HEAVY METAL CONTAMINATION ASSESSMENT OF THE BURIGANGA RIVER BED SEDIMENT

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ABSTRACT
The Buriganga has become a dead river with thousand tons of polluted materials which are being deposited in the sediment from different sources containing heavy metals as well as non-biodegradable plastics. The sediment bed is the living place for different species which are dependent on it for their food and shelter. The accumulation of the contaminating elements in their body will be magnified through the ecosystem and will ultimately affect human health. By dredging, river bed sediment are transported for land filling purposes. The crops that are grown on the reclaimed land will accumulate the contaminants and ultimately affect the human health. For a developing country like Bangladesh, the solution for the problem is not sustainable if the cost is high or the technology requires much specialization. This study is to assess the present condition of the sediment of the Buriganga river bed. The sediments of the Buriganga have been found to be highly polluted with respect to Cu and Zn; unpolluted to moderately polluted with respect to Pb and moderately polluted to highly polluted with respect to Cr on the basis of USEPA sediment quality guideline.

Keywords: Riverbed sediment; heavy metal contamination; EPA guidelines; geo-accumulation index

INTRODUCTION
Rapid industrial development, coupled with the growing population has led to the generation of large quantities of industrial and municipal wastewaters, which are typically discharged into drainage canals/khals, that eventually take them to peripheral rivers and other water bodies. Buriganga river is the lifeline of many economic endeavors in Dhaka. In terms of quality, Buriganga is vulnerable to pollution from untreated industrial effluents and municipal wastewater, runoff from chemical fertilizers and pesticides, and oil spillage in and around the operation of river ports (Kamal et al., 1999; Ahmad et al., 2010; Saha and Hossain, 2011; Islam, 2015; Sikder, 2016). Wastewater pollution and its management is one of the biggest environmental concerns for Bangladesh. Pollution of the natural environment by heavy metals is a worldwide problem because these metals are permanent and most of them have toxic effects on living organisms when they exceed a threshold concentration. Discharge of greater quantity pollutants into aquatic environment may result in deterioration of ecological balance, changing the physical and chemical nature of the water and aquatic biota. River sediments are a major carrier of heavy metals in the aquatic environment. In addition, sediment-associated chemicals have the potential to adversely affect sediment-dwelling organisms (e.g., by causing direct toxicity or altering benthic invertebrate community structure). Therefore, sediment quality data (i.e., information on the concentrations of chemical substances) provide essential information for evaluating ambient environmental quality conditions in freshwater systems. This study assesses the present condition of the Buriganga river bed sediment and possible cost effective and eco-friendly measures to remediate the heavy metal contamination.

METHODOLOGY
The research work was conducted in the following way:
(1) Site Exploration: Before collection of the soil samples, the site of the bank of the Buriganga was visited several times for reconnaissance purpose for site selection and sample collection.
(2) Sample Collection: Disturbed soil samples were collected from surface and deep sediments of the river bed. For surface layer sediment, samples were collected by hand. For deep layer of deposition, dredging by excavator in the river bed was used as the soil sampling method. For the river bank soil,

hand sampling was used for sample collection. Fig. 1 shows the soil sampling from river bed and bank.

(3) Soil Classification: Soil samples were tested and classified as per the MIT Soil Classification

Table 1: Location of Sites for Sample Collection

Stations	Site Name	Longitude	Latitude
1	Shoari Ghat	E 90º 23′ 36.4″	N 23º 42′ 45.1″
2	Mitford Ghat	E 90º 23′ 54.4″	N 23º 42′ 43.6″
3	Babu Bazar Ghat	E 90º 24′ 9.78″	N 23º 42′ 33.57″
4	Sadarghat	E 90º 24′ 31.6″	N 23º 42′24.5″
5	Badamtoli Ghat	E 90º 24′ 13.47″	N 23º 42′ 31.8″

(a) **(b)** **(c)**

Fig. 1: Photographs showing: (a) hand sampling of soil samples; (b) collection of soil samples from riverbed using excavator and (c) collecting riverbed sediments using excavator

System. Clay and silt are commonly referred to as fine grained soils, while sand and clay are referred to as coarse grained soils. ASTM D422 was performed to determine the soil grain size distribution.

(4) Tests on Soil Samples**:** Tests were done to determine the grain size distribution, specific gravity, organic content and heavy metal content of the soil of the Buriganga river.

RESULTS AND DISCUSSIONS

The contamination from the perspective of heavy metals present in the sediment is compared using different international guidelines and index values. The results are compared using different bar charts, graphs and tables.

Physical Properties

Physical properties include specific gravity and grain size distribution of the soil samples. The specific gravity of soils varies within the range of 2.65 to 2.75.Grain size has a great influence over the adsorption capacity of heavy metals. The soil samples contained 16% silt (size from 0.002 mm to 0.06 mm) and sand 84% (size ranging from 0.06 mm to 2 mm) . According to MIT soil classification system, the soil samples are silty sand. Average organic content of the samples was 1.65%.

Chemical Properties

Chemical properties include organic content and heavy metal content in the Buriganga river bank soil. Five samples were collected from the five locations of the Buriganga river bank for heavy metal content. The results are presented in Table 2.

The chemical contamination in the Buruganga river bank soil can be evaluated by comparison with the sediment quality guideline proposed by USEPA. These criteria are shown in Table 3.

Present study shows that for Pb, Site 1 and 3 are heavily polluted while Site 2 and 3 are moderately polluted and Site 4 is not polluted. For Cr and Zn, sites 1, 2, 3and 4 are heavily polluted and site 5is moderately polluted. For Cu, all the five sites are heavily polluted. For Ni, there is no guideline value.

In the present study, maximum contamination factor was found at Site 5 where the degree of contamination is 14.56. Contamination factors, $C_f > 6$ (very high contamination) have been found in Site 1, 4 and 5 for Cu. All the sites have a contamination factor (C_f) > 1 for all tested heavy metals except site 2 and 4 for Cr, site 2 and 5 for Ni (Table 4 and Table 5).

In the present study, according to the Muller's scale, the calculated results I_{geo} values indicate that the Buriganga river sediments for Pb is unpolluted to moderately polluted for station 2, 4 and 5. At stations 1 and 3, the sediments are moderately polluted for Pb. For Cr, all the stations are unpolluted indicating negative values. For Cu, at stations 1, 4 and 5 the sediments are moderately to strongly polluted. At station 2, the sediments are moderately polluted. At station 3, the sediments are unpolluted to moderately polluted. For Zn, all the stations are unpolluted to moderately polluted except station 4 with indications of being unpolluted. For Ni, all the stations are unpolluted except station 4 which shows unpolluted to moderately polluted indication.

Table 2: Concentration of heavy metals in the Buriganga riverbank soil

Sample No.	Concentration of heavy metal (mg/kg)				
	Pb	Cr	Cu	Zn	Ni
1	71.11	100.51	203.86	251.85	26.10
2	42.43	79.52	151.96	267.09	11.11
3	65.46	108.16	77.30	333.22	31.11
4	35.51	45.18	192.03	152.04	55.11
5	45.42	132.19	234.02	355.03	19.12
Maximum	71.11	132.19	234.02	355.03	55.11
Minimum	35.51	45.18	77.30	152.04	11.11
Background value	20.00	97.00	32.00	129.00	22.00

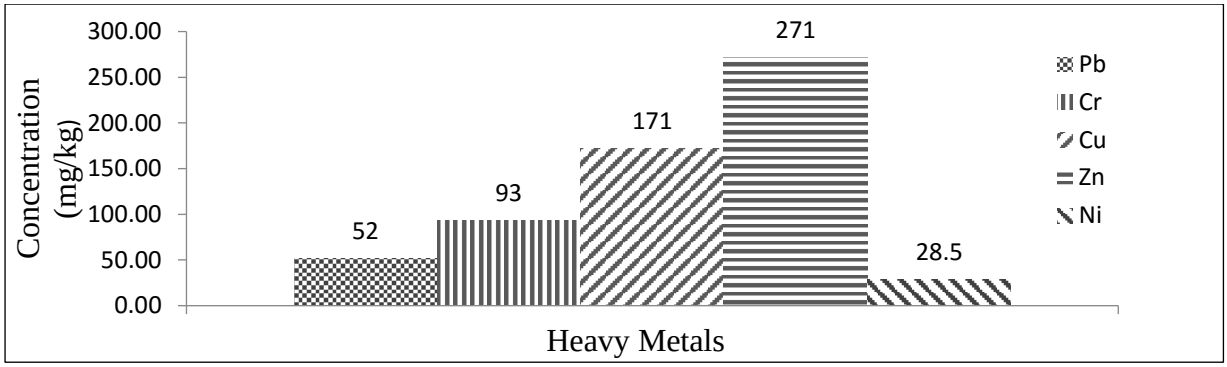

Fig. 2: Comparison among concentrations of heavy metals using the mean value from five locations

Table 3: EPA guidelines for sediment contamination for heavy metals

Metal	Not Polluted	Moderately Polluted	Heavily Polluted	Present value
	(mg/kg)	(mg/kg)	(mg/kg)	(mg/kg)
Pb	<40	40-60	>60	35.5– 71.1
Cr	<25	25-75	>75	45.2 – 132.2
Cu	<25	25-50	>50	77.3 – 234.0
Zn	<90	90-200	>200	152.0 – 355.0
Ni	–	–	–	11.1– 55.1

Table 4: Contamination factor and level of contamination

Contamination Factor (C_f)	Level of Contamination
$C_f < 1$	Low contamination
$1 \leq C_f < 3$	Moderate contamination
$3 \leq C_f < 6$	Considerable contamination
$C_f > 6$	Very high contamination

Table 5: Contamination factor values for sediment samples of the Buriganga river

Stations	Contamination Factor (C_f)					Degree of Contamination
	Pb	Cr	Cu	Zn	Ni	
1	3.56	1.04	6.37	1.95	1.19	14.11
2	2.12	0.82	4.75	2.07	0.50	10.26
3	3.27	1.12	2.41	2.58	1.41	10.79
4	1.78	0.47	6.00	1.18	2.50	11.93
5	2.27	1.36	7.31	2.75	0.87	14.56

Saha and Hossain (2011) also reported similar results. For the safe use of Buriganga water and river bed sediment, remediation of heavy metal is necessary. In a recent study, Choudhury et al. (2015) presented that Indian Mustard and Marigold plants can be used for treating heavy metal from the Burigonga river bed sediment.

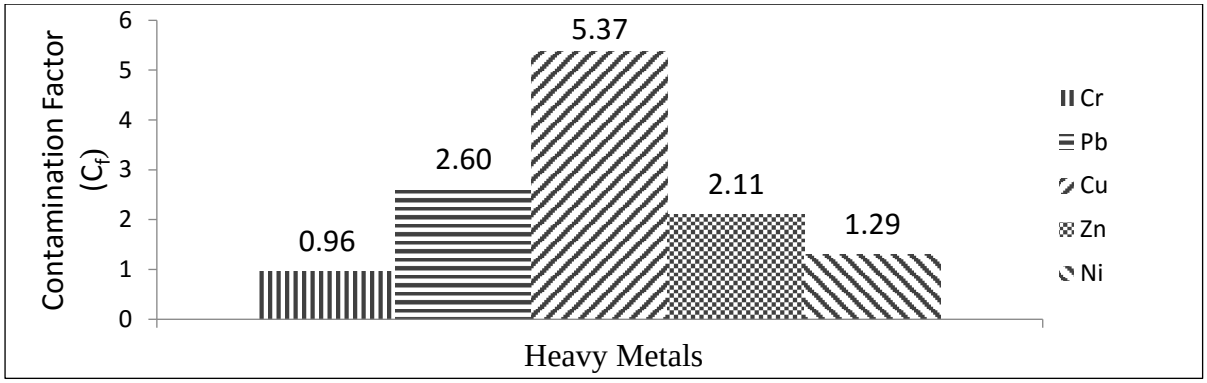

Fig. 3: Comparison among contamination factors for different heavy metals from five locations

Table 6: Muller's Classification for the Geo-accumulation Index

I_{geo} Value	Class	Sediment Quality
<0	0	Unpolluted
0-1	1	From unpolluted to moderately polluted
1-2	2	Moderately polluted
2-3	3	From moderately to strongly polluted
3-4	4	Strongly polluted
4-5	5	From strongly to extremely polluted
>6	6	Extremely polluted

Table 7: Geo-accumulation index values (Igeo) for the sediment samples of the Buriganga river

Station	I_{geo}				
	Pb	Cr	Cu	Zn	Ni
1	1.25	-0.53	2.09	0.38	-0.34
2	0.50	-0.87	1.66	0.47	-1.57
3	1.13	-0.43	0.69	0.78	-0.08
4	0.24	-1.69	2.00	-0.35	0.74
5	0.60	-0.14	2.29	0.86	-0.79

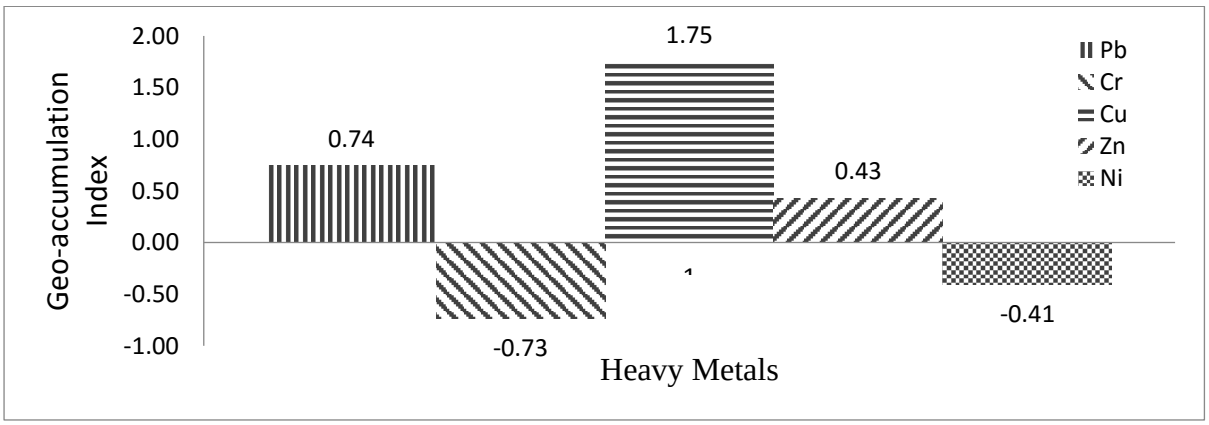

Fig. 4: Geo-accumulation index values for different heavy metals at five locations

CONCLUSIONS

Soil samples were collected from Burigonga river bed and bank. Heavy metal content of the samples was assessed in the study.

(1) The sediments of Burigonga river assessed in this study have been found to be highly polluted with respect to Cu and Zn; unpolluted to moderately polluted with respect to Pb and moderately polluted to highly polluted with respect to Cr on the basis of USEPA sediment quality guideline.
(2) According to contamination factor, level of contamination is moderate to considerable for Pb, moderate to low for Cr, very high to considerable for Cu, moderate for Zn and moderate to low for Ni.
(3) In accordance with geo-accumulation index, sediment quality is unpolluted to moderately polluted for Pb, unpolluted for Cr, moderate to strongly polluted for Cu, unpolluted to moderately polluted for Zn, unpolluted for Ni. The degree of contamination is greater than 10 for each station. At station 1 and 5, the condition is worst.
(4) Bioremediation for the existing extreme condition of contamination is suggested for low cost and eco-friendly solution for Bangladesh.

Other heavy metals (Cd, Fe, Al, As, Hg) and other parameters such as total organic carbon, sediment oxygen demand and moisture content may be considered for further analysis and in-depth research. Assessment of heavy metal contamination in water samples can be carried out and correlation of heavy metal contamination between sediment and water samples of the Buriganga river can be prepared. Other rivers of Bangladesh may be considered for further research. GIS and Remote Sensing based maps on sediment contamination can be prepared. It is suggested that pH, salinity, temperature etc. should be investigated further to comprehend details about metals in this environment of the Buriganga river.

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