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Seasonal variations of chemical properties of water of the Kaptai lake, Rangamati, Bangladesh

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Abstract

The chemical properties are the most important factors in the aquatic environment. The present study was carried out to analyze the chemical properties of the water of the Kaptai lake, Rangamati. The investigation was done from December, 2007 to November, 2008, during four seasons in two sites and three sub-sites. The main aim of the present research was to analyze the water quality of the Kaptai lake. Chemical properties of the water of this lake were determined by different standard methods. The chemical properties of water varied in different sites and seasons. The value of pH and dissolved oxygen (DO) was higher in undisturbed (UD) area than in less disturbed (LD) and disturbed (D) area (UD>LD>D). The nitrate (NO_3) value was higher in disturbed area than undisturbed and less disturbed area (D>UD>LD). The phosphate (PO_4) value was higher in less disturbed area than disturbed and undisturbed area (LD>D>UD). The electrical conductivity (EC), biological oxygen demand (BOD) chemical oxygen demand (COD) were higher in disturbed area than less disturbed and undisturbed area (D>LD>UD). The potassium (K) value was LD>UD>D. The pH value was higher in winter (W) than in late monsoon (LM), early monsoon (EM) and monsoon (M) (W>LM>EM>M). The NO_3^{-1} value was EM>M>LM>W>EM. The PO_4^{-2} value was LM>M>W>EM. The EC value was W>LM>M>EM. The biological oxygen demand (BOD) value was EM> W>LM>M. The DO value was higher in monsoon than late monsoon, early monsoon, and winter (M>LM>EM>W). The COD was EM>M>W>LM. The K value was EM>W>M>LM. The highest value of pH, K, NO_3 and BOD were recorded in the Kaptai hydroelectricity project area (site –A) and the highest value of the DO, EC and COD were recorded in the Longudu area (site-B). This study is the first initiative to assess the detail chemical properties of water of the Kaptai lake.

Key words: Chemical properties, Water, Seasonal variations, Sites, Kaptai lake.

INTRODUCTION

The Kaptai lake is a unique water reservoir for the Kaptai hydroelectricity project. The lake was created with a view to produce hydro-electricity through building a dam on the Karnaphuly river near Kaptai in 1962. Due to the creation of the lake 54,000 acres of land go under water, which is about 64.77% of the total area of Rangamati Hill Tracts (Rangamati Soil Research Institute, 2007) district. It also affected the lands of 103 Mouzas directly and indirectly. About one lac people became homeless (Chowdhury & Majumder, 1981). Though the creation of the lake caused suffering for the local people to some extent, it provides hydroelectricity and huge potentials for fish resources, Phyto-diversity, irrigation and navigation facilities for the local people. The lake has immense

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resources of water. Aquatic plants uptake their essential nutrients from the water. The normal growth and development of aquatic plants are largely depended on water nutrient status and other meteorological conditions (Odum, 1971). Water contains various macro and micro nutrients. The amount of elements may be variable in different locations of the lake. Water organic carbon, nitrogen and phosphorous are correlated to plant roots creating micro-habits (Jacobson *et al.*, 1966). The water resource of the lake has declined in recent years (Chowdhury and Majumder, 1981). Nitrate is added in the water due to biological oxidation of nitrogenous matter of both autochthonous and allochithonous origin. Domestic sources have been regarded as the main sources of allochithonous nitrogenous organic matter. Metabolic wastes of aquatic community and dead organisms add to the autochthonous nitrogenous organic matters (APHA, 1989). Phosphorus plays an important role on the growth of phytoplankton in the lake. Phytoplankton blooms in the lake can be a limiting factor for the contents of phosphorus in water (Kaul & Sarin *et al.*,1976). Association of macrophytes is affected by temperature fluctuation, nature of substrate and presence of toxic substances in lake water. Amount of chemical nutrient vary in seasons and sites. The positive relationship exists between p^H and carbonates (Rao, 1979; Zafar *et al.*, 1982). Water quality of the lake can be moderated by various factors, such as soil erosion precipitation and siltation etc. The depth of the Kaptai lake has decreased by siltation and other organic and inorganic substances. Comprehensive baseline information about these factors and other chemical properties of the water of Kaptai lake is necessary for its sustainable use. No detailed study is available on the present status of chemical properties of the water of this lake except some sporadic reports. Considering the fact, an attempt has been made to assess the present condition of chemical properties of the water of the Kaptai lake.

MATERIALS AND METHODS

The study was conducted from December, 2007 to November, 2008, in two different sites belonging to two Upzilas of Rangamati Hill Tracts district. One was in Longudu Upzila, nearest to Longudu Cantonment and another was in Kaptai Upzila, which was the front site of Kaptai hydroelectricity project area and located in western part of the Kaptai lake (Figure 1). The total area of the lake is 254 square miles and during the rainy season the area becomes to about 400 square miles. The location of the study area lies between $22^0$0 30′ and $22^0$04′ latitude and between 92 ^{0}04′ and $90^0$22′ E longitudes. The Kaptai lake is the largest lake of the south Asia. Each study site was divided into three sub-sites on the basis of degree of disturbances and human interferences. These were distinguished as disturbed (D) less disturbed (LD) and undisturbed (UD) sites. Data were collected in in four seasons, *viz.* early monsoon (EM) (March to May), monsoon (M), (June to August), late monsoon (LM), (September to November), and winter (W) (December to February). Chemical properties were determined on the basis of seasons, sites, sub-sites. The water samples were randomly collected from three different sub-sites of each main site on the basis of topography for the chemical analysis in the laboratory. Each water sample was collected from three different depths, such as upper layer (0-10 cm), middle layer (10-25 cm), and the lower layer (25-40 cm). Normally the samples of top water, middle water and deep water were respectively collected into separate bottles (2.00liter plastic bottle).

The temperature of water samples was measured at the time of water sampling with the help of mercury thermometer. Eighteen water samples were collected from the two different sites. These water samples were carried to the laboratory and preserved for determining the chemical properties. The value of pH was measured by HANNA digital pH meter (Model H198107). The inorganic nitrogen of water was measured by using the Kjeldahl distillation method (Jacobson, 1966). The phosphorous content of water was determined by ascorbic acid blue color method (Murphy & Riley, 1962). Electrolytic conductivity of water samples was determined by EC meter (Bennet 1, HI 3291, ATC-conductivity probe). Dissolved oxygen (DO) content sample water was determined by using DO meter (Portugal, Model). At five (5) days interval, Biological oxygen demand (BOD) was determined by the dilution method (APHA, 1989). Mohr's solution was used for the determination of chemical oxygen demand (COD). Potassium content was estimated by Flame Photometric method (APHA, 1989). These results were expressed in mg/l.

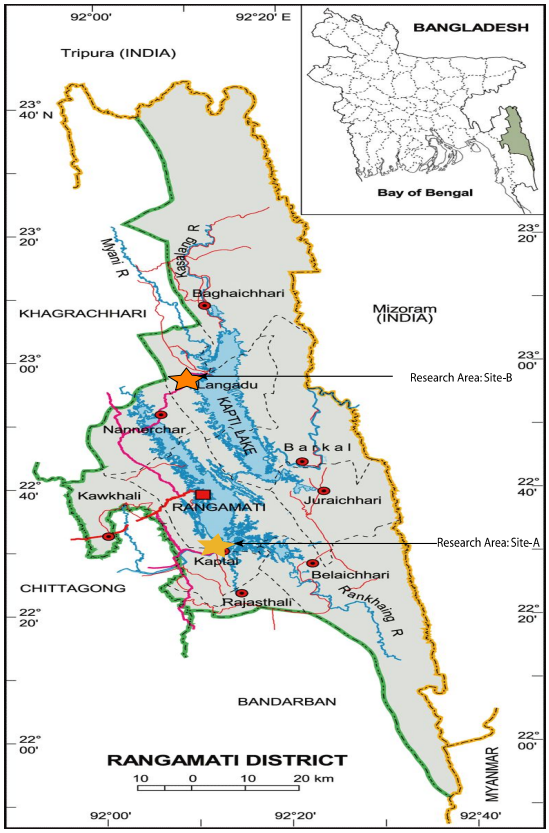

Fig. 1. Map showing the location of the study areas (Source: Banglapedia, 2003)

RESULTS AND DISCUSSION

Hydrogen ion concentration (p^H): Hydrogen ion concentration is the most important determinant of acid and base in the water. Aquatic flora and fauna are influenced by this determinant. During this study, the p^H value of the lake was found to vary from 5.66 to 5.93 (Annex 1). The maximum value of hydrogen-ion concentration (pH) was found in winter (6.01) and the minimum value was recorded in early monsoon (5.66) and this trend was recorded in different (W>EM=LM>M) seasons (Fig. 2). The highest pH value was found in undisturbed area (6.09) and this trend was found UD>LD>D (Fig. 3). Site-A (5.96) was greater than site-B (5.76) (Fig. 4).

Dissolved oxygen (DO): Dissolved oxygen is the most important factor in the aquatic environment. Aquatic organisms are directly depending on dissolved oxygen. Dissolved oxygen content in water of the lake varied from 8.28mg/l to 9.59 mg/l (Annex 1). The maximum value of DO was found in monsoon (9.59 mg/l) and late monsoon and the minimum value was found in winter (8.28 mg/l) and this trend was recorded in different (EM>M=LM>W) seasons (Figure 2). The highest value was in undisturbed area ((9.47 mg/l) and this trend was recorded in different sub-sites UD>LD>D (Figure-3). The value of the DO of site-A was 9.11 mg/l and site- B was 9.94 mg/l (Figure 4).

Bio-chemical oxygen demand (BOD): Bio-chemical oxygen demand helps to indicate the nutrient status in the aquatic environment. Bio-chemical oxygen demand of water varied from 1.11 mg/L to 1.47 mg/l (Annex 1). During this study, the maximum value of BOD was found in early monsoon (1.47 mg/l) and the minimum value of the BOD was in late monsoon (1.11 mg/l) and this trend was recorded in different (EM>W>M.LM) seasons (Figure 2). The highest value of the BOD was recorded in disturbed area and this trend was recorded as D>LD>UD (Figure-3). The mean value of BOD of site-A was 1.37 mg/l and site -B was 1.13 mg/l (Figure 4).

Chemical oxygen demand (COD): Chemical oxygen demand plays a great role in the aquatic flora and fauna. Chemical Oxygen demand of water varied from 20.80 mg/l to 26.55 mg/l (Annex 1). The maximum value of COD was recorded in early monsoon (26.55 mg/l) and the minimum value in monsoon (20.80 mg/l) and this trend was recorded in different seasons (EM>M>W>LM) (Figure 4). The highest value was found in disturbed (D) area and this trend was recorded as D>LD>UD (Figure 3). The value of site-A was 21.17 mg/l and that of site-B was 24.48 mg/l (Figure 4).

Nitrate content of water (NO_3): Aquatic flora and fauna are influenced by nitrate content. The nitrate value varied from 0.79 mg/l to 1.11 mg/l (Annex 1). The maximum value of nitrate was found in monsoon (1.11 mg/l) and the minimum value was found in the early monsoon (0.79 mg/l) and this trend was recorded in different seasons (M>LM>W>EM) (Figure 2). The highest nitrate value was recorded in disturbed (D) area (1.67 mg/l) and the following trend was found- D>UD>LD (Figure 3). The nitrate means value of site - A was 0.92 mg/ l and site-B was 0.78 mg/l (Figure 4).

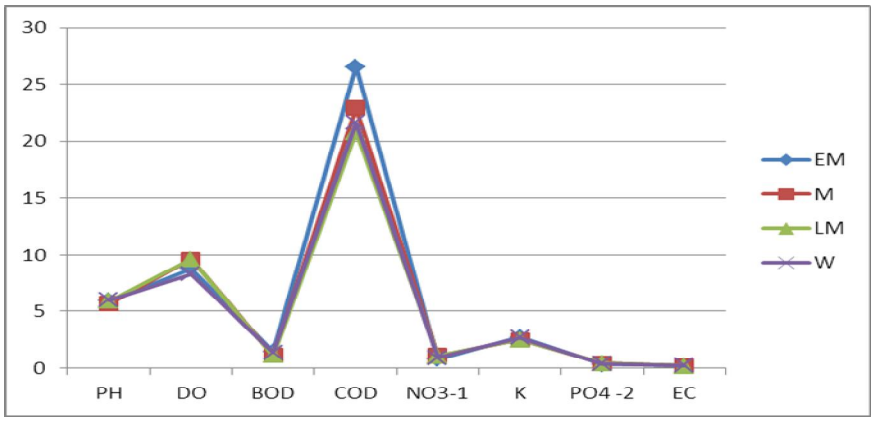

Fig. 2. Variations of p^H, DO, BOD, COD, $NO_3^{-1}K$, PO_4^{-2} and EC in different seasons (EM= Early Monsoon, M= Monsoon, LM= Late Monsoon, W= Winter)

Potassium content of water (K): Potassium content of water varied from 2.49 mg/L to 2.74 mg/l (Annex-1). The maximum value of potassium was found in early monsoon (2.74 mg/l) and the minimum value of Potassium was found in late monsoon (2.49 mg/l) and this trends were recorded in different seasons (EM>W>EM>LM) (Fig.2). The highest value of potassium was recorded in less disturbed (LD) and this trends were recorded LD>UD>D (Figure 3). The value of potassium of site-A was 2.65 mg/l and site-B was 2.56 mg (Figure 4).

Phosphate content of water (P): Phosphate content of water varied from 0.34 mg/l to 0.42 mg/L (Annex 1). The maximum phosphate of water was found in late monsoon (0.42 mg/l) and the minimum phosphate was found in early monsoon (0.34 mg/l) and this trend was recorded in different (LM>M>W>M) season (Figure 2). The highest value of Phosphate was recorded in less disturbed (0.43 mg/L) and the following trends were found LD>D>UD (Figure 3). The value of Phosphate of site-A was 0.39 mg/l and site - B was also 0.39 mg/l (Figure 4).

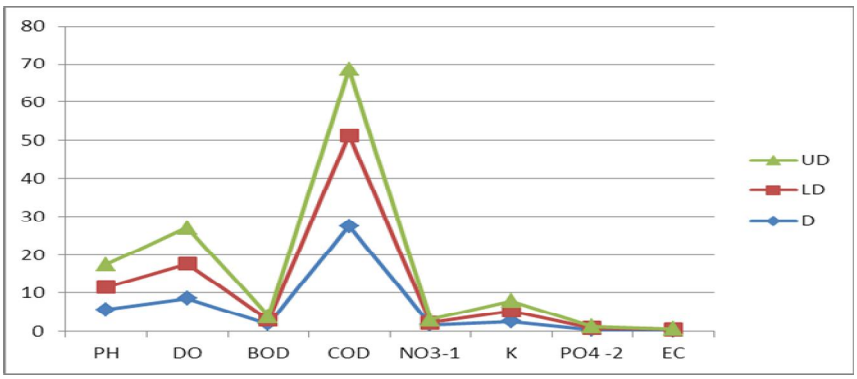

Fig. 3. Variations of p^H, DO, BOD, COD, $NO_3^{-1}K$, PO_4^{-2} & EC in Disturbed (D), Less disturbed (LD) and Undisturbed (UD) sites

Electrical conductivity (EC): EC value of water varied 0.17 to 0.20 (Annex 1). The maximum value of CEC of water was found in winter (0.20) and the minimum value of EC of water was found in the early monsoon (0.17) and this trend (W>LM>EM=M) was recorded in different seasons (Figure 2). The highest value of CEC was found in disturbed areas (0.18) and this trend was D>LD>UD (Figure 3). In site-A and site-B the values were 0.17 and 0.18 respectively, (Figure 4).

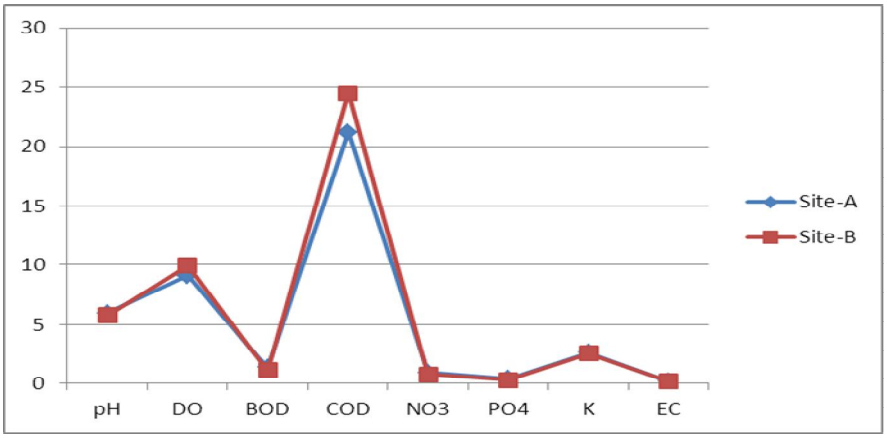

Fig. 4. Variations of p^H, DO, BOD, COD, NO_3^{-1}K, PO_4^{-2} & EC in site-A & site-B.

Site variations were the most important factors for the chemical properties of the water. The chemical properties of the water were fully depended on the basis of degree of disturbances and human interferences. The pH is the most important factor in the distribution of aquatic flora and fauna. The optimum range of p^H for aquatic life is 6.80 to 9.00 (Gautom & Ashutosh, 1990). It was proved that the study area was slightly acidic (5.76 to 5.96). Dissolved oxygen is a fundamental requirement of aquatic organisms. Their survival capacity is depending upon the ability of water to certain minimum concentrations (Trivedi & Raj, 1992). The standard value of dissolved oxygen (DO) is 5 mg/l in the aquatic environment (APHA, 1989). This value is influenced by temperature, photosynthesis, respiration rate, and oxidation of wastage substances. Its value is reduced by the activities of aquatic organisms. The biological oxygen demand (BOD) is the most important determinant of the water chemical properties. The standard value of the biological oxygen demand is 1 mg/l to 3 mg/l in the aquatic environment (APHA, 1989). In this case, the estimated value of the study was 1.11 mg/l to 1.47 mg/l. The amounts of organic matters were determined by the chemical oxygen demand (COD). The value of the COD is higher than the BOD. Biodegraded and non-biodegraded matters were oxidized by the chemical oxygen demand. Nitrogen helps to grow the bloom in the water body. Primary production increased with the increase of nitrogen (NO_3^{-1}). Phosphorous (PO_4^{-2}) also helps the succession of the aquatic plankton. In natural phosphorous is present in the form of phosphate (PO_4^{-2}). The prominent sources of phosphorous in natural water are industrial effluents, sewage, agricultural run-off, and detergents (Gautom & Ahutosh, 1990; APHA, 1989). The higher concentration of phosphate causes

eutrophication in natural water, which indicates pollution of water (Chowdhury, 1999). At least 0 .06 mg/l phosphate is required for optimal growth of various algae (Hutchinson, 1957). As a result, nitrogen and phosphorous had a great role in the development of the aquatic flora and fauna in the study area. Potassium is an essential nutrient for both plants and animals (APHA, 1989). The estimated value of potassium was favorable to the aquatic organisms. Statistical significance was found in seasons and sub-sites. This study has exposed that, the total chemical properties of Kaptai lake were increased by different human activities in the study area. The variation in different chemical properties was statistically significant in different seasons and sites.

Through this research, a comprehensive status of chemical properties of Kaptai lake water has been obtained. The total chemical properties of the lake water indicate that chemical substances have been added in the water due to the different disturbing interferences. The findings of the study will be useful for the conservation of aquatic flora and fauna of the lake and also for the environment friendly management of the Kaptai lake ecosystem. This study suggests to undertake further research on the influence of water chemical attributes to aquatic flora and fauna of the lake.

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