2007 and August, 2007. Ahmed *et al.* [11] observed similar result from *Shakla beel*, Brahmanbaria, Bangladesh. The pH value indicated that the water of the *Baor* was always alkaline in nature ($\bar{x}$ ± SE : 8.54 ± 0.19). In the present investigation, pH showed strong and positive correlation with free CO_2 ($r = –0.661$ $p < 0.05$) (Table 2). Similar finding was also observed by Sarker and Rai[25] from Indian water.

Free CO_2 ranged between 0.00 to 30.0 mg/l ($\bar{x}$ ± SE : 14.58 ± 2.64 mg/l). The maximum (30.0 mg/l) value was recorded in November, 2006 and absent in May, 2007. Similar observation was also made by Islam and Mendes,[26] Patra and Azadi[27] and Miah *et al*.[28] in different waterbodies of Bangladesh. In the present investigation free CO_2 showed inverse correlation with dissolved oxygen ($r = -0.636$, $p < 0.05$) and pH ($r = –0.825$, $p < 0.01$) (Table 2). Boyd,[23] Dewan,[15] Chowdhury and Mazumdar[12] also described such relationships in other waterbodies. The low free CO_2 content in May, 2007 was possibly due to low rainfall which caused low decomposition of organic matter and high photosynthesis which consumed free CO_2.. Saha *et al.*[29] also made similar observation from a fresh water fish pond.

Dissolved oxygen contents was found to be fluctuated from a minimum of 5.0 mg/l in July, 2007 to maximum of 12 mg/l in May, 2007 ($\bar{x}$ ± SE : 8.42 ± 0.62 mg/l). The high values of dissolved oxygen recorded in July, 2007 were mainly due to active photosynthesis process by phytoplankton. Similar trend was also recorded by Chowdhury and Mazumdar,[12] Ali *et al.*[30] and Naser *et al*.[18] in different waterbodies of Bangladesh. During the present study dissolved oxygen showed an inverse relationship with free CO_2 ($r = –0.636$, $p < 0.05$) (Table 2).

The value of total alkalinity was found to fluctuate from the minimum of 51.3 mg/l to the maximum of 85.5 mg/l ($\bar{x}$ ± SE : 68.4 ± 3.64 mg/l). The highest value was recorded in September 2006, November, 2006 and December, 2006 and the lowest in April, 2007; July, 2007 and August, 2007. Rahman *et al.*[32] observed similar results from the *Hamil beel*, Bangladesh. Jhingran[5] mentioned that alkalinity values of more than 50 mg/l are most productive. Thus, *Chandbill Baor* can be regarded as nutrient rich water body. In the present study total alkalinity showed a strong positive correlation with total hardness ($r = 0.861$, $p < 0.01$) (Table 2). Similar correlation was found by Arce and Boyd [31] from pond in Alabama, USA. Seasonally, the highest values of alkalinity were observed in winter months. Similar findings were also recorded by Ali *et al*.[30] and Chowdhury and Mazumdar.[12] The low alkalinity recorded during summer months showed similarities with the findings of George.[33] The high alkalinity during winter months was possibly due to low temperature and rainfall.

Total hardness varied from 85.5 to 188.1 mg/l with mean value of ($\bar{x}$ ± SE : 125.81 ± 9.38 mg/l). The highest amount of hardness was recorded in September, 2006 and the lowest in August, 2007. Chowdhury and Mazumder[12] observed similar results in Kaptai

lake. Total hardness showed a strong positive correlation with total alkalinity ($r = 0.861$, $p < 0.01$) (Table 2). The similar observation was also observed by Boyd.[23]

Ammonia-nitrogen ranged from 0.3 to 0.7 mg/l throughout the study period ($\overline{x} \pm SE$: 0.46 ± 0.04 mg/l). The highest concentration of ammonia-nitrogen was recorded in June 2007 and the lowest in October 2006 to December, 2006 and August, 2007. Stavroulakis *et al.*[34] found the maximum ammonia-nitrogen concentration in December and August from the lake Kournas, Greece. In the present investigation, ammonia nitrogen inversely correlated with Secchi depth ($r = –0.840$, $p < 0.01$), water depth ($r = –0.727$, $p < 0.01$) and free CO_2 ($r = –0.640$, $p < 0.05$) (Table 2) which showed dissimilarities with the findings of Boyd.[23]

The productivity of the *Chandbill Baor* was medium to high. The alkaline pH ($\overline{x} \pm SE$: 8.54 ± 0.19) in the *Baor* water was seemed to be helpful for proper growth and development of fishes and aquatic organisms. For detailed limnological information of *Baor* further study is needed.

Acknowledgements

The authors are grateful to Mr. Md. Aktarul Haque, District Fisheries Officer and Mr. Abul Kalam Azad, Assistant Fisheries Officer, Meherpur for assisting with HACH aquaculture water testing kit. They acknowledge the suggestion made by the reviewer which certainly helped in improving the clarity and quality of the paper.

References

1. DoF 2009. Fisheries Statistical Yearbook of Bangladesh, FRSS, Dept. of Fisheries, MOFL, GoB, 42pp.
2. Cole GA 1975. Textbook of Limnology. C V Mosby & Co., USA, 283 pp.
3. Boyd CE 1990. Water Quality in Ponds for Aquaculture, Birmingham Publishing Co, Alabama, USA, 482 pp.
4. Rottmann RW and JV Shireman 1992. Management of water quality for fish. University Press. University of Florida. 6 pp.
5. Jhingran VG 1991. Fish and Fisheries of India. 3rd Edn. Hindustan Publishing Corporation, Delhi, India. 727 p.
6. Ahmed KKU, SU Ahmed, MRA Hossain, T Ahmed and S Barman 2003. Quantitative and qualitative assessment of plankton: Some ecological aspect and water quality parameters of the river Meghna, Bangladesh. Bangladesh J. Fish. Res. **7**(2)**:** 131-140.
7. Chowdhury AH and M Zaman 2000. Limnological conditions of of the river Padma, near Rajshahi city. Bangladesh J. Bot. **29**(2):159-165.
8. Patra RWR. and MA Azadi 1985. Limnology of the Halda river. J. Noami **2**(2): 31-38
9. Shafi M, MMA Quddus and N Islam 1978. Studies on the limnology of the river Meghna. Bangladesh J. Fish. **1**(2) :85-97.
10. Ahmed KK, MKI Haque and ME Haque 1999. Studies on some physico-chemical factors of Kaptai lake. Bangladesh J. Fish. Res. **3**(1)**:** 33-39.

11. Ahmed KKU, KR Hasan, SU Ahmed, T Ahmed and G Mustafa 2004. Ecology of Shakla beel (Brahmanbaria), Bangladesh. Bangladesh J. Fish. Res. **8**(2): 101-111.
12. Chowdhury SH and A Mazumder 1981. Limnology of Lake Kaptai. I. Physico-chemical features. Bangladesh J. Zool. **9**(2):59-72.
13. Hossain MS, MA Mazid, S Rahman, MA Ehsan, A Razzaque, and MR Islam 1997. Limnological observations on Basukhali-Salimpur-Kola-Barnal (BSKB) Beel. Part I: Physico-chemical parameters. Bangladesh J. Zool. **22**(2): 161-164.
14. Khan SHMH, KMS Aziz, MG Morshed and M Shafi 1990. Seasonal variation in physico-chemical conditions of Dhanmondi lake water. Bangladesh J. Zool. **18**(1): 61-66.
15. Dewan S 1973. Investigations into the ecology of fishesin a Mymenshingh Lake. Ph.D. thesis. Bangladesh Agricultural University, Mymenshingh. 335 pp.
16. Ali S, AN Chowdhury, DR Chowdhury and S Begum 1989. Studies on seasonal variations of physico-chemical and biological conditions in a pond. Dhaka Univ. Stud. Part E **4**(2): 113-123
17. Begum S, AN Chowdhury and N Sultana 1994. Physico-chemical parameters of a semi-intensively managed fish pond. Bangladesh J. Sci. Res. **12**(1): 115-119.
18. Naser MN, M Shafi, MS Shah, and G Barua 1990.Physico-chemical conditions of two catfish rearing ponds at Mymensingh, Bangladesh. J. Asiat. Soc. Bangladesh, Sci. **16** (2):91-95.
19. Sufi GB and D Farooque 1983. Water quality of fish ponds in Dhaka city in relation to fish production. Dhaka Univ. Stud. **B. 31**(1): 61-66.
20. Zar JH 1996. Biostatistical Analysis, 3rd edn., Prentice Hall Int. Inc. NJ, USA. 662 pp.
21. Roy HK 1955. Plankton ecology of the river Hoogly at Patna, West Bengal. Ecol. **36**: 169-175.
22. Michael RG 1969. Seasonal trends in physico-chemical factors of a fresh water fish ponds and their role in fish culture. Hydrobiol. **33**: 144-160.
23. Boyd CE 1982. Water quality managed for fish culture pond. Dev, in Aquaculture and FisheriesSc.vol.9, Elsevier Sci. Pub. Co. Amsterdam, Oxford, New York 318 pp.
24. Islam MN, TA Khan and AS Bhuiyan. 2000. Ecology and seasonal abundance of some zooplankton of a pond in Rajshahi. Univ. J. Zool. Rajshahi Univ. **19**: 23-32.
25. Sarker HL and H Rai 1964. The limnology of Surajkund, India (Physico-chemical condition and Plankton) Trans-Amer. Micros. Sci. 83 pp.
26. Islam AKMN and F Mendes 1976. Limnological studies of a Jheel in Sher-e-Bangla Nagar. Dhaka Uni.Stu. Pt. B **24**(2): 63-71.
27. Patra RWR and MA Azadi 1987. Ecological studies on the planktonic organisms of Halda River. Bangladesh J. Zool. **15**(2): 109-123.
28. Miah MJV, MA Islam, M Das, NC Das, and MM Ali 1983. A study on the benthos of a one year old fish pond in Bangladesh Agricultural University Campus Mymenshingh. Bangladesh J. Agricultural Sci. **2-5**(1): 25-31.
29. Saha GN, KL Sehgal, E Moitra and AC Nandy 1971. Studies on the seasonal and diurnal variation in physico-chemical and biological conditions of a perennial freshwater pond. Indian J. Inland Fish. Soc. **3**: 79-102.
30. Ali S, A Choudhury and AR Ray 1980. Ecology and seasonal abundance of zooplankton in a pond in Tongi, Dhaka. Bangladesh J. Zool. **8**(1): 41-49.

31. Arce RG and CE Boyd 1980. Water chemistry of Alabama Ponds. Auburn University Agricultural Experiment station. Auburn University, Alabama. Bull. No. 522 : 35 pp.

32. Rahman MM, Begum A and Ali S 2006. Abundance and seasonal variation of zooplankton in relation to some physico-chemical factors in the Hamil beel of Bangladesh. Bangladesh J. Zool. **34**(1): 7-12.

33. George MG 1966. Occurrence of permanent algal bloom in a fish tank in Delhi with special reference to factors responsible for its production. Proc. Indian. Acad. Sci. **61**: 354-362.

34. Stavroulakis G, ST Kirikou, M Barbouni and G Panagiotakis 2007. Seasonal water quality variations of the lake Kournas, Greece. Proceedings of the Int. Conf. on Env. Management, Engineering, Planning and Economics, Skiathos. 985-990 pp.