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ASSESSMENT OF HEAVY METALS CONTENTS IN WATER AND SEDIMENTS OF THE MEGHNA RIVER IN BANGLADESH

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ABSTRACT

A study was determined the heavy metals concentration in water and sediments of the Meghna river during the period from April to December 2018. The water and sediments samples were collected in monthly basis covering both in wet (April to June) as well as dry seasons (October to December) from three sampling stations as St-1 (Kauriapara), St-2 (Nagoriakandi) and St-3 (Kamargaon). In water, available Pb, Cu, Zn and Mn contents were varied seasonally and spatially from 0.002 to 0.0.019, 0.00 to 0.026, 0.001 to 0.082 and 0.003 to 0.062 mg/l, respectively. The Zn was the most abundant in the water during dry season as Zn is normally associated with a variety of other metal activities and mining. In sediments, Pb, Cu, Zn, and Fe contents were also varied seasonally and spatially from 6.34 to 20.46, 1.39 to 28.06, 81.30 to 98.90 and 2274.28 to 34.62.10 mg/kg, respectively. The Fe content in all sediment samples were above the EPA guideline whereas the content of Cu and Zn fall in the criteria of moderately polluted range. So, the water is not completely safe for aquatic organisms in respect of heavy metal pollution in the Meghna river.
Key words: Heavy metal, Meghna river, water and sediment

Introduction

Water is known as blue gold, one of the most priceless gifts of nature is also regarded as the life line on earth, because evolution of life and development of human civilization could not have been possible without water (Islam *et al*., 2015). Again the river water quality is a key concern as it is used for drinking and domestic purposes, irrigation and aquatic life including fish and fisheries (Uddin *et al*., 2014). Large number of rivers flowing through Bangladesh originated outside of the country and these carry heavy loads of sediments and other debris including domestic wastes, agrochemicals and industrial wastes from local and far places. Thus making the water body saturated and times over saturated with organic and inorganic pollutants which creates serious environmental impacts. So, pollution become serious problem all over the world and is getting aggravated in developing countries particularly like Bangladesh (Sarker, 2005). Bangladesh is one of the most polluted countries, which currently holds 1176 industries that discharge about 0.4 million m^3 of untreated waste to the rivers in a day (Rabbani and Sharif, 2005). The industrial discharge is one of the major sources of heavy metal. Heavy metals are stable, xenobiotic and are non-biodegradable, once taken they persist in the body, tissues and cells. Exposure to the toxic environment is done by inhalation of air contaminated with metal dusts, fumes and small particle generated by combustions, intake of contaminated food, eating at contaminated site, eating without washing hands (Bhargava *et al.,* 2017). Studies on heavy metals in rivers, lakes, fish and sediments have been a major environmental focus especially during the last decade (Fernandes *et al*., 2008; Pote *et al*., 2008; Praveena *et al*., 2008). Heavy metals accumulation and distribution in sediments, water and environment are increasing at an alarming rate causing deposition and sedimentation in water reservoirs and affecting aquatic organisms as well (Mohiuddin *et al*., 2011).Though some metals like Fe, Cu and Zn are essential micronutrients, they can be detrimental to the physiology of the living organisms at higher concentrations (Kar *et al.*, 2008; Nair *et al.,* 2010). Others like chromium, lead, cadmium, arsenic, etc. exhibit extreme toxicity even at trace levels (Miller *et al.,* 2003).Once the heavy metals are consumed they keep on accumulating and at higher concentration they form complex compounds within the cells and tissues, leading to diseases. On intake, the heavy metals become integral part of some body parts like bones, kidney, liver and brain (Bhargava *et al*., 2017). Acute Pb poisoning may results in a dysfunction in the kidney, reproduction system, liver and brain resulting in sickness and death. Zinc compounds affect the

gastrointestinal system. High uptake of Cu can cause liver and kidney damage (Anarado *et al.,* 2019). The Meghna river is polluting at different sites from industries, agricultural runoff and brick fields which situated on the banks of this river or very close to the river system. The river receives industrial waste water from textile and food processing industries, emission from brick kilns which contain heavy metals and fly ash, and fall down due to gravity. Domestic and agro-chemical wastes also contribute heavy metal pollution in water and sediment of Meghna river. But no significant studies have been undertaken to investigate the pollution of the Meghna river. So it is necessary to assess the state of the water and sediment quality of the Meghna river. The objective of the present study is to assess the level of heavy metal contents in water and sediments that will focus on the pollution status of the Meghna river.

Materials and Methods

Study area: The study was conducted in 2018 covering both wet (April to June) and dry seasons (October to December) at the Meghna river in Narsingdi sadar upazila of Bangladesh.A part of the Surma-Meghna river system, the Meghna is formed inside Bangladesh in Kishoreganj district above the town of Bhairab bazar by the joining of the Surma and the Kushiyara, both of which originate in the hilly regions of eastern India as the Barak river.The total catchment area of the Meghna river is 82000 km^2 and 13 million tons of sediment is being transported per year. Three sampling stations were selected for this study indicated as St-1(Kauriapara), St-2 (Nagoriakandi) and St-3 (Kamargaon)in Meghna river.

Water sample collection and analysis: The water samples were collected fortnightly from St-1, St-2 and St-3 during the study period. The heavy metals as Lead (Pb), Copper (Cu), Zinc (Zn) and Manganese (Mn) in water were determined with the help of Atomic Absorption Spectrophotometer (AAS) in the laboratory of Soil Resource Development Institute, Krishi Khamar Sarak, Khamar Bari, Farmgate, Dhaka.

Sediment sample collection and analysis: The sediments samples were collected from about 1 m below the water surface of the three sampling stations (St-1, St-2 and St-3) during the study period. Approximately 1000 gm sediment sample was collected from each sampling station for analysis with the help of Grab sampler and then placed in polyethylene bag to transport immediately to the laboratory. Sediment samples were air dried, sieved with 230 mesh (600μ) stainless screens to separate larger particles and pebbles and digested with 4:1 mixture of nitric acid. The heavy metals as Pb, Cu, Zn and Fe in sediments were also determined with the help of Atomic Absorption Spectrophotometer (AAS) in the Laboratory of Soil Resource Development Institute, Krishi Khamar Sarak, Khamar Bari, Farmgate, Dhaka.

Statistical analysis: The collected data were compiled and tabulated in proper form and were subjected to statistical analysis. The Microsoft Office Excel software was used to present and interpret the collected data.

Results and Discussion

Heavy metals in water: The concentration of Pb in the river water was ranged from 0.002 to 0.007 and 0.008 to 0.019 ppm during wet and dry season, respectively (Table 1). The highest content of Pb (0.019 mg/l) was found at St-3 in dry season and lowest concentration (0.002 mg/l) was found at St-1 in wet season (Fig. 1). These variations are likely to be due to different collection spots and seasons. Mean concentration of Pb 0.004 and 0.012 mg/l found during wet and dry season, respectively. Both the values are lower than standard level given by ECR (1997). Yasmeen *et al*. (2012) found concentration of Pb of the Buriganga river water during wet season < 0.01, 0.011 and 0.0403 in mg/l different location of the river. These results are similar to the present study. Ahmed *et al*. (2010) observed the concentration of Pb ranged from 0.058 mg/l during pre-monsoon to 0.072 mg/l during monsoon in the Buriganga river.

The concentrations of Cu in the river water were ranged from 0.00 to 0.016 and 0.014 to 0.026 mg/l during wet and dry season, respectively (Table 1). The highest content of Cu (0.26 mg/l) was found at St-3 during dry season and lowest content (0.00 mg/l) was found at St-1 and St-2 during wet season (Fig. 2). The mean concentration of Cu along the river was 0.010 and 0.020 mg/l during wet and dry season, respectively which were lower than the standard level given by ECR (1997). Ahmed *et al*. (2010) studied that the

concentration of Cu ranged from 0.111 mg/l during pre-monsoon to 0.2 mg/l during monsoon in the Buriganga river. These results are mostly similar with the present study. Meghla *et al*. (2013) found that the water samples of Turag river contained significant amount of Cu ranged from 0.01 to 0.02, 0.02 to 0.03 and -0.27 to -0.21 mg/l during post-monsoon, pre-monsoon and monsoon seasons, respectively which are much lower than the present study due to the discharging of effluent from textile industries, dumping of solid waste, and run-off from agricultural activities in Meghna river.

The concentrations of Zn recorded in the river water were ranging from 0.001 to 0.020 and 0.031 to 0.082 mg/l in wet and dry season, respectively (Table 1). The highest concentration of Zn (0.082mg/l) was found at St-3 during dry season and lowest concentration (0.001mg/l) was found at St-1 during wet season. Mean concentration of Zn 0.008 and 0.54 mg/l found during wet and dry season, respectively. Both the finding is lower than the standard level provided by ECR (1997).

Table 1. Heavy metals (Pb, Cu, Zn, Mn) contents in water (mg/l) of the Meghna river during wet and dry season

Heavy metals	Sampling stations	Wet season (Apr-Jun)		Dry season (Oct-Dec)		Standard
		Avg. (N=3)	Range	Avg. (N=3)	Range	
Lead (Pb)	1	0.003	0.002 to 0.007	0.009	0.008 to 0.019	0.05 (ECR, 1997)
	2	0.004		0.012		
	3	0.006		0.015		
	Mean	0.004		0.012		
Copper (Cu)	1	0.008	0.00 to 0.016	0.020	0.014 to 0.026	1.0 (ECR, 1997)
	2	0.009		0.019		
	3	0.013		0.021		
	Mean	0.010		0.020		
Zinc (Zn)	1	0.006	0.001 to 0.014	0.035	0.031 to 0.082	5.0 (ECR, 1997)
	2	0.010		0.051		
	3	0.008		0.078		
	Mean	0.008		0.054		
Manganese (Mn)	1	0.005	0.003 to 0.016	0.019	0.016 to 0.062	0.100 (DoE, 1997)
	2	0.004		0.019		
	3	0.013		0.042		
	Mean	0.007		0.027		

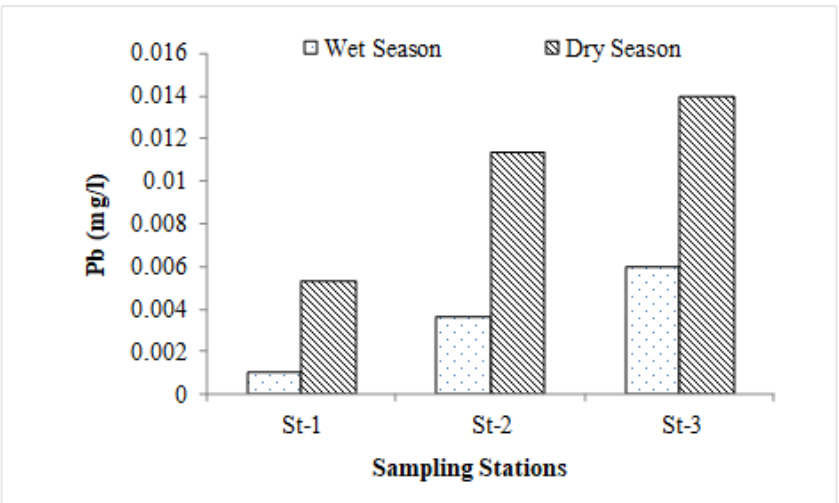

Fig. 1. The contents of Pb at different sampling stations during wet and dry season

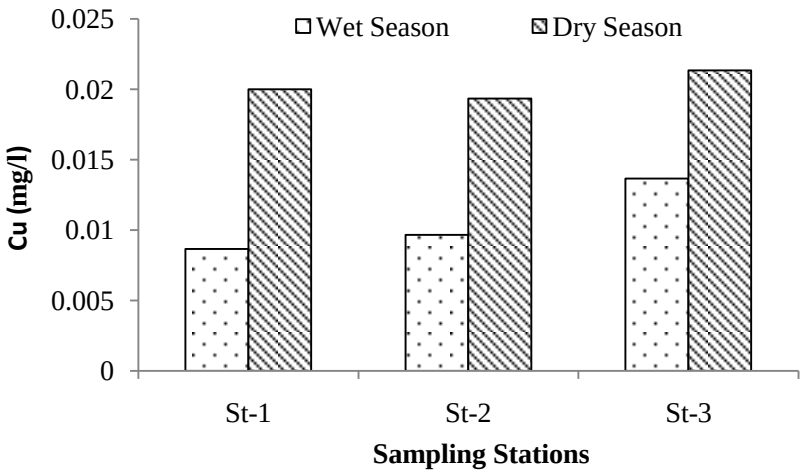

Fig. 2.The contents of Cu at different sampling stations during wet and dry season

Hasan *et al*. (2014) found the mean concentration of Zn during winter and rainy season of the Balu river water 0.38 and 0.05mg/l, respectively. Mokaddes *et al*. (2013) recorded concentration of Zn in river water of Dhaka metropolitan city 0.021mg/l. All the findings are much lower than the present study due to the discharge of effluent from textile industry, pollution from brick kilns, dumping of waste beside the study area and agricultural runoff.

The concentration of Mn in river water ranges from 0.003 to 0.016 and 0.014 to 0.062mg/l in wet and dry season, respectively (Table 1). The highest concentration of Mn (0.62mg/l) was found at St-3 during dry season and lowest concentration (0.003mg/l) was found at St-1 during wet season. The mean concentration of Mn along the river was 0.007 and 0.027mg/l during wet and dry season, respectively which were lower than the standard limits. Mondol *et al*. (2011) observed concentration of Mn in water of Tejgaon industrial area during dry season ranged from 0.019 to 0.34 mg/l, which is more or less similar with the present study.

Table 2. Comparison of heavy metals concentration (mg/l) in water among the Passur, Shitalakhyaand Meghna rivers

Heavy metals (mg/l)	Passur river (Shil *et al*., 2017)	Shitalakhya river (Islam *et al*., 2015)	Meghna river (Hassan *et al*., 2015)	Meghna River (present study)
Pb	NT	0.006	ND	0.008
Cu	0.020	0.020	NT	0.015
Zn	0.010	0.020	0.036	0.031
Mn	NT	NT	0.0088	0.017

Note: NT=Not tested; ND=Not detected

The comparative study between the heavy metal concentrations in water of Meghna river (present study) and other rivers of Bangladesh such as Buriganga, Shitalakhya and also a previous work on Meghna rivers was performed to depict the metallic pollution status of Meghna river (Table 2). The study observed similar level of Cu concentration (0.015 mg/l) in water of Passur and Shitalakhya rivers. It also observed similar level of Pb concentration (0.008 mg/1) in water of Shitalakhya river. Zn concentration of Meghna river was higher than Buriganga and Shitalakhya river. The study depicted that Meghna river was slightly contaminated with Mn.

Heavy metal concentration in sediments: Sediments are normally mixtures of several components including different mineral species as well as organic debris. The mean concentration of Pb in sediment samples was found 8.99 and 17.34 mg/kg during the wet and dry season, respectively (Table 3). According

to EPA (1977), the standard conc. of Pb in sediment is <40 mg/kg indicate unpolluted sediments, which revealed that the sediment of the Meghna river was not polluted by Pb (Table 4). The highest concentration of Pb was found 20.46 mg/kg at station St-3 whereas the lowest was 6.34 mg/kg at station St-1 (Fig 3).

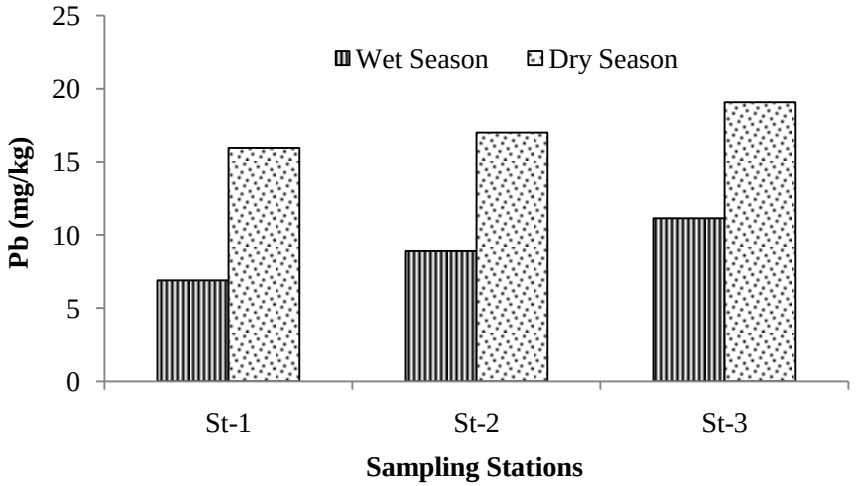

Fig. 3. The conc. of Pb in sediment at different sampling stations during wet and dry season

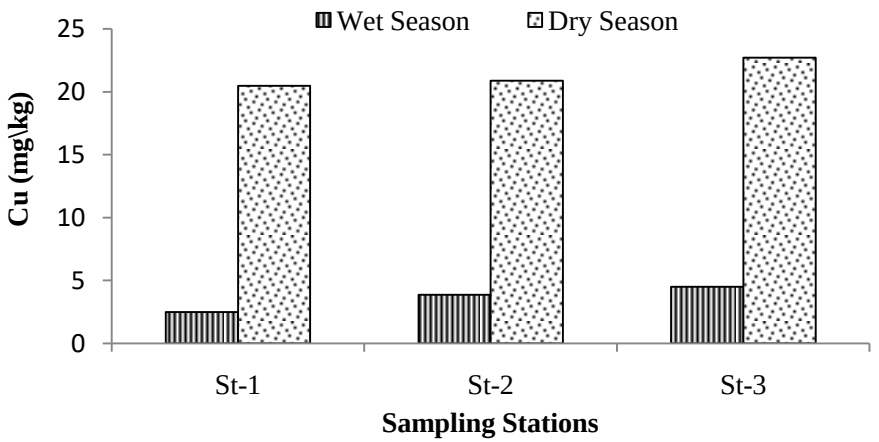

Fig. 4. The conc. of Cu in sediment at different sampling stations during wet and dry season

The mean concentration of Cu in sediment samples was found 3.62 and 21.35 mg/kg during the wet and dry season, respectively and the sediment was not polluted as per EPA (<25 mg/kg) guideline (Tables 3-4). The highest Cu concentration was 28.06 mg/kg at station St-3 during the dry season (Fig. 4).This may be due to the discharge of huge waste water from various industries and less rain water and runoff. Sediment is the ultimate depository of many chemical compounds including heavy metals from natural and anthropogenic sources. According to Rauf *et al*. (2009), the sediments also showed spatial and temporal variation of Cu ranged from 147.06 to 258.17 mg/kg. Average concentration of Cu in sediments of Turag river was 54.95 to 92.18 mg/kg (Mandal and Ahmed, 2013). Mehedi (1994) found that the concentration of Cu ranged from 31 to 60.88 mg/kg in the shipbreaking area of Chittagong.

The mean concentration of Zn in sediment was found 87.87 and 96.02 mg/kg during wet and dry season, respectively (Table 3) and as per the guidelines of EPA (1977) the moderately polluted sediments contain 90 to 200 mg/kg zinc (Table 4).The result of the study revealed that the highest Zn concentration was found

at St-3 during dry season. This might be due to the presence of large scale industries in the sampling area which discharge huge amount of waste water. Gaur *et al*. (2005) studied the distributions of heavy metal in sediment of Gomti river and found high concentration of all the metals in water and sediment in rainy season compared to summer and winter. Because in rainy season runoff from open contaminated sites, agricultural field and industries, directly comes into the river without any treatment. In both the cases, the concentration of zinc was maximum (0.091 µg/ml in water and 182.13 µg/ml in sediment), which is almost opposite to the present study.

Table 3. Heavy metals (Pb,Cu, Zn, Fe) conc. in sediment (mg/kg) of the Meghna river during wet and dry season

Seasons	Sampling stations	Heavy metal concentrations (mg/kg)			
		Pb	Cu	Zn	Fe
Wet (Apr.-Jun.)	St-1	6.90	2.50	86.04	2350.60
	St-2	8.91	3.86	88.97	2709.49
	St-3	11.15	4.51	88.62	2719.23
	Mean	8.99	3.62	87.87	2593.10
Dry (Oct.-Dec.)	St-1	15.96	20.47	94.96	3076.20
	St-2	16.99	20.87	95.56	3091.9
	St-3	19.08	22.70	97.57	3248.26
	Mean	17.34	21.35	96.02	3138.79

Table 4. Comparison of heavy metal contents (mg/kg) in sediment of Meghna river with EPA guideline

Heavy metals	EPA guideline (EPA, 1997)			Present study
	Not polluted	Moderately polluted	Highly polluted	
Pb	< 40	40-60	> 60	6.34-20.46
Cu	< 25	25-50	> 50	1.39-28.06
Zn	< 90	90-200	> 200	81.30-98.90
Fe	< 1.7	1.7-2.5	> 2.5	2274.28-3462.10

The lowest concentration of Fe was 2274.28 mg/kg found at St-1 during wet season whereas the highest was 3462.10 mg/kg at St-3 in dry season (Table 3). As per guidelines of EPA (1977), the polluted sediments contain more than 1.7 mg/kg iron (Table 4). The result of the study depicted that the sediment samples were contaminated with Fe over all seasons in all the stations. This might be due to the supply of large scale of iron compound into the river water from the surroundings environment. Various industries, municipal sewerage line, agricultural land, residential areas are situated in the study area.

Table 5. Comparisons of heavy metals conc. in sediment among the Passur, Turag, Dhaleswari and Meghna river

Heavy metals (mg/l)	Passur river (Shil *et al*., 2017)	Turag river (Mandal and Ahmed, 2013)	Dhaleswari river (Ahmed *et al*., 2010)	Meghna river (Present study)
Pb	7.26	34.89	60.21	11.85
Cu	15.83	54.95	73.79	12.23
Zn	NT	NT	NT	92.03
Fe	21141.96	NT	NT	2865.94

Note: NT=Not tested.

A comparative study among the heavy metal concentration in sediment of the Meghna river and others river such as Passur, Turag and Dhaleswar river were also performed to depict the status of heavy metal contamination in sediment of Meghna river in relation to others (Table 5). The study depicted that Pb and Cu contents of Dhaleswari river sediment severely exceeded the standard level. The Meghna river sediment showed higher level of Fe contamination and it was moderately polluted by Zn. From the overall discussion the study concluded that Dhaleswari river sediment highly contaminated by heavy metals followed by Shitalakhya, Turag and Passur river. The extent of heavy metals pollution in all the river system implies that the condition is much frightening and may severely affect the aquatic ecology of the river.

Conclusion

The rapid growth of industrialization and urbanization greatly disrupts the aquatic environment through indiscriminate disposal of industrial effluents and solid waste. The present investigation revealed that the Zn was the most abundant in the water during dry season as Zn is normally associated with a variety of other metal activities and mining. The concentrations of Fe in all sediment samples were above the EPA guideline for highly polluted sediment and the concentration of Cu and Zn are fall in the criteria of moderately polluted range. The study also revealed that the aquatic environment of Meghna river is not completely safe for fisheries. So, appropriate steps needed to be taken immediately to maintain the sound and healthy aquatic environment of the Meghna river.

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