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ASSESMENT OF LEAD IN WATER, SEDIMENTS, SOILS AND VEGETABLES GROWN ON THE BANK OF SHITALAKHYA RIVER, BANGLADESH

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ABSTRACT

The study was carried out to examine the Pb concentrations of water, sediment and soil of Shitalakhya River at Polash and Ghorashal areas in Bangladesh. The ranges of Pb in water, sediments, soils and vegetables like pumpkin leaves and alligator weeds were found 1.87 - 49.08, 8.49 - 75.81, 19.68 - 85.13, 1.08 - 3.92 and 1.18 - 4.22 mg/kg, respectively. The lead concentrations of surface water, sediment and soil samples were within the safe limit of different international standard except samples of the point source of urea fertilizer factory. The highest concentrations of Pb in alligator weeds and pumpkin vegetable leaves were recorded 3.92 and 4.224 mg/kg, respectively at the point source of urea fertilizer factory.

Key words: Point source, Pb, Alloy, White metal, Shitalakhya

INTRODUCTION

Pb is very toxic to humans. This is only tolerable at extremely at low concentration and excesses are associated with many adverse health effects. Exposure to Pb has been associated with reduced IQ, learning disabilities, slow growth, hyperactivity, and antisocial behaviors and impaired hearing (Dahiya *et al*. 2005). Generally Pb-poisoning is ranked as the most common environmental health hazard. The US EPA has classified Pb as a probable human carcinogen (Adriano 2001).

The Shitalakhya River generated from old Brahmaputra at Tok of greater Mymensingh. This flows south, touching the eastern part of Dhaka city and flowing through Narayanganj and meets Meghna River at Kolagachia of Monshiganj. In recent years, the Polash area of Narsingdi has become one of the rapidest developing regions in Bangladesh. The Shitalakhya River receives effluents from five jute mills, two fertilizer factories, one sugar mill, one cement industry, one textile industry, one dairy plant, two food processing industries, one hardboard mill, one paper mill and one of joint thermal power plant within 13 km range of its flow in Ghorashal region. Shitalakhya River is the

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main source of industrial and drinking water in this region. Surface water is used in industry for cooling, process, steam generation, safety and miscellaneous purposes. The present study was focused on the investigation of the contamination level of Pb in water, sediments, soils and vegetables grown on the bank of Shitalakhya River near Polash-Ghorashal region where many red and orange category industries are situated. The aim of this study is to explore the natural and industrial impacts of Pb and to assess the pollution status on that area.

MATERIALS AND METHODS

Surface waters were collected from Polash fertilizer factories area and Capital paper mill in Ghorashal region. Three sampling locations such as fertilizer factories, Seven Ring Cement industry and Capital paper mill areas were selected for soil and sediment.

Nine samples of surface water from the different sampling stations were collected in monsoon and pre-monsoon seasons distinctly. Surface water samples were collected away from the river bank and close to mid width of the river and a depth of about 20 - 25 cm below the water surface. The water samples were collected in plastic bottles and acidified immediately with 2 ml of HNO_3 per liter of water and preserved in refrigerator at 4^oC for laboratory analysis.

Sediment sampling was carried out from December, 2011 to July, 2012 for three seasons namely, dry season (December), pre-monsoon (March) and monsoon (July). On the other hand, soil sampling was carried out in pre-monsoon, 2012 (March). About 200 g of each wet soil and sediment were collected and transferred into the pre-cleaned plastic bags. The air dried soil/sediment samples were finely powered and sieved through a 2-mm nylon mesh to remove large debris, stones and pebbles. Then the samples were dried at 105^oC for 2 hours to remove all the moisture content and ground to pass through 60 mesh sieves and homogenized for analysis. Then the dried samples were digested.

Vegetable samples were collected randomly on March, 2011 from the bank of the river. Nine alligator weeds and four pumpkin vegetable leaves were collected by hand using vinyl gloves, carefully packed into polyethylene bags. The plant samples were pre-cleaned by tap water and finally cleaned with deionized water to remove airborne pollutants. Then the samples were cut into 2-cm pieces and dried in a hot air oven at 70 - 80^oC till the constant weight was achieved. The dried samples were ground in a stainless steel blender and then passed through a 2 mm sieve.

The water samples were digested with HNO_3 (APHA 1989). Sediment and soil samples were digested according to the $HNO_3/HClO_4$ digestion method (ASTM 2003). Vegetables were digested according to the $HNO_3/HClO_4$ method (Sullivan and Carpenter 1993). All reagents used were Merck analytical grade.

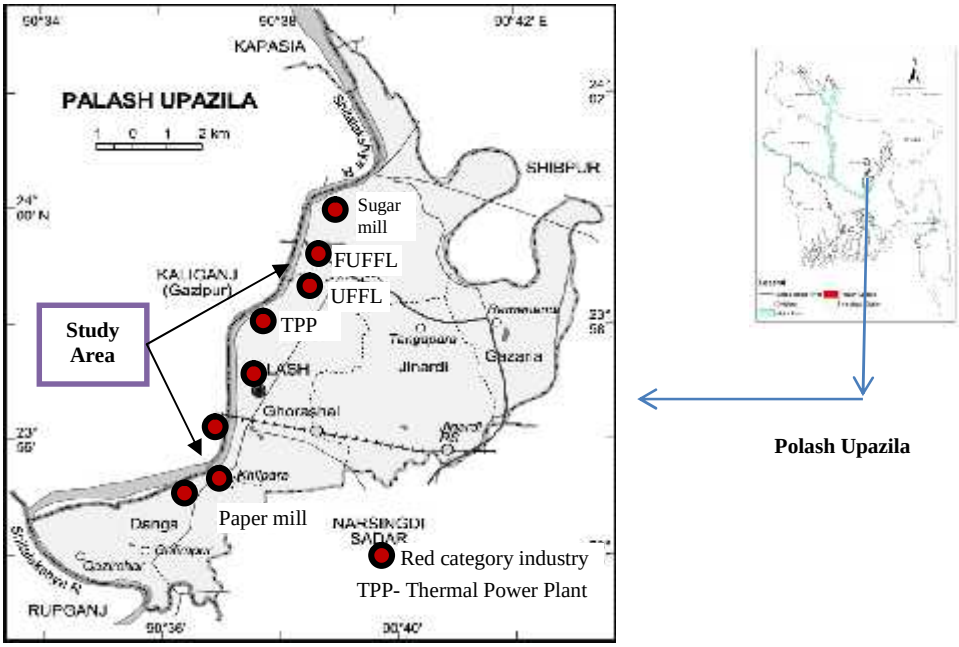

Fig. 1. Study area map.

Table 1. Locations of the sampling stations of sediment, soil, water and plants along the Shitalakhya River basin in Polash-Ghorashal region.

Region	Sediment	Soil	Water	Plant	Direction UP/down	Distance from *P.S. of UFF	Description
	F_{Sd1}	F_{S1}	-	F_1	Upstream	100 meter	
	-	-	F_{SW1}	-	”	20 ”	
	F_{Sd2}	F_{S2}	F_{SW2}	F_2	Downstream	03 ”	Near P.S. of UFF
	-	-	F_{SW3}	-	”	20 ”	
	-	-	F_{SW4}	-	”	100 ”	
Fertilizer factories region	F_{Sd3}	F_{S3}	-	F_3	”	400 ”	
			F_{SW5}		”	600 ”	Near P.S. of PUFF
	F_{Sd4}	F_{S4}		F_4	”	800 ”	
	-	F_{S5}	-	-	”	150 ”	Opposite from P.S. of UFF
	-	F_{S6}	-	-	”	500 ”	Opposite from P.S. of UFF
Cement industry	C_{Sd1}	C_{S1}	C_{Sw1}	-	”	10 Km	Seven ring cement area
	C_{Sd2}	C_{S2}	C_{Sw2}	-	”	11 ”	
Paper mill	P_{Sd1}	P_{S1}	P_{Sw1}	-	”	12 ”	Capital paper mill area
	P_{Sd2}	P_{S2}	P_{Sw2}	-	”	13 ”	P.S. of Capital Paper mill
	P_{Sd3}	P_{S3}	P_{Sw3}	-	”	14 ”	

*P.S.: Point Source, UFF: Urea fertilizer factory; PUFF: Polash urea fertilizer factory

The concentration of Pb in the samples was determined by AAS (Model No.120, Graphite Tube Atomizer, AAS, Agilent, Australia). The calibration curve for Pb was prepared by certified reference materials (CRM). The CRM were verified against SRM 3100 series developed by NIST via ICP-OES using an internal laboratory developed method. The uncertainty in the certificate value of CRM was calculated for a 95% confidence interval.

RESULTS AND DISCUSSION

This study revealed that the concentration of Pb in surface water at the different points of Shitalakhya River at Polash region in pre-monsoon season ranged from 1.87 to 23.03 μg/L and in monsoon ranged from 27.86 to 49.08 μg/L.

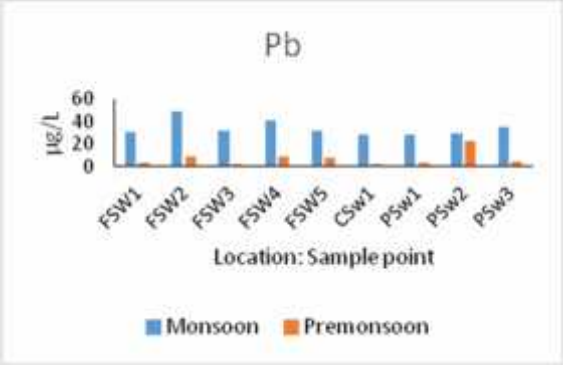

Fig. 2. Seasonal variation of Pb in surface water (duration: March to July, 12).

In all the points, lead concentration is higher in monsoon than pre-monsoon. This may be due to the flushing of the metal from immobilized deposits like domestic, natural and industrial sludge in rainy season. The results (1.87 - 49.08 μg/L) were below the recommended values for the protection of humans by US EPA (Sittig 1991). The highest concentration was recorded (49.08 μg/L) at near the point source of UFFL (F_{SW2}) and the second highest concentration was recorded (40.26 μg/L) at near the PUFFL point source (F_{SW4}). In pre-monsoon the highest concentration of Pb (23.02 μg/L) was recorded at the point source of paper mill (P_{sw2}). The level (41.24 to 63.15 μg/L) of Pb found in water in the present study was close to the findings of Ahmed *et al*. (2009).

Table 2 revealed that the average results of Pb concentration in present study in sediments (20.01 mg/kg) of Shitalakhya River were lower than Buriganga River but higher than Padma (17.00 mg/kg) and Jamuna River (19.00 mg/kg). The average concentrations of Pb in sediment (20.01 mg/kg) and soil (28.21 mg/kg) of the present study was lower than Ahmad *et al*. (2010), Mohiuddin *et al.* (2011), Saha and Hossain

(2011) and found the average Pb concentration in sediments of Buriganga River to be 69.75, 478.00 and 79.40 (mg/kg), respectively.

Table 2. Comparison of Pb in sediments and soils of Shitalakhya River with previous study of different rivers and reference value in the Bangladesh (mg/kg).

	Study area	Conc. mean	Range	Reference/ source
Reference value		20		[a](ASV) (Turekian and Wedepohl 1961)
		17		[b]CRC (Rudnick and Gao 2003)
		31		[c]TRV (US EPA 1999)
		31		[d] LEL (Persuad 1993)
		250		SEL
Bangladeshi river Previous study	Shitalakhya River	60.21	54.52-65.90	Ahmed *et al*. (2009)
	[e] Padma	17.00		[e]Datta and Subramanian (1998)
	[e]Jamuna	19.00		
	Buriganga River	69.75	65.18-77.13	Ahmad *et al*. (2010)
	Buriganga River	478.00	79.0-1552.0	Mohiuddin *et al.* (2011)
	Buriganga River	79.40	60.30-105.60	Saha and Hossain (2011)
Bangladeshi river	Sediments, Shitalakhya River, n = 27	20.01	8.49-75.81	Present study
	Soil, Shitalakhya River, n = 11	28.21	19.68-85.13	Present study

[a]ASV - Average shale value proposed by Turekian and Wedepohl 1961, [b]CRC - Continental upper crust values proposed by Rudnick and Gao (2003), [c]TRV - Toxicity reference value proposed by US EPA (1999), [d]LEL - Lowest effect level, SEL - Severe effect level, Ontario Ministry of Environment and Energy through aquatic sediment quality guidelines (Persuad *et al.* 1993) and [e]Datta and Subramanian (1998).

Fig. 3 represents the concentration of Pb in sediments of Shitalakhya River in three seasons. Four samples such as F_{sd2}, F_{sd4}, C_{sd1} and P_{sd2} were collected from near the point source of urea fertilizer factory (UFF), polash urea fertilizer factory (PUFF), Cement and paper mill, respectively. The highest concentration of Pb in sediment was recorded (75.81 mg/kg) at near to the point source of urea fertilizer factory in pre-monsoon but in monsoon it was found 29.47 mg/kg. This might have happened due to industrial pollutants were overlapped by natural sediments. The lowest concentration was recorded (8.49 mg/kg) at near the point source of Seven Ring cement industry in monsoon. Ahmad *et al*. (2010) previously studied the sediments of Buriganga River and found the highest concentration of Pb (77.13 mg/kg) in Balughat during pre-monsoon and the lowest in Shawaryghat in monsoon. The concentration of Pb at present study point did not exceed the sever effect level (SEL) values, proposed by Ontario Ministry of Environment and

Energy through aquatic sediment quality guidelines but sampling point F_{sd2} exceeded the lowest effect level (LEL) (Persuad *et al.* 1993).

On the other hand sampling point P_{sd3} also exceeded the lowest effect level (LEL) but that is not the industrial effect, it may be from natural phenomena such as weathering, seasonal and geological effect.

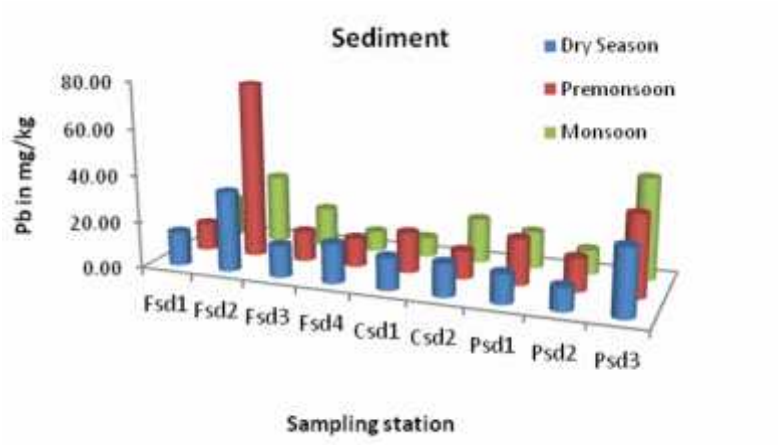

Fig. 3. Seasonal variation of Pb in sediments at different locations of river (dry wt. mg/kg).

Fig. 4 presents the concentration of Pb in soils on the bank of Shitalakhya River at pre-monsoon. The highest concentration of Pb in soil was recorded (85.13 mg/kg) at near the point source of urea fertilizer factory. The fertilizer industry uses babbitt metal, white metal, and chemicals which were major sources of Pb. The white metal that contain 70 - 80% Pb, 15% Sb, 12% Sn, 1.0 - 1.5% Cu is used in plain bearing. The concentrations of Pb in soils were found within the permissible level of different international standards. Maximum permissible concentration of Pb in soil in India is 250 - 500 mg/kg (Awashthi 2000).

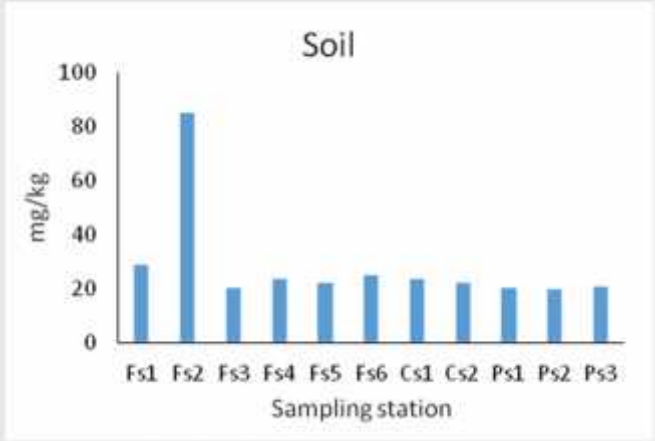

Fig. 4. Pb in soils (mg/kg) on the bank of the river at different locations in Pre-monsoon.

Fig. 5 represents the concentrations of Pb that were found in pumpkin vegetable leaves. These ranged from 1.08 - 3.92 mg/kg and alligator weeds from 4.22 - 1.08 mg/kg. The highest concentration of Pb in pumpkin vegetable leaves and alligator weeds were recorded 3.92 and 4.22 mg/kg, respectively, at near the point source of urea fertilizer factory which were also within the safe limit of FAO/WHO (5.0 mg/kg) and SEPA (2005) (9.0 mg/kg) but exceeded the Indian standard 2.5 mg/kg (Awashthi 2000). Sources of heavy metals for plants include rainfall in atmospheric polluted areas, high discharge of exhaust effluents, indiscriminate disposal of different types of Pb based white metal, solid wastages of bearing, babbitt metal and chemicals which could be absorbed by different plant through leaf blades and uptake by plant roots. Babbitt metal is most commonly used as a thin surface layer in a complex, multi-metal structure. Moreover, the concentrations of essential elements in plants is affected by the characteristics of the soil and the ability of plants to select and accumulate some metals.

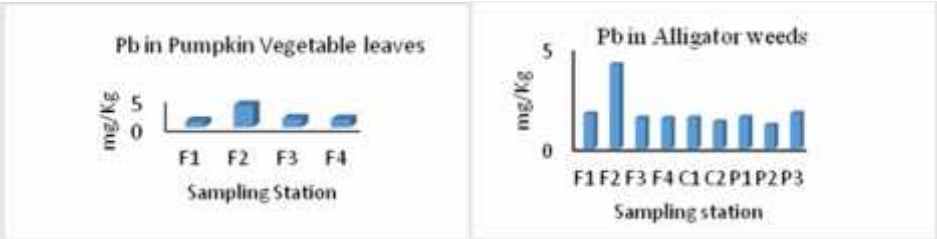

Fig. 5. Pb in pumpkin vegetable leaves and alligator weeds in pre-monsoon (dry basis) on the bank of Shitalakhya river.

CONCLUSION

The highest concentration of Pb in water, sediment and soil was recorded at the point

source adjacent to the urea fertilizer factory (UFF) in every season. Different types of alloy of white metal is used in heavy duty pumps and high pressure compressors of ammonia, urea and power plant of UFF. Tin-lead alloys such as babbitt metal have a low melting point that is ideal for using as solder, but these alloys also have ideal characteristics for plain bearings. Lead foil is used as gland packing and lead ware is used in bearing clearance of heavy duty pump and compressors. The industrial spare parts undergoing various types of repairs, mechanic workshops, heavy exhaust emissions and heavy duty vehicles, lorries may be the primary source of pollution to the point source of urea fertilizer factory. Pb concentration in sediment was found to decrease in order of Pre-monsoon < dry- season < monsoon. Although the concentrations of Pb in soils and sediments are lower than the safe recommended value but alligator weed and pumpkin vegetable leaves inside the UFF and its point source area exceeded the safe limit of Indian standard. The observed alligator weed and pumpkin vegetables leaves in the soil near point source will, in the long run, endanger consumer's health since the ingested heavy metals bioaccumulates in the human body. Moreover, with the gradual development of industries, intensive use of pesticides and discharge of untreated industrial effluent may further exacerbate the situation in coming years.

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