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Physico-chemical characteristics and accumulation of heavy metals in water and sediments of the river Dakatia, Bangladesh

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Abstract
The present study briefly deals with the presence of trace heavy metals in the waters and sediments of River Dakatia in Chandpur district of Bangladesh and their relation with some physico-chemical parameters. The study was carried out from June 2013 to July 2014 on three selected sampling stations of River Dakatia. The transparency was found in Hajigonj, Puranbazar and Eachali were 176.33, 37 and 41 (cm) respectively. The concentration of DO was higher in Puranbazar when compared with Hazigonj and Eachali. In water the highest concentrations of Pb, Cu, Mn and Zn were found in Eachali. The highest concentrations of Cu, Fe, Cr, and Zn were found in sediment from the Eachali. From the data obtained on physicochemical parameters, it was found that the water quality of Dakatia River was fairly good in order to sustain life and also water was in a condition to be used for different purposes.

Keywords: Water quality, Heavy metals, Sediments, Dakatia River

1. Introduction

Pollution of surface and ground waters from point and non-point sources is prevalent in most countries of the world. Rapid population growth, urbanization, intensive agricultural and industrial production, all gives rise to increased levels of emissions of organic and inorganic pollutants into the environment. The surface water resource is very much essential for any country because of its human and animal living, aquatic flora and fauna, navigation, agriculture, etc. It is also necessary for keeping alive the distributaries in the delta and maintaining the brackish water ecosystem along the sea, on an annual cycle (Haque, 2008). Thus, the surface water is essential for keeping the environmental balance of the total region, particularly in the estuaries to the south, and at the mouth of the rivers. Surface water monitoring is essential for aquatic resources management and flood forecasting (Haque, 2008). The surface water qualities of the rivers of Bangladesh are getting highly polluted day by day (DoE. 1992, Alam *et al*., 2007) [13, 4]. The long term effects of the water contamination by inorganic and organic substances, many of them toxic, are incalculable and the chemicals that enter into the food chain have public health implications (Ahmed and Reaz uddin, 2000) [1].

River pollution has been a major problem in the developing countries. Industrial growth has led to increase in quantity of chemical materials used in industry, as well as in industrial facilities which use the chemicals as raw materials. As a result, there is an increasing emission of dangerous materials into the air, water and soil. Although the problems occur in specific locations and regions, they are in fact global problems in that their frequency, magnitude, and potential effects are increasing rapidly. Industrial wastes are known to adversely affect natural life by direct toxic action or indirectly through qualitative alterations in the character of the water (Ahmed and Reaz uddin, 2000) [1].

Nature is the nourisher of all kinds of life system on earth by providing proper environment to the living beings. Diverse environment is the base for the diversity of lives both of plants and animals. The diverse environment includes land, air and water. Bangladesh has the widest spectrum of inland open water resources and marine resources. But water is being harmed profusely everywhere in all over the country by the insane intrusion of human beings. Quality of water is generally refers to component of water, which is to be present at the optimum level suitable for growth of aquatic plants and animals. Various factors like water temperature, turbidity, nutrient, hardness, alkalinity, dissolved oxygen (DO) play an important role for the growth of plants and animals in the water.

The contamination of water with heavy metals is another major environmental problem. Anthropogenic activities continuously increase the amount of heavy metals in the environment, especially in aquatic ecosystem. Pollution of heavy metals in aquatic system is growing at an alarming rate and has become an important worldwide problem (Malik *et al*., 2010) [23]. Increase in population, urbanization, industrialization and agriculture Practices have further aggravated the situation (Giguere *et al*., 2004; Gupta *et al*., 2009) [15, 16]. Some of these metals are potentially toxic or carcinogenic at high concentrations and can cause serious health hazard if they enter into the food chain. Heavy metals like Cu, Zn, Mn, Fe, Ni, Cd, Cr, Co, Pb etc. are usually present in water at low concentration, but enhanced concentration of these metals have found as a result of human activities. Investigation have been made in different countries by different researchers on the extent of heavy metals pollution in surface water, ground water, soil, sediments and vegetation (Zakir *et al*., 2006; Mohiuddin *et al*., 2010; Akbal *et al*., 2011; Zakir *et al*., 2011; Shikazono *et al*., 2012) [34, 25, 3, 35, 30].

Dakatia River is the first tributary that the Meghna receives after entering Noakhali. It is the combination of several hill streams via Sonaichari, Pagli Boaljar and Kakri, etc., originating from Tippera Hills have been playing an important role in trade, water transportation and inland openwater fish production of the region. After traversIng a distance of about 6 mIles in the south it bifurcates at Latitude 230.21" and Longitude 910 31 '. The left hand branch follows a sinuous course in the south till it meets little Feni River, whereas the right hand branch flows in the south-west and north-west up to Hajiganj where Boaljuri river meets it on the right bank. Before taking an abrupt turn to the south at about 15 miles down Hajigonj the river throws off a channel, known as Chandpur Nullah which falls into the Meghna and the river following a meanderIng course drops into Meghna at Hazimara." Dakatia was formerly a most important channel for trade. It is still navigable in the lower region by country boats during the monsoon season. The upper region is navigable throughout the year. There are three gauging stations on Dakatia River at Hajiganj, Raipur and Hazimara. The study was carried out to determine water quality and levels of some heavy metals Pb, Cd, Cr, Cu, Fe, Mn and Zn in water, bottom sediments thus evaluate the suitability of the Dakatia River as a fish habitat.

2. Materials and method

2.1 Study area

Dakatia river of Chandpur was selected as the study site since this river is likely to be affected by municipal and industrial pollution during recent days. Three sampling points were selected on the basis of some features such as: effective factors in water's quality, human and environmental factors and the probability of pollution by emission sources. These stations are:

Station-1: Near Hazigonj Bazar Bridge where urban sewages is running into and establishing few minor handicraft and small scale steel and iron factories.

Station-2: Eachali regarding its neighboring to the jute factory, small ship dock yard, and internal water transport terminal.

Station-3: Puranbazar where urban sewages is running into and establishing few minor handicraft and small scale steel and iron factories, food staff factories, salt processing factory, fish landing centre.

2.2 Sample collection

Water and soil samples were sampled at an interval of 2 months from June 2013 to July 2014. Soil samples were collected from top 20 cm of soil in polythene bags and water samples were collected from 0.50 m below the water surface using 500 ml high density polyethylene (HDPE) bottle (APHA. 1998) [8], stored in ice box, transported to the laboratory and preserved in 4°C until subsequent analysis.

2.3 Sample preparation

Water samples were filtered through membrane filter and analyzed. The fish and soil sediments were prepared following the standard protocol. Muscle samples of fishes were taken with a knife after removing the skin. The muscles were fragmented, homogenized and packed in a polyethylene wrap; stored at −20°C in order to be preserved for further analysis. Soil samples were also fragmented, homogenized and prepared in the same manner compliant with the acid digestion method. Soil samples were digested with the mixture of nitric acid, perchloric acid and sulfuric acid (3:2:1) for 1 hr at 120°C (AOAC, 2000) [6]. Digested samples were then filtered with Whitman 42 filter and raised the volume to 100 ml with distilled water.

2.4 Sample analysis

Physico-chemical Water quality parameters, such as Water temp (^{0}C), Water color, Odor of water, Conductivity (µs/cm), transparency, TDS (mg/l), dissolve oxygen (DO), pH, total alkalinity, total hardness, ammonia (NH3) were analyzed on the same day of sampling. A seechi-disc measured transparency. A centigrade thermometer measured temperature of air and water. Free CO_2 content was determined by phenolphthalein indicator method (Welch, 1948) [33]. Total alkalinity was estimated by using phenolphthalein and methyl orange indicator method (Welch, 1948) [33]. Total hardness was determined by EDTA titrimetric method (APHA, 1995) [7]. HACH test kit (Model-FF-2, USA) was used to measure pH, dissolved oxygen (DO), ammonia. Total Dissolved Solid (TDS), conductivity was measured by EC meter (HANNA instruments: H19143). The concentration of heavy metals such as Pb, Cd, Cr, Cu, Mn, Zn in water and soil were determined by Atomic Absorption Spectrophotometer (AAS).

2.5 Evaluation of water quality

In the present study Physico-chemical Water quality parameters and heavy metal concentration in the water of Dakatia River were evaluated by comparing with various standard values of surface water. In case of heavy metal concentration in sediment of the river, the degree of contamination in the sediments is determined with the help of two parameters - Pollution Load Index (PLI) and Geo-accumulation Index (Igeo).

2.6 Pollution Load Index (PLI): Pollution load index (PLI), for a particular site, has been evaluated following the method proposed by (Tomilson *et al.,* 1980). This parameter is expressed as:

PLI = (CF1x CF2 x CF3 x ……….. x CFn)1/n

where, n is the number of metals (nine in the present study) and CF is the contamination factor.

The contamination factor can be calculated from the following relation:

$$\text{CF (Contamination factor)} = \frac{\text{Metal concentration in the sediments}}{\text{Background value of the metal}}$$

2.7 Geo-accumulation Index (Igeo): The geoaccumulation index (Igeo), introduced by Muller (1979) [26] for determining the extent of metal accumulation in sediments, has been used by (Bhosale and Sahu 1991) [11]; (Singh 1999) [31]; (Rath *et al.* 2005) [29]. Igeo is mathematically expressed as: Igeo = log2Cn/1.5Bn, where, Cn is the concentration of element 'n' and Bn is the geochemical background value [world surface rock average given by Martin and Meybeck (1979)] [24]. The factor 1.5 is incorporated in the relationship to account for possible variation in background data due to lithogenic effect. The geo-accumulation index (Igeo) scale consists of seven grades (0-6) ranging from unpolluted to highly pollute.

Many authors prefer to express the metal contamination with respect to average shale to represent the degree of quantification of pollution (Muller 1979) [26]; (Forstner and Wittmann 1983) [14]. Some authors (Baruah *et al.* 1998) [9] have considered the background value of their area of study to be the geometric mean of concentration at the different sample sites, which is the antilog of the arithmetic average of log10 (log to the base 10) of the concentration values. According to them, the geometric mean reduces the importance of a few high values in a sample group and, therefore, is numerically less than the arithmetic mean, making it a useful indicator of background for most geochemical data. Such background value, however, varies from place to place. As such, this methodology of determining background value has not been considered in the present study. Instead, the world surface rock average (Martin and Meybeck, 1979) [24] of individual metal has been taken to be the background following the recent works of some authors (Rath *et al.,* 2005) [29].

F. Data analysis

All the data were revealed using a two-way analysis of variance (ANOVA), the level of significance thereby being set at 5% (probability limit of $P<0.05$). Data analysis was done using SPSS software.

3. Results & Discussion

3.1 Water Quality Parameters

Temperature recorded in the river water reflects that it changed with the time of the year as well as with the season. Water temperature was found lower in Puranbazar. In most cases, it was 26.73˚C which was within the standard limit for uses of all purposes (Fig. 1). The pH measured in the river revealed that the water was rather alkaline, i.e. pH was higher than 7.0 in Eachali and Puranbazar. In Hazigonj, pH was lower than 7.0 (Fig. 1). Results of the study indicated that the water was a tendency to become acidic in Hazigonj and again become alkaline in nature. In this study, the transparency was found in Hazigonj, Puranbazar and Eachali were 176.33, 37 and 41 (cm) respectively (Fig. 1). The transparency of productive water bodies should be 40cm or less (Rahman, 1992) [27].

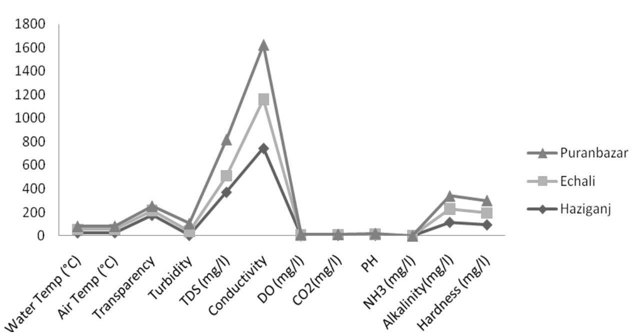

Fig 1: Annual average variation of physico-chemical parameters

TDS is an important chemical parameter in water, mainly indicated the presence of various minerals including ammonia, nitrite, nitrate, phosphate, alkalis, some acids, sulphates, metallic ions, etc., which are comprised both colloidal and dissolved solids in water (Kabir *et al*., 2002, Rahman *et al*., 2012) [21, 28]. The TDS concentrations were ranged 372.3, 308.83 and 138 mg/l in Hazigonj, Puranbazar and Eachali respectively (Fig. 1). TDS concentrations both in post- and pre-monsoon seasons were exceeded the standard limit of 165 ppm and it could be due to cut off the river bank for agricultural practices, cultivation in the river bed and along the bank area as well as use of fertilizers and pesticides, and river bank erosion (Huq and Alam, 2005) [19].

Adequate DO is necessary for good water quality, survival of aquatic organism and decomposition of waste by microorganism (Dara, 2002; Islam *et al.,* 2010; Rahman *et al*., 2012) [12, 28]. The DO found in Hazigonj, Puranbazar and Eachali were 2.19, 5.96 and 5.4 mg/l, respectively (Fig. 1). The concentration of DO was higher in Puranbazar when compared with Hazigonj and Eachali. The mean values of DO in dry-5.52 mg/l and monsoon-5.72 mg/l (Alam *et al.* 2007a) [5].

3.2 Heavy metals in water

The concentrations of Pb, Cd, Cr, Cu, Fe, Mn and Zn were determined in water samples from the three points of Dakatia River near the Meghna River, Bangladesh (Table 1). In almost all the cases the lowest concentrations of metals in water were found in Hazigonj point except iron (Fe) compared to others point (Table 1). The highest concentrations of Pb, Cu, Mn and Zn were found in Eachali (Table 1).

Table 1: Concentration of Heavy metals (mg/l) in water

Parameters	Hazigonj	Puranbazar	Eachali
Pb	0.0±0.0	0.006±0.013	0.013±0.023
Cd	0.002±0.003	0.001±0.00	0.001±0.001
Cr	0.004±0.002	0.004±0.005	0.001±0.002
Cu	0.001±0.002	0.030±0.066	0.067±0.114
Fe	0.299±0.241	0.243±0.211	0.111±0.111
Mn	0.023±0.011	0.313±0.691	0.666±1.129
Zn	0.002±0.001	0.130±0.284	0.210±0.363

Concentrations of toxic metal in the water of Buriganga River, Bangladesh were reported to be 65.45, 9.34, 8.08, 163.09 and 587.20 mgL-1 for Pb, Cd, Ni, Cu and Cr, respectively; levels were much higher than the permissible limit (Ahmed *et al*., 2010). Begum *et al*., 2009 found concentration of heavy metals in Cauvery River, India were 0.32, 2.23, 1.12 1.25, 5.25, 10.70 and 9.95 mgL-1 for Cr, Co, Cu, Mn, Ni, Zn and Pb, respectively; some parameter found within the recommended limit and some parameters beyond the permissible limit.

3.4 Heavy metals in sediment

Metal concentrations in sediment increase with the decrease of the particle size and increase of organic matter content (Halcrow *et al*., 1973) [17]. Analysis on the presence of heavy metals was performed in sediment sampled in 3 places (Table 2). The highest concentrations of Cu, Fe, Cr, and Zn were found in sediment from the Eachali. As far as Fe is concerned, its concentration was highest amount in all points. The lowest concentrations of Cr, Cu and Zn were found in Hazigonj (Table 2). Lovejoy (1999) [22] found his study the highest concentrations of heavy metals was Zn

Table 2: Concentration of Heavy metals (mg/l) in Sediment

Parameters	Hazigonj	Puranbazar	Eachali
Pb	5.284±3.895	3.918±3.246	1.900±3.291
Cd	0.080±0.084	0.102±0.103	0.033±0.058
Cr	29.736±4.463	30.666±12.972	32.873±12.540
Cu	18.560±4.274	25.984±10.290	27.433±7.267
Fe	23209.52±3508.360	23755.840±6304.171	23777.517±4296.958
Mn	293.504±83.874	244.260±66.959	259.440±58.869
Zn	65.692±19.218	67.080±17.115	68.803±14.331

Ahmed *et al*. (2010) found Seasonal distribution of the concentrations of Cd, Cr, Cu, Ni, and Pb in the sediments of the Buriganga River as follows 2.36-4.25, 118.63-218.19, 21.75-32.54, 147.06-258.17, 64.71-77.13 mg/kg respectively.

4. Conclusion

Life and river are closely integrated in most parts of Bangladesh. The country depends on its river system for fishery, agriculture, navigation and even sanitation. Chemical profiles of Dakatia River water in the present study indicate that the water is beyond the acceptable limit for fish, *i.e.*, Dakatia River as a polluted river. Among all, DO was in most critical state, always recorded below the acceptable range among all the sampling points. DO, being the most important parameter of water for survival, distribution and growth of fish, indicates a state of unfavorable, unhealthy and polluted environment of Dakatia River due to discharges from industrial and municipal sources. However, it is recommended to suggest a way forward in achieving proper management though effective planning for the conservation of this river in near future.

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