Evaluation of surface water quality of the Buriganga River
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ABSTRACT

The Buriganga River receives partially treated sewage effluent, sewage polluted surface runoff and untreated industrial effluent from Dhaka city. This study examines the present status of surface water quality of Buriganga River at different locations in Dhaka City. The values of dissolved oxygen (DO), pH, colour, total coliforms, turbidity and ammonia were always very high over the year 2011. The maximum level of DO concentration was 3.4 mg/l, which is below the acceptable limit for surface water. Results also showed that high turbidity and low colour values were found in the rainy season while low turbidity and high colour values were found in the dry season. Moreover, the values of all parameters were always high at Buri 2 (Hazaribagh) because of the proximity of industrial sites. It is important to improve the water quality of the Buriganga River by protecting it from pollution.

Key words | acceptable limit, Buriganga River, contamination, water quality

INTRODUCTION

The water resources of Dhaka city are a burning issue in terms of extreme degradation of water quality of the surrounding water bodies. The water quality of the Buriganga River has been seriously affected by the dumping of municipal waste and toxic industrial discharges from industries on its banks, especially from the tanneries of the Hazaribagh (Kamal et al. 1999; Karn & Harada 2001). Studies have also shown a significant impact on the water quality of Ganga River of extremely low quality wastewater effluent from a treatment plant and lack of proper environmental planning and implementation (Singh et al. 2011; Saha et al. 2012). Figure 1 shows examples of industrial waste and wastewater dumped directly into the Buriganga River.

Rivers are significant resources for drinking water, irrigation, fisheries and energy production all over the world (Hacioglu & Dulger 2009; Kumar et al. 2011). People suffer from health hazards because of the disposal of chemical and toxic wastes by mills and factories in many rivers of Bangladesh. Several diseases such as cancer, birth defects, central nervous system disorders, disruption of endocrine system and heart diseases may be associated with polluted water consumption. Nitrate- and nitrite-contaminated water sources are also associated with bluebaby diseases, gastric cancer and other diseases (Doyle et al. 1985; Gálvez et al. 2003; Biplob et al. 2011).

The water quality of the Buriganga River is too poor to be considered as safe for human consumption. Already the minimum dissolved oxygen (DO), the prime indicator of water quality, has been found to be less than the desirable level for certain sections of the Buriganga river during certain periods of the year. The DoE (1993) found the level of DO was below 2 mg/l, which is far below the allowable limit for recreational and fishing purposes, as the standard minimum limit of DO is 5 ppm. Saha (2010) also investigated the water quality of the Damodar River in India with the average DO, pH, biochemical oxygen demand and NO3 value of 6.21 mg/l, 7.73, 3.86 mg/l and 0.861 mg/l, respectively. The chromium (Cr) concentration in the Buriganga River near Hazaribagh was found to be 0.232 mg/l while the recommended value is 0.05 mg/l (DoE 1992). Therefore, all the parameters indicate that the water quality in the Buriganga River is worse than the required standards, particularly in the dry season because of the low dilution factor created by the low flows in the river. During this time, the tidal nature of the flow causes pollutants to move in both directions and leads to a worsening of the problems.
The river turns deadly for fish and other organisms during this lean season. Once the level of water quality parameters drops to such an extent and the fish and other aquatic species die, it is almost impossible for the river to recover later on. Other studies also showed that the water quality of the Surma River is moderately polluted in different parts of Bangladesh (DoE 1993; Hossain 2001; Alam et al. 2007b).

Water is of fundamental importance for ecosystems and the environment. The Buriganga River water is not used directly for drinking, but, as a resource for bathing, swimming and washing clothes, it is still widely used. So it is necessary to monitor the water quality of the Buriganga River to determine if the water is safe for various uses. However, the main objective of the present research was to analyse the water quality of the Buriganga River for the year 2011.

**METHODOLOGY**

**Study area**

The River Buriganga flowing past Dhaka City, the capital of Bangladesh, is one of the most polluted rivers in Bangladesh. The Buriganga River is hydrologically connected with Balu, Dhaleswari, Kaliganga, Karnatali, Shitalakhya, Tongi Khal and Turag. The upstream end of the Buriganga is 11 km down from the Mirpur Bridge and the downstream end is at Hariharpara. The total length of the Buriganga River is 17 km and its average width around Dhaka City is nearly 500 m. The average flow of this river is 700 and 140 m$^3$ during the wet season (June to October) and dry season (November to May) respectively (Rahman & Rana 1996; BBS 2005; Rahman & Bakri 2010). In recent years, this portion of the river has silted up and during the lean period the flow at Turag is the main source of discharge through the Buriganga.

Generally, the flow of the Buriganga River is non-tidal and tidal during the wet and dry seasons respectively. The tidal range is between 6.0 and 8.0 m. However, the Buriganga is fed mainly by the Turag River, which receives flows from local rainfall and spill flows from the left bank of the Jamuna River.

**Collection of data**

Water samples were collected at four stations on the Buriganga River over 2011. These stations were Buri 1 (Gabtoli, Mirpur), Buri 2 (Hazaribag), Buri 3 (Millbarak, Laxmi Narayan Cotton mill) and Buri 4 (Fatulla, Narayanganj).

**Analysis parameters**

DO, pH and turbidity were measured using a DO meter, pH meter and turbidity meter, respectively. All samples were
analysed after being filtered through 0.45-μm pore size filter paper. Colour was measured using a spectrophotometer. The coliform tests were by the membrane filter method. Ammonia-nitrogen was measured using the standard method 4500-NH₃ C (APHA 1998). Nitrate was determined by ion chromatography. Chromium and lead were analysed by high-performance liquid chromatography.

RESULTS AND DISCUSSION

Dissolved oxygen concentration

Dissolved oxygen concentration is a major issue for the survival of aquatic organisms in surface water (Agbaire & Obi 2009; Kumar et al. 2011), and its level is also an indication of organic pollutants present in the water body, lower values indicating highly polluted water. The main sources of pollution are the untreated industrial wastes, sewage and solid wastes which are directly discharged into the river. Moreover, the quality abruptly degrades in the vicinity of Hazaribagh tannery because of disposal of untreated tannery wastes directly in the river.

DO concentrations for the sampling sites Buri 1, Buri 2, Buri 3 and Buri 4 are presented in Figure 2. The flow through the rivers is sometimes so low that the water quality becomes septic, especially in Buriganga River during the dry period.

The DO value was always low for Buri 2 with respect to other sampling sites because of the proximity of several factories. From January to June and in December, the value of DO was also very low because of absence of water flow in the river. Because of gradual sedimentation in the Turag-Buriganga and Tongi khal-Balu-Lakhya river systems, the conveyance capacities have decreased, causing no flow conditions during the dry season, and consequently the navigational drafts have been reduced, although DO increased with the increase of river flow during the other periods of the year and it remained below the standard value of 5 mg/l for surface water according to DoE (2000).

The highest DO concentrations were found in September for Buri 1, Buri 2 and Buri 4, with values of 3.1 mg/l, 2.9 mg/l and 3.4 mg/l. Alam et al. (2007b) found that the DO levels of the Surma River were 5.52 mg/l and 5.72 mg/l in the dry and monsoon season respectively. Another study showed DO values of 4.998 mg/l and 7.742 mg/l in July and January respectively at the site of Vavta GIDC, Kharcut canal, Ahmedabad, Gujarat (Kumar et al. 2011). Studies reported DO concentration ranges of 2.74–5.12 mg/l and 3.95–5.97 mg/l for river water samples and 3.73–5.01 mg/l and 5.04–5.49 mg/l for lake water samples in the dry and rainy seasons, respectively (Alam et al. 1996; Ahmed et al. 2010).

On the other hand, Majid & Sharma (1999) and Ahmed et al. (2010) observed a decreasing trend of DO values in the Karnafuli River where the minimum value was found as low as 0 mg/l. This indicates the critical condition of this river. A similar situation was observed in the Bebar River in Pahang, Malaysia (Gasim et al. 2011).

The effect of DO concentration presents serious problems for living organisms in water bodies. Therefore, the development of strong institutional mechanisms and sustainable technology for the management of water resources is necessary to prevent their deterioration (Viju 1995; Ahmed et al. 2010).

pH

Figure 3 illustrates the average monthly pH for Buri 1, Buri 2, Buri 3 and Buri 4 during 2011. From May to November for all sampling sites, the pH value was 6.7–7.9; thus it was within the standard range of 6.0–8.5 recommended for surface water (DoE 2000).

The maximum values of pH recorded were 11.4, 12.1, 9.8 and 10.3 for Buri 1, Buri 2, Buri 3 and Buri 4, respectively, in...
March, and clearly above the recommended range. Moreover, the pH value was high for Buri 2 for all months because of several factories close by. From January to April and in December, the value of pH was also very high for all sites (above the acceptable limit) because of absence of water flow in the river. However, pH value decreased when river flow increased.

**Turbidity**

The present study shows turbidity in the range of 6.8–28.7 NTU (nephelometric turbidity units) for all sampling sites on the Buriganga River. Figure 4 illustrates the average monthly turbidity for all sites during 2011. According to DoE (2000), the highest acceptable limit of turbidity for surface water is 10.0 NTU; this limit was exceeded for all sites throughout the year, except October. The maximum value of turbidity was in March with peak values of 85.45, 90.34, 88.9 and 78.56 TCU for Buri 1, Buri 2, Buri 3 and Buri 4, respectively. Moreover, the value was always high for Buri 2 with respect to other sites over the year.

**Colour**

Figure 5 illustrates the average monthly colour of the Buriganga River for all sampling sites during 2011, measured in true colour units (TCU). According to DoE (2000), the highest acceptable limit of colour for surface water is 20.0 TCU. The value of colour increased from January to March and in November and December; it exceeded the acceptable limit for all sites throughout the year, except October. The maximum value of colour was in March with peak values of 85.45, 90.34, 88.9 and 78.56 TCU for Buri 1, Buri 2, Buri 3 and Buri 4, respectively. Moreover, the colour value was always high for Buri 2 with respect to other sites over the year.
The colour in the Buriganga River water tends to be at the complete opposite of the turbidity, i.e. there are high turbidity and low colour values in the rainy season and low turbidity and high colour values during the dry season. The higher value of colour during the dry season is also a result of algae bloom during this time, which in turn is a result of high ammonia concentration, i.e. high organic load.

**Biochemical oxygen demand concentration**

Biochemical oxygen demand (BOD) is usually defined as the amount of oxygen required by bacteria in stabilizing the decomposable organic matter. BOD is another important parameter of water quality assessment. In the present study BOD was found to be in the range 1.5–15.3 mg/l. Kumar *et al.* (2011) observed BOD values ranged from 11.56 ± 4.23 mg/l to 133.28 ± 68.75 mg/l at five sampling sites on the Surma River. Figure 6 illustrates the average monthly BOD values for the present study sites in 2011. For all sites, the BOD value exceeded the acceptable value of 2 mg/l for surface water (DoE 2003), except in August and September for Buri 4.

The maximum values of BOD were 13.4, 15.3, 11.2 and 10.5 mg/l for Buri 1, Buri 2, Buri 3 and Buri 4, respectively, in March. From January to April and in December, the value of BOD was very high for all sites, but it decreased in the wet season when river flow increased. The results indicate that the water body may have suffered deterioration and degradation because of continuous discharge of untreated effluent and/or solid waste directly to the river. In comparison, Rahman & Hadiuzzaman (2005) found a maximum value of BOD of 280 mg/l at Majhipara Khal. Another study also showed that there is a heavy load of organic waste in the Balu and Sitalakhya River causing an alarming situation in the dry season because of high BOD (Rahman & Hadiuzzaman 2005; IWM 2003).

**Ammonia concentration**

Figure 7 illustrates the average monthly ammonia concentration at all sites in 2011. Except in March for all sites, it is below the acceptable value of 1.5 mg/l for surface water (DoE 2000). The maximum value of ammonia was recorded as 1.6, 1.7, 1.7 and 1.5 mg/l for Buri 1, Buri 2, Buri 3 and Buri 4, respectively, in March. By comparison, the highest ammonia concentration was 85.25 mg/l at Tanbazar Khal, Lakhy (Rahman & Hadiuzzaman 2005). Alam *et al.* (2007a) found that the concentration of ammonia had increased at Guali Chara and Balramer Khal on the Surma River and exceeded the DOE standard for fishing and recreational purposes.

From January to March and in December, the value of ammonia was also very high for all sites because of absence of water flow in the river but was below the acceptable limit. The concentration of ammonia decreased with the increase of river flow in the rainy periods of the year.

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**Figure 6** | Average BOD concentration at: Buri 1 (n = 20), Buri 2 (n = 18), Buri 3 (n = 24) and Buri 4 (n = 22).

**Figure 7** | Average ammonia concentration at: Buri 1 (n = 20), Buri 2 (n = 18), Buri 3 (n = 24) and Buri 4 (n = 22).
Nitrate concentration

The nitrate concentration in Buriganga River increased from January to March when it reached maximum values of 4.8, 5.6, 4.9 and 3.8 mg/l for Buri 1, Buri 2, Buri 3 and Buri 4, respectively, for all stations; concentrations then decreased again to reach the lowest average value in September (0.6 mg/l) for Buri 1 (Figure 8). Rahman & Hadiuzzaman (2005) found that nitrate values for various locations along Lakhya River varied from 0.1 to 3.5 mg/l. The nitrate value was always high for the station of Buri 2 with respect to other stations.

From January to March and in November and December, the value of nitrate was higher for all stations because of lack of water flow in the river during this period, but did not exceed the acceptable limit of 50 mg/l (DoE 2000). Nitrate decreases with the increase of river flow during other periods of the year and because of the rainy season. In 2011, the maximum nitrate content of Buriganga River water was 5.6 mg/l, while the allowable concentration of nitrate in surface water is 50 mg/l (DoE 2000).

Chromium concentration

Concentrations of chromium (Cr) are not very alarming at the present moment but, as the amount of Cr is increasing in the wastewater, there is a probability that the level of heavy metal may exceed the tolerable limit in future. The concentrations of Cr for 2011 are shown in Figure 9. The maximum values of Cr were 0.02, 0.0025, 0.0018 and 0.0022 mg/l for Buri 1, Buri 2, Buri 3 and Buri 4, respectively, in March. The average concentration of Cr was 38.2 ppb (0.00382 mg/l) in the Surma River (Alam et al. 2007a). Studies also reported that concentration of Cr in the Buriganga and Shitallahkha Rivers was 20.6 ppb (0.00206 mg/l) (Shiddiky 2002; Alam et al. 2007b). Rahman & Hadiuzzaman (2005) also found that Cr concentration at wastewater outfalls varied from 0.002 to 0.023 mg/l at Majhipara Khal. According to DoE (2000), the allowable limit of Cr is 0.05 mg/l for surface water; none of our results exceeded this limit in 2011. However, the concentration of heavy metal has been varying seasonally. From January to March and in December, the concentration of Cr was high for all sites because of low water flow in the river.

Lead concentration

Contamination by heavy metals in aquatic environments is of critical concern, because of toxicity of metals and their accumulation in aquatic habitats. Heavy metals, being non-biodegradable, can be concentrated along the food chain, producing their toxic effect at points far removed from the source of pollution. Lead (Pb) concentrations for various stations of Buriganga River are shown in Figure 10.

The maximum values of Pb recorded were 0.22, 0.254, 0.2 and 0.2 mg/l for Buri 1, Buri 2, Buri 3 and Buri 4, respectively, in March. From January to April and in
December, the concentration of Pb was high for all sites because of absence of water flow in the river and it exceeded the acceptable limit of 0.1 mg/l for surface water (DoE 2000). From June to October, the concentration of Pb was low for all sites because of the rainy season. In a study by Alam et al. (2007a), the average Pb concentration was 13 ppb (0.0015 mg/l) in the Surma River, and Majid & Sharma (1999) found the Pb concentration in the Karnaphuly River was 0.04 ppb. According to Alam et al. (2007a), the standard limit of Pb is 50 ppb (0.005 mg/l) for domestic and irrigation water.

No comprehensive study of the river Buriganga has been carried out so far. Thus, it is important to determine the intensity of pollution by inventorying the heavy metal concentrations and their spatial and temporal distribution in Buriganga River water.

Total coliform concentration

The faecal coliform test is one of the most important biological parameters in drinking water quality. The microbiological quality of a river is controlled by human activities. According to Lika et al. (2010), faecal micro-organisms are mainly brought to aquatic environments through the discharge of untreated domestic wastewater and some industrial wastewaters in urban areas. The maximum amounts of total coliforms in our samples were 9,800, 10,200, 8,700 and 9,250 CFU/100 ml for Buri 1, Buri 2, Buri 3 and Buri 4, respectively, in February (Figure 11). According to DoE (2000), the amount of total coliforms of 0 is recommended for surface water; thus all total coliform counts in this study exceed the allowable limit. Rahman & Hadiuzzaman (2005) found coliform concentration at the wastewater outfalls varied from $4 \times 10^4$ to $4.4 \times 10^7$/100 ml at Tanbazar Khal. Moreover, the amount of total coliforms was always high for Buri 2. From July to December, the total coliform counts were less for all sites because of the rainy season, while from January to June, the total coliform counts were very high because of absence of water flow in the river. The faecal contamination of water from slums located along the course of the river bed may be the reason for the high values in the present study.

CONCLUSIONS

The disposal of industrial waste effluent into riverine systems has given rise to heavily localized pollution and seriously threatens the environment. DO concentration is alarmingly low in the Buriganga River. Results also showed that high turbidity and low colour values were found in the rainy season, whereas low turbidity and high colour values were seen in the dry season. Moreover, the concentration of BOD was found in the range of 1.5–15.3 mg/l, indicating that the pollution affects water quality. Moreover, the concentration of all water parameters was always high for the site of Buri 2 because of the industries situated there. So, the pollution level of the River Buriganga is increasing sharply; as we know, once a trend in pollution
sets in, it generally accelerates to cause greater deterioration. So a few years from now, serious water quality deterioration could take place.

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