



RESEARCH ARTICLE

COMPARATIVE STUDY OF WATER QUALITY OF BURIGANGA AND BALU RIVER,
DHAKA, BANGLADESH

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ABSTRACT

A study was conducted on physico-chemical parameters and heavy metal contents of water from the selected area of Buriganga and Balu River of Dhaka, Bangladesh. Four physico-chemical parameters such as pH, electric conductivity (EC), biochemical oxygen demand (BOD), chemical oxygen demand (COD) and six heavy metals like Fe, Zn, Cd, Cr, Hg and Pb were investigated to assess water quality of these rivers on April-May, 2016. The pH, EC, BOD, COD of Buriganga River were found 7.57-7.64, 1096-1117 μ S/cm, 109-163 mg/L, 185-381 mg/L whereas 7.58-8.35, 996-1099 μ S/cm, 102-149 mg/L, and 204.8-307.2 mg/L respectively found in Balu river water. The concentration of heavy metals in water samples were determined by Atomic Absorption Spectrophotometer (AAS). The amount of Fe, Zn, Cd, Cr, Hg, and Pb in Buriganga and Balu River were 0.47-2.83 ppm, 0.95-2.759 ppm; 0.47-0.90 ppm, 0.47-0.83 ppm; 0.959-8.003 ppb, 0.563-1.296 ppb; 270-556 ppb, 200-485 ppb; 0.62-2.23 ppb, 1.44-2.34 ppb and 22.1-60.6 ppb, 7.5-38.1 ppb respectively. The obtained results revealed that the COD, BOD and heavy metal concentration of both the river water were higher than Bangladesh standard where as pH and EC values were within the permissible limit. The measured physico-chemical properties and heavy metal concentration of study area shows that Buriganga River is more polluted than Balu River.

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INTRODUCTION

Dhaka is the most populated city in Bangladesh and there are different kinds of industry established around the Dhaka city. Two important rivers, Buriganga and Balu River across the Dhaka city. Buriganga River flows through west and south of Dhaka which is one of the largest rivers in Bangladesh [Ahmed et al., 2001]. Buriganga, the lifeline of Dhaka city is a source of water used by the city residents for bathing, drinking, irrigation and industrial purposes. The river is significantly polluted by industrial effluents, solid wastes, urban sewage from human activities. There were about 200 tanneries in Hazaribagh area on the bank of Buriganga River which discharged 21,600 square meter effluents into this river daily (Kamal et al., 1999). These effluents containing chromium, aluminum, sulphur, lead, salts and other chemicals were polluting Buriganga River severely. These effluents carry some toxic chemicals such as epoxy, polyurethane, enamel, ductile-silvery white metal, organic and inorganic acids, alkalis, lime,

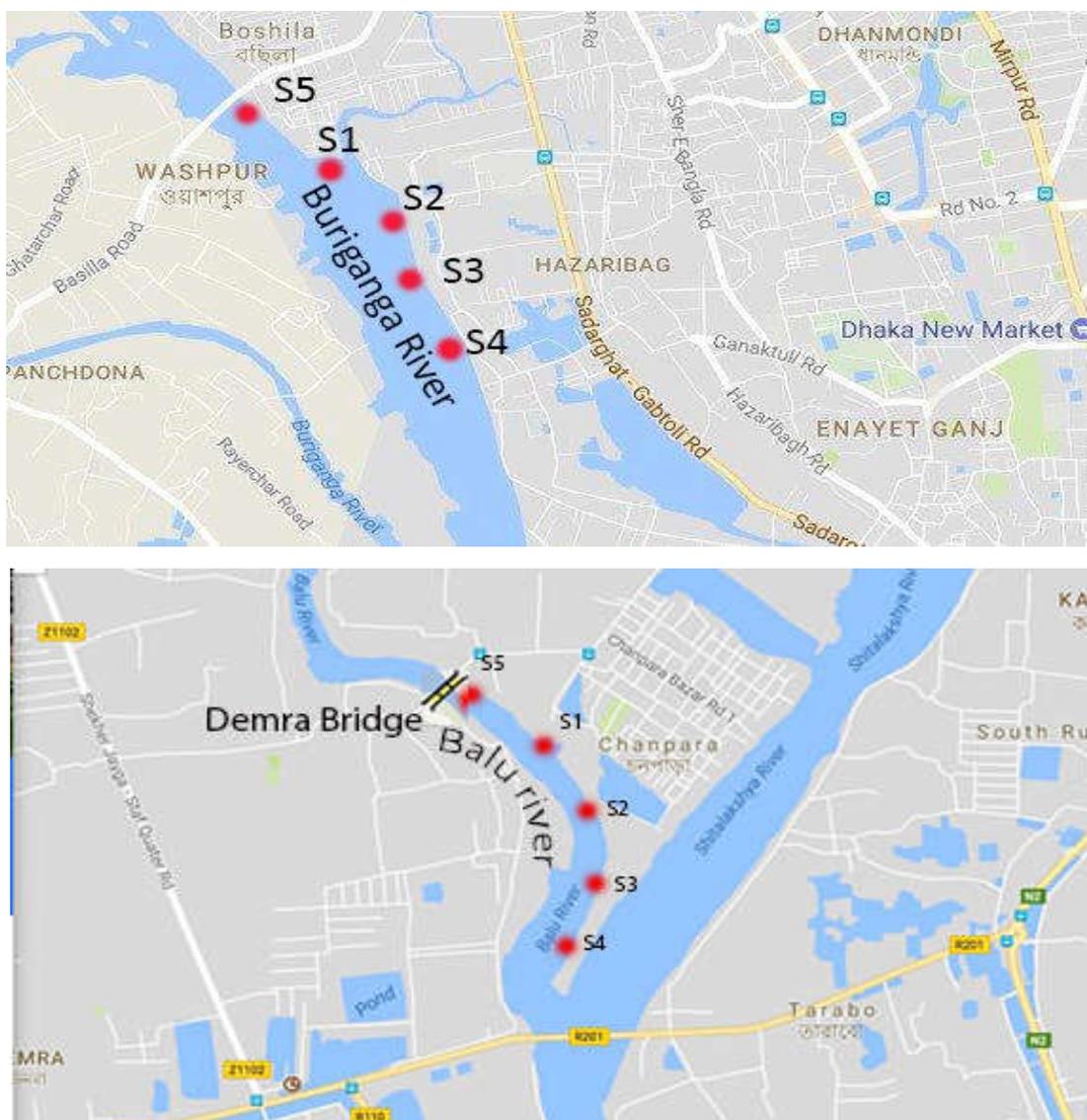
caustic soda, aluminum, zinc chromate, zinc phosphate, asbestos etc. This river also receives effluents of many textile, dyeing, battery manufacturing industries from Turag River. Turag River polluted by industrial effluents from Tongi area towards downstream and it meets with Buriganga River at Gabtoli bridge area. Industries such as tanneries, dyeing, textile, battery producers, steel plants responsible to pollute Buriganga River (Kamal et al., 1999; Rahman et al., 2010 and Halim et al., 2011). The disposal of untreated waste water of various industries, urban wastes and agrochemical wastes in the low land, open water bodies and rivers has reached an alarming situation in Bangladesh which is increasing day by day (Islam et al., 2015, Ali et al., 2016, Mottalib et al., 2016 and Al-Razee et al., 2016). Another important river of Dhaka city is Balu River which is a tributary of Shitalakhya River. Balu River is one of the important water resources in Dhaka district. This river is used for industrial, domestic, residential and various purposes. Many textile, dying, battery manufacturing industry etc. discharge their effluents onto the river and have a significant impact on surface water quality. About 10% of industries discharge treated effluent and the rest of the industries discharge effluent in the rivers or water body

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without any treatment (Satter *et al.*, 2005). Tejgaon metropolitan area is such a type of industrial area having more than 300 industries and these units dispose about 12000 m³ untreated waste per day which consists residue of soap, dyeing, pharmaceuticals, metals industries (Roy *et al.*, 2013). Wastes of this industrial area is directly discharged into Begunbari and Narai canal which carries the waste through Balu River and ultimately flows on Sitalakhya River which is used in Saydabad water treatment plant for meeting water consumption demand of Dhaka city dwellers. Thus Balu River and its canal system in Dhaka east especially Narai canal is the most polluted area which is responsible for polluting Sitalakhya river day by day (Roy *et al.*, 2014). The aim of the present study was to assess pollution level and suitability for swimming, drinking, irrigation, industrial uses and for aquatic lives of Buriganga and Balu Rivers. This study was conducted on five important locations of each river.

The distance between each two points was 500 m. From each point 2 water samples were collected, one sample used for the determination of physico-chemical properties and other one for heavy metal concentration. Each sample was collected in 500 mL plastic bottle those were made of polyethylene and before collecting sample all bottles were washed with distilled water and dried well. 1 mL of concentrated nitric acid was added to 500 mL samples which were collected for determining selected heavy metals. The tanning industries of Hazaribagh area discharged their liquid waste into a main canal which passed the Hazaribagh-Gabtolli road at Rayer Bazar and met the Buriganga River at Baroipara, Hazaribagh with a large amount of wastes. By this way industrial and other wastes were discharged into Buriganga River and polluted surface water significantly. The sample which was collected from meeting point of Buriganga River and canal was expressed as S1. The samples S2, S3, S4 were collected from 500 m regular distance

Location of sampling area



MATERIALS AND METHODS

Sample collection and study area

To investigate the water quality of Buriganga and Balu River, samples were collected from 1.5 ft depth of the water surface and 10 samples were collected from five points of each river.

towards downstream of the river from location S1. The sample S5 was collected from the 500 m upstream of the meeting point S1.

Similarly another five samples were collected from Balu river. S1 sample was collected from a meeting point of Balu River and a canal which was near the Chanpara mosque. This canal

carries a large amount of waste from the industries. The samples S2, S2, S3 and S4 were collected from 500 m regular distance towards downstream from each sample. The sample S5 was collected from 500 m upstream of sampling point S1. Before determining the concentration of heavy metals acid digestion was carried out for activation of metals following APHA (1985) process. The samples were collected on April, 2016.

Acid digestion for heavy metal determination

100 mL water sample was taken in a beaker from which sample was collected for heavy metal determination. 2 mL concentrated nitric acid was added to the beaker and upper open part of the beaker was covered with a watch glass. Then beaker was heated slowly until 100 mL sample was reduced to 60 mL sample. Heating was stopped and allowed for cooling. Then the sample was filtered and diluted into 100 mL with double distilled water. All chemicals used were in MERK Germany analytical grade.

RESULTS AND DISCUSSION

Method of analysis

In this research each parameter was measured five times and the presented data is the mean value of five readings. pH was measured by a digital pH meter and EC value was determined by conductivity meter. BOD and COD values were measured by BOD incubator and COD reactor. The concentration of heavy metals (Fe, Zn, Pb, Cr and Cd) was determined by using Atomic Absorption Spectroscopy (AAS 6800, Shimadzu, Japan) and the concentration of Mercury (Hg) was determined by using Hg Analyzer. The obtained results of physico-chemical properties of both the rivers are shown in Table 1.

Table 1. The summary of physico-chemical properties of Buriganga and Balu Rivers

Sample ID	Buriganga River				Balu River			
	pH	EC(μ S/cm)	BOD(mg/L)	COD(mg/L)	pH	EC(μ S/cm)	BOD(mg/L)	COD(mg/L)
S1	7.64	1117	163	384	8.35	1099	149	307
S2	7.60	1102	145	281	7.80	1096	106	203
S3	7.58	1097	138	255	7.64	1063	125	241
S4	7.57	1083	120	200	7.58	1001	111	228
S5	7.63	1096	109	184	7.76	996	102	204
average	7.60	1099	135	261	7.83	1045	119	237
StandardDoE, 2003	6.5-9.2	1200	50	200	6.5-9.2	1200	50	200

Biochemical oxygen demand is the amount of oxygen required during the biochemical degradation and transformation of organic compounds in wastewater under aerobic conditions by bacteria and other microorganism (Dara 2002). BOD is considered one of the most important parameters for water body. The BOD values obtained (Table 1) in the current research ranged from 109 to 163 mg/L in Buriganga River whereas ranged 102 to 149 mg/L in Balu River. The average values of this parameter in the study area were 135 mg/L and 118 mg/L respectively in Buriganga and Balu Rivers those are higher than the DoE standard (50 mg/L) (DoE, 2003). These higher values indicate that there were huge organic pollutants in both river water. In the case of Buriganga River S1 point was worst affected probably because of discharge wastes from Rayer Bajar and Hazaribagh tannery industrial area and sewage discharged from Dhaka city. This value was gradually decreasing on both upstream and downstream of the river. The results in table 1 show that BOD value is the mirror of COD value. It is noted that COD value indicates the amount of bio-

degradable and non-biodegradable pollutants present in water body. Again the higher COD values compared to the BOD values indicate the presence of inert organic material in the river water. The average COD value in the study area of Buriganga and Balu River were 275 mg/L and 199 mg/L respectively. In the case of Buriganga River water COD values of 4 points decreased gradually towards downstream which revealed the most responsible sources locations on upstream of the river. Surface water of rivers usually have a BOD value 1 mg/L to 8 mg/L (Retrieved 2016). Tasfina *et al.* (2016) assessed average BOD value of Buriganga River water which was 82.8 mg/L.

The variation of BOD and COD values in Balu River were little dissimilar to Buriganga River and these values also were lower than the Buriganga River. The highest BOD and COD values in Balu River found at sampling point S1 and decreased to the point S2 and again increased at sampling point S3. The lowest BOD and COD values were found at the sampling point S4. There were some small canals were found between sampling points S2 and S3 those canals carried industrial effluents to Balu river, as a result sampling point S3 became more polluted than point S2. BOD and COD values of both rivers exceed the Bangladesh standard 50 mg/L and 200 mg/L respectively (DoE 2003). The pH value refers to the alkali, acidic or neutral condition of water body. Average pH values in Buriganga and Balu River water were 7.60 & 7.83 respectively. pH values for both the rivers crossed the value of neutral water. Interestingly, Balu River having little higher pH value than Buriganga River. Electric conductivity measures the salinity of water and depends on presence of ion in water body. The EC of the present study found ranged from 1083 to 1117 μ S/cm in Buriganga River while ranged 996 to 1099 μ S/cm in Balu River. The EC value of Buriganga River was higher than Balu River which indicates that more ions are present in

Buriganga River. The EC of both the river water were lower than the Bangladesh standard 1200 μ S/cm (DoE 2003).

Table 2. A comparison of physico-chemical properties of Buriganga and Balu river with standard

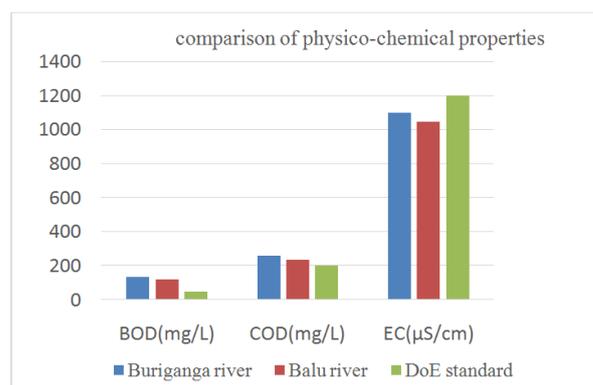


Table 3. Pearson correlations of physico-chemical properties of surface water of Buriganga River, N=5

	pH	EC	BOD	COD
pH	1			
EC	0.768	1		
BOD	0.283	0.814	1	
COD	0.471	0.897*	0.973**	1

* Correlation is significant at the 0.05 level (2-tailed).

** Correlation is significant at the 0.01 level (2-tailed).

The excellent correlations of BOD with COD were found in the above correlation index. The Buriganga River is polluted by tannery wastages and sewage discharges from Dhaka city. In this regard organic pollution load predominated. As the COD and BOD indicates the organic compound therefore the table 3 highlights that BOD (0.973) is strongly correlated with COD.

Table 4. Pearson correlations of physico-chemical parameters of surface water of Balu River

	pH	EC	BOD	COD
pH	1			
EC	0.616	1		
BOD	0.772	0.593	1	
COD	0.791	0.487	0.985**	1

**Correlation is significant at the 0.01 level (2-tailed). N=5, no. of samples

Table 4 also focused that BOD (0.985) is strongly correlated with COD in the case of Balu River.

Assessment of heavy metals

Heavy metal pollution of aquatic environment has become a great concern in recent years because they are very harmful as a reason of their non-biodegradable nature, long life and their potential to accumulate in different aquatic organism. Heavy metal concentrations of the selected sampling point of both the rivers are summarized in Tables 5 and 6. The obtained results revealed that the concentration of Fe, Zn, Pb, Cr, Ad and Hg ranged from 0.50 to 2.83 ppm, 0.95 to 2.76 ppm; 0.47 to 0.90 ppm, 0.46 to 0.83 ppm; 22.1 to 60.6 ppb, 7.6 to 38.1 ppb; 270 to 556 ppb, 180 to 485 ppb; 0.96 to 8.00, 0.53 to 1.30 ppm; 0.62 to 2.23 ppb, 1.44 to 2.62 ppb in Buriganga and Balu rivers respectively. These data shows that the amount of Fe, Pb and Cr in both rivers water were much more higher than the WHO standards. A significant reading of heavy metals concentration indicates the input of pollutants from various sources like industrial effluents, domestic sewage, municipal sewage, agricultural runoff and so on. In the Buriganga River Cr concentration was ranged from 556 ppb to 270 ppb which were much more higher than other four tested metals like Cd, Zn, Pb, Hg concentration. Major source of Cr in Buriganga River was tanning industry at Hazaribagh.

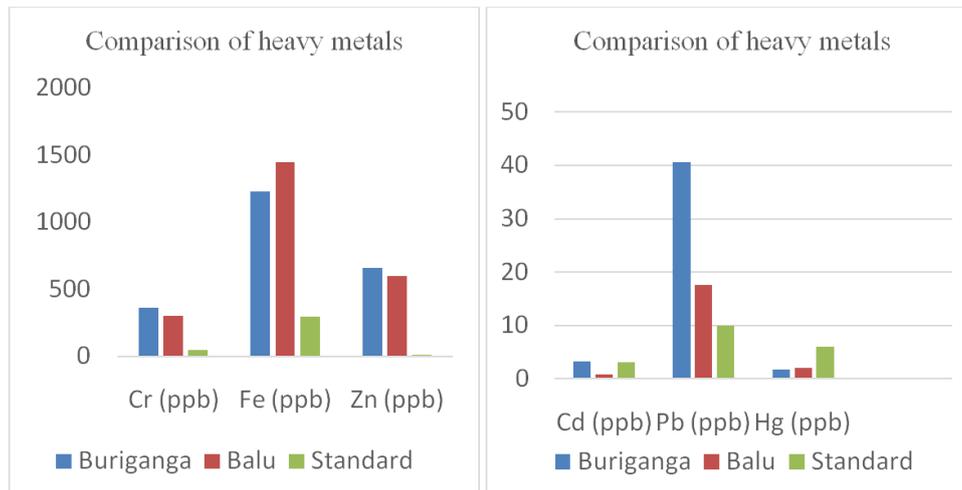
Table 5. The concentration of heavy metals in Buriganga river at Hazaribagh area

Sample ID	Fe(ppm)	Zn(ppm)	Pb(ppb)	Cr(ppb)	Cd(ppb)	Hg(ppb)
S1	2.83	0.90	60.6	556	8.00	2.23
S2	1.22	0.83	46.2	405	3.75	1.90
S3	1.03	0.57	38.1	313	2.00	1.80
S4	0.50	0.54	36.3	281	1.24	1.52
S5	0.55	0.47	22.1	270	0.96	0.62
Average value	1.23	0.66	40.66	365	3.19	1.61
WHO	0.300	0.010	10	50	3	6
Surface water stand. ^a	-	-	5	160	10	-

^aNew Jersey Water Supply, "Surface water quality and pollutant loadings," A Technical Report for the Baritan Basin Watershed Management Project, 2002.

Table 6. The concentration of heavy metals in Balu River

Sample ID	Fe(ppm)	Zn(ppm)	Pb(ppb)	Cr(ppb)	Cd(ppb)	Hg(ppb)
S1	2.76	0.83	38.1	485	1.30	2.34
S2	1.20	0.57	10.5	321	0.56	2.09
S3	1.35	0.61	23.03	331	0.66	2.62
S4	0.98	0.55	9.0	180	0.53	1.58
S5	0.95	0.46	7.6	200	0.56	1.44
Average value	1.45	0.60	17.64	303	0.72	2.01

Table 7. Comparison of heavy metals with standard

To convert raw hides/skins into leather basic chromium sulfate used in tanning process. 60-70% of basic chromium sulfate reacts with hides and rest of Cr remain unreacted and discharged directly from the industry and its final destination was Buriganga river (Alireza and Reza 2005). Ahmad *et al.* investigated the heavy metal concentration in Buriganga River and found the concentration of Cd, Cr and Pb ranged 7.08-12.33, 489.27-647 and 58.7-72.45 mg/L which was varied seasonally (Ahmad 2010).

Table 8. Pearson Correlations of heavy metals in Balu River, N=5

	Fe	Zn	Pb	Cr	Cd	Hg
Fe	1					
Zn	0.969**	1				
Pb	0.951*	0.952*	1			
Cr	0.925*	0.921*	0.919*	1		
Cd	0.992**	0.941*	0.939*	0.880*	1	
Hg	0.559	0.657	0.729	0.778	0.482	1

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

Balu River also gave the results of highly polluted water. A very few industries discharge treated effluent and most of the industries discharge effluent in the rivers or water body without any treatment or with minimal treatment. Tejgaon metropolitan area is such a type of industrial area where more than 300 industrial units are located and these units dispose about 12000 m³ untreated waste per day which consists residue of soap, dyeing, pharmaceuticals, metals industries etc. (Roy 2013). Effluent of this industrial area is directly discharged into Begunbari and Narai canal which carries the waste through Balu River and ultimately flows on Sitalakhya River. In Balu river Cr concentration was ranged from 485 ppb to 200 ppb which were higher than the standard value but lower than Buriganga River. Chromium based dye, pigment, paint or other industrial wastewater are responsible to increase Cr concentration in Balu River. Metal concentration in all points in both rivers gradually decreases down the stream. The metal possessing the highest concentration next to Cr was Pb for both the river. In Buriganga River the highest value was 60.6 ppb at point S1 and the lowest value was 22.1 ppb at S5 point. In the Balu River the similar sample ID gave the highest value of 38.1 ppb and the lowest value of 7.6 ppb. Pb concentration in all points in Buriganga River crossed the WHO standard whereas those values at the sampling point S4 and S5 in Balu River were within the acceptable limit. It is noted that dye and pigment industries are the main source of lead pollutants. Both the leather and textile industries play a vital role to increase Pb concentration in Buriganga and Balu river respectively as both types of industries need to use a huge amount of dyes and pigments to impart colour. The average concentrations of Zn in both the rivers were lower than the permissible limit. The highest concentration of Cd was found 8.03 ppb at the sampling point S1 in Buriganga river which exceeded the tolerable limit but other locations gave within permissible limit (WHO). Similarly S1 point near Chandpara Mosque of Balu river gave higher value of Cd, 1.30 ppb than other locations. It is very noticeable that among the tested metals of both rivers the average concentration of Fe and Hg were higher in Balu river than Buriganga river. The average concentration of Fe in both rivers crossed the permissible limit of WHO while concentration of Hg at all points in Buriganga and Balu river were lower than WHO standard. Battery manufacturing industries and some other sources on the bank of rivers increase the concentration of Hg in water body which is very

harmful to aquatic lives. Both physico-chemical properties and heavy metal concentration of Buriganga and Balu Rivers shows that both river water are not suitable for drinking, bathing, house hold activities and aquatic life.

The relationship between the heavy metals studied offer remarkable information on the sources and pathway of the heavy metals. Table 8 indicates Fe is significantly strong correlated with Zn (0.969), Pb (0.951), Cr (0.929), Cd (0.992). The significant strong positive correlations between the heavy metals indicate high degrees of association. The correlation analyses showed a high degree of metal association in the order of Fe/Cd> Fe/Zn> Zn/Pb> Fe/Pb>Zn/Cd> Pb/Cd> Fe/Cr> Zn/Cr> Pb/Cr> Cr/Cd> Cr/Hg> Pb/Hg> Zn/Hg> Fe/Hg> and Cd/Hg.

Conclusion

The quality of drinking and irrigation water is a basic need for a healthy society. Assurance of drinking water safety is a foundation for the prevention and control of waterborne diseases. In present research BOD & COD values for both the rivers were higher than standard values. The EC and pH values of both rivers were within the acceptable limit. The present work shows that the concentration of Fe, Pb and Cr in both the river water were very high and these concentrations are harmful to aquatic life. Buriganga River is polluted by many sources but mainly by leather industries and from these industries inorganic and organic pollutants discharged into Buriganga River regularly without any treatment. On the other hand, the measured concentrations of heavy metals in Balu River were comparatively lower than those in Buriganga River except Fe and Hg. The Balu River is polluted by various industries and mainly by fabric dyeing industries in which huge amount of organic chemicals are used. However, the metal concentrations of Balu River were less than Buriganga River but these values exceeded the acceptable limit compared with water quality standards. In conclusion authors made a comment that both the rivers are highly polluted by industrial and sewerage wastewater.

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