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Temporal Variation of Physicochemical Parameters in Kaptai Lake, Bangladesh

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Abstract: The present investigation was conducted to reveal the physicochemical status of Kaptai Lake, Bangladesh. Water samples were collected from five sampling stations (Rangamati Sadar, Kaptai, Barkal, Langadhu and Naniarchar upazilla) over a period of 12 months from July, 2012 to June, 2013. Air and water temperatures were estimated using centigrade thermometer, transparency using secchi disk while pH, CO_2, total alkalinity, total hardness and dissolved oxygen (DO) were estimated using HACH water testing kit. Temporal variations in physicochemical parameters were found in all cases. Highest air temperature (30.9°C) was recorded in June, 2013 and the lowest (23.1°C) in January, 2013. On the other hand, the water temperature varied from 21.1°C in January, 2012 to 32.8°C in July (27.09±5.89°C). The pH of water always found to be alkaline in nature and varied between 6.9 in July and 7.6 in May (7.6±0.52). The maximum free CO_2 value (3.32 mg/l) was recorded in May and minimum value (2.36 mg/l) in November. The value of total alkalinity was found to fluctuate from 51.9 mg/l in December to 65.2 mg/l in March (59.45±6.71 mg/l). Hardness of lake water varied from 37.8 mg/l in August to 47.3 mg/l in November with mean value of 43.08±5.51 mg/l. Water transparency ranged from 0.97 m in July to 2.43 m in May with a mean value of 1.94±0.57 m. The value of dissolved oxygen (DO) was found to fluctuate from the minimum value of 6.10 mg/l in June to the maximum value of 6.80 mg/l in November with a mean value of 6.41±0.51 mg/l. The physicochemical parameters of lake water were found to be within suitable limits for survival of aquatic flora and fauna including fish production. The present research provides baseline information on monthly variations of physicochemical parameters of Kaptai Lake which will be effective for sustainable management and conservation of this important lake ecosystem.

Key words: Kaptai Lake · Physicochemical Parameters · Temporal Variation · Bangladesh

INTRODUCTION

Bangladesh is enriched with extensive water resources distributed all over the country. Kaptai Lake, the largest man-made lake in South Asia, was created in 1955 during the construction of an earth dam across the Karnaphuli River at Kaptai, Chittagong for production of hydroelectricity. Three main streams namely, Karnaphuli, Kasalong and Chengi and their numerous small streams joining near Rangamati formed flow of Karnaphuli River. The streams combining together covers 11008 km^2 with water surface area of 588 km^2 and maximum width of 4 km. Bottom sediment materials of the lake range from clay to medium sand [1]. At present, Kaptai Lake supports small-scale fisheries, which is rich in fish species diversity and contributing approximately 8980 metric ton freshwater fish annually [2]. Aquatic Research Group [3] recorded 49 indigenous fish species and 5 exotic fishes in this lake. Later, Halder *et al.* [4] reported a total of 71 fish species including 5 exotic fishes and 2 species of prawn. However, over the years, eight species of fish disappeared while seven species dwindling [4]. At present, land use changes, urban human habitation, inland navigation, tourism activity, as well as major development scheme in terms of road, bridge and other construction work are greatly affecting this important fresh water resource. As fishery is the secondary enterprise in this lake, Bangladesh Fisheries Development Corporation (BFDC) has no control over the water level fluctuations [5]. Thereby water quality of Kaptai Lake also fluctuates considerably. Nonetheless, water quality is important for long term uses, which affects community health, diversity of aquatic organisms, aquaculture practices and also creates aesthetic problems in the locality.

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Though a few works on physical and chemical limnology of Kaptai Lake are available in literature [6-9], however, detailed study on temporal variation of physicochemical parameters in Kaptai Lake is evidently lacking. Therefore, this article aims to provide data on variations of physicochemical parameters of Kaptai Lake over a period of one year to provide baseline information for assisting management decisions of Lake Ecosystem.

METHODS AND MATERIALS

Study site and sampling: Present study was conducted from July, 2012 to June, 2013. Five sampling stations (Rangamati Sadar, Kaptai, Barkal, Langadhu and Naniarchar upazilla) were selected taking 3 aspects into consideration: i) the streams and drainage arms, ii) catchment area and iii) water level of the lake. Water samples for physicochemical parameters were collected fortnightly from each sampling station with water sampler bottle during morning hours.

Study of Water Quality Parameters: Air and water temperatures were recorded by a centigrade thermometer while water transparency was measured through secchi disc. Dissolved Oxygen (DO), pH, free CO_2, total alkalinity, total hardness of water were measured by using HACH water testing kit (Model: FF-3, USA).

RESULTS AND DISCUSSION

Minimum and maximum values, monthly fluctuations, mean and standard deviation (SD) of different physicochemical factors and relationships among the factors are presented in Tables 1 and 2.

Monthly variation of air temperature ranged from 24.0°C to 30.9°C (27.97±3.08°C). Highest air temperature (30.9°C) was recorded in June and the lowest (23.1°C) in January. On the other hand, the water temperature varied from 21.1° C in January to 32.8°C in July (27.09 ± 5.89°C) (Table 1). Clearly, air and water temperatures were high during the hot summer season (June-July) and lower during winter months (December-January). The water temperature values showed positive correlation with air temperature ($r = 0.863$, $p<0.01$) (Table 2). A similar correlation with the air temperature and water temperature was also reported by Chowdhury and Mozumder [8].

The pH of the lake was water always found to be alkaline in nature and varied between 6.9 in July and 7.6 in May (7.6 ± 0.52). Similar result was observed by Kabir and Naser [10] where they reported alkaline water in Chandbill Baor Oxbow Lake, Bangladesh. Singh *et al*. [11] also described alkaline nature of Maheshara Lake water in Gorakhpur, India. In the present investigation, pH showed positive correlation with free CO_2 ($r^2 = 0.252$, $p<0.05$) (Table 2).

Free CO_2 ranged between 2.36 to 3.32 mg/l (2.92±0.60) mg/l during the experimental period in the Kaptai Lake. The maximum free CO_2 value (3.32 mg/l) was recorded in May and minimum value (2.36 mg/l) in November (Table 1). Present investigation also demonstrated that free CO_2 had inverse correlation with dissolved oxygen ($r = -0.398$, < 0.05) (Table 2). The low free CO_2 content in November, 2012 was possibly due to low rainfall which caused low decomposition of organic matter and high photosynthesis which consumed free CO_2 [10].

Table 1: Monthly fluctuation of different physicochemical parameters of water during study period in the Kaptai Lake with range and mean values (Mean ± SD)

	2012						2013						
Parameters	Jul.	Aug.	Sep.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May.	Jun.	Mean ± SD
Air tem. (°C)	29.02	30.8	30.7	30.5	27.4	24.0	23.1	23.2	26.6	27.7	30.5	30.9	27.97 ± 3.08
Water tem. (°C)	32.8	29.1	29.1	28.8	26.1	25.1	21.1	22.6	24.8	26.3	28.9	29.2	27.09 ± 5.89
pH	6.9	7.1	7.0	7.2	7.1	7.4	6.9	7.5	7.5	7.2	7.6	7.3	7.6 ± 0.52
CO_2 (ppm)	3.12	2.95	2.45	2.93	2.36	2.63	3.04	2.99	2.99	3.19	3.32	3.13	2.92 ± 0.60
T. A. (mg/l)	62.6	54.6	58.2	59.1	60.2	51.9	61.8	61.4	65.2	61.6	56.9	57.4	59.45 ± 6.71
T. H. (mg/l)	44.5	37.8	43.5	42.3	47.3	43.9	43.9	44.8	40.8	43.3	41.9	42.5	43.08 ± 5.51
Trans. (m)	0.97	1.7	1.6	2.06	2.04	2.09	2.29	2.25	2.05	2.43	2.25	1.62	1.94 ± 0.57
DO (mg/l)	6.68	6.34	6.52	6.53	6.80	6.34	6.20	6.10	6.42	6.40	6.49	6.10	6.4 ± 1.51

(T.A. = Total alkalinity, T.H. = Total hardness, Trans. = Transparency)

Table 2: Correlation among parameters of water in Kaptai Lake (Values are shown as r = coefficient correlation)

Parameters	Air tem (°C)	Water tem. (°C)	pH	CO_2 (ppm)	T. alkalinity (mg/l)	T. hardness (mg/l)	Transparency (m)	DO (mg/l)
Air tem. (°C)	1							
Water tem. (°C)	.863(**)	1						
pH	-.111	-.275	1					
CO_2 (ppm)	.081	.122	.252	1				
Total alkalinity (mg/l)	-.374	-.247	-.049	.196	1			
Total hardness(mg/l)	-.447	-.237	-.119	-.416	.300	1		
Transparency (m)	-.018	-.233	.637(*)	.366	-.162	-.088	1	
DO (mg/l)	.358	.482	-.242	-.398	.137	.296	-.048	1

(** Correlation is significant at the 0.01 level. * Correlation is significant at the 0.05 level.)

The alkalinity or acid combining capacity of impounded waters is generally caused by carbonates and bicarbonates of calcium and magnesium combining with dissolved CO_2. These carbonates and bicarbonates form an equilibrium which plays an important role in the productivity of the system. The value of total alkalinity was found to fluctuate from 51.9 mg/l in December to 65.2 mg/l in March (59.45 ± 6.71 mg/l) (Table 1). Jhingran [12] mentioned that alkalinity values of more than 50 mg/l are most productive. In the present study, total alkalinity showed a strong positive correlation with total hardness ($r = 0.300$, $p<0.01$) (Table 2). Seasonally, the highest value of alkalinity was observed in winter month. Analogous findings were also recorded by Chowdhury and Mazumder [8]. The high alkalinity during winter months was possibly due to low temperature and rainfall [10].

Total hardness in water is the sum of the concentrations of alkaline earth metal ions. Hardness of lake water varied from 37.8 mg/l in August to 47.3 mg/l in November with mean value of 43.08±5.51 mg/l. Total hardness showed a positive correlation with total alkalinity ($r = 0.300$, $p<0.01$) (Table 2) which is natural for lake ecosystem. In the present study range of hardness of the lake water was narrower than that reported by ARG [3] a range of 14-73 mg/l. Chowdhury and Mazumder [8] also reported a narrow range of hardness (50.00 - 66.67 mg/l) from the same reservoir.

The transparency of the lake depends upon the turbidity of water which is caused by silting, micro-organisms and suspended organic matter in the water. Clarity of water varied from 0.97 m in July to 2.43 m in May with a mean value of 1.94±0.57 m (Table 1). In present investigation the secchi disc depth showed positive correlation with pH ($r=0.637$, $p<0.05$). The higher value of transparency might be due to the low biomass of plankton and suspended materials present in the water. Sreenivasan [13] considered dense population of planktonic organisms to be an important contributing factor for high turbidity. However, plankton population in Kaptai Lake water was found low in a study conducted by Ahmed [14]. Water transparency of Kaptai Lake was higher during the rainy months and lower in winter. Low transparency during the rainy months could be attributed to the heavy load of organic matter carried into the lake by surface run-off, silt generated by the disturbance of the hilly streams (sediment), by the greater turbulence of flood water which comes after heavy rains and gusty wind action. On the other hand, the highest value of water transparency occurred in winter at all sampling sites and may be attributed to lack of rain, low suspended organic matter and poor planktonic growth [15].

Dissolved oxygen (DO) is a good indication of water pollution. Low level of DO indicates polluted water [16]. The value of dissolved oxygen was found to fluctuate from the minimum value of 6.10 mg/l in June to the maximum value of 6.80 mg/l in November with a mean value of 6.41±0.51 mg/l (Table 1). Present study also revealed positive correlation of DO with air and water temperatures but inverse relationship with free CO_2 ($r = -0.398$) (Table 2). Seasonal trends of dissolved oxygen were found in Kaptai Lake during the study with higher value during warmer months and lower values during winter months. Similar trends were also recorded by Chowdhury and Mozumder [8], Kabir and Naser [10] in different water bodies of Bangladesh.

CONCLUSION

The present study revealed that the water quality of Kaptai Lake is still in well condition in spite of taking wastes from several anthropogenic chemical sources. The present study is baseline study on monthly variation of physicochemical variables of the Kaptai Lake which will provide effective information for the Lake Ecosystem management and conservation. The findings of the present study will be helpful for the future researcher to work on these aspects and replace the discrete data about physicochemical variables of Kaptai Lake and

establish a faithful document explaining variation and inter-relation among different physical and chemical parameters of Kaptai Lake ecosystem.

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