ASSESSMENT OF CONTAMINATED SOIL NEAR HATIRJHEEL LAKE AT DHAKA CITY OF BANGLADESH

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ABSTRACT

Sediment, soil or water contamination with heavy metals is a big threat for the environment. Heavy metals from sediment, soil or water could easily enter into the food chain or can enter human body. Due to the industrialization disposing of industrial wastes also increased. Mostly industries are located near/on the bank of the rivers or lakes where they dump effluents directly without proper management. In this study, an investigation was carried out to determine the toxic heavy metals of the contaminated soil near Hatirjheel area, Dhaka, Bangladesh. Soil samples were collected from the five points of Hatirjheel Lake as well as joining points of Hatirjheel Lake and Gulshan Lake. The collected soil samples were acid digested following EPA method (3050B) and aliquots were analyzed by atomic absorption spectroscopy for quantification of arsenic (As), chromium (Cr), cadmium (Cd), lead (Pb) and manganese (Mn). The heavy metals were contained in the soil: Cr 21.8–43.1 mg/kg, Pb 9.5–74.9 mg/kg, As 2.7–33.3 mg/kg and Mn 138.3–222.7 mg/kg. The amount of Cd was in the soil below detection limit. However, the amounts of heavy metals contain in soil, they have adverse effect. It could be a great threat to the mankind as well as to the environment if the heavy metals leach from the soil into ground water. Heavy metals, even in trace amount are harmful to human health. Arsenic is responsible for skin damage, lead poisoning increases the cancer risk of kidney, lung and bladder whereas chromium (VI) is carcinogenic to human body.

Keywords: *Soil, heavy metals, environment, hatirjheel lake, dhaka*

1. INTRODUCTION

Bangladesh is a developing country where rapid industrialization is the most common because of having low cost labour and availability of raw materials. Unfortunately the industries are establishing without any planning and regulating rule. Increasing industrialization disposing of industrial solid or liquid waste is also increased (Jacob and Otte, 2004; Stoltz and Greger, 2006; Ettler et al., 2004; Carbonell-Barrachina, 1999). Most of the industries are located near/on the bank of rivers or lakes where industries dump effluents directly without proper treatment. Thus, industries are creating environmental pollution, especially water pollution and also in consequence soil and air pollution. The impact of rapid industrialization on the environment is threatening both to the nature as well the existing and forthcoming generation.

Environmental pollution is due to toxic heavy metals having gained attention. During manufacturing process it consumes a huge amount of natural and synthetic chemicals, which mainly based on heavy metals. Contamination of sediment, soil or water with heavy metals is a big threat to the environment because of its various detrimental effects on human and other animals (Patra et al., 2007). Vehicular exhaust and industrial activities are the major sources of soil contamination with heavy metals. Due to increasing industrialization, disposing of industrial waste, mine tailings, metallurgical slags and municipal sewage sludge are also increased. Hereafter, soil is contaminated from where possibilities to leach toxic heavy metals into groundwater or surface water or enter the human food chain through various chemical and biological reactions. Small amount of heavy metals is beneficial for the metabolism of our body and beyond the limit is dangerous to our body and can cause different disease (AACAP, 2012). The accumulation of heavy metals in soil also adversely affects its physicochemical properties leading to infertility and low yield of crops (Khan et al., 2009). Contamination of groundwater by heavy metals may pose a more serious and continuing health risk to humans as well as the environment (Bhagure and Mirgane, 2011).

Hatirjheel is one of the polluting lakes situated in Dhaka metropolitan which is surrounded by Tejgaon, Gulshan, Badda, Rampura, Niketon, Maghbazar etc. Various industries like textiles, Polycon, battery and paint etc. are established around the lake and most of them are textiles. During the textile manufacturing process it consumes a huge amount of water, dyestuffs and synthetic chemicals, which mainly based on heavy metals. Wastewater from textile requires a complicated treatment like physicochemical or biological treatment due to containing high concentration of pollutants, complex composition and high concentration of dyes. It is matter of distress that most industries have not installed waste treatment plant to minimize overall production cost. The lake is polluted by the industrial activities, i.e. discharge of industrial effluents directly or indirectly, without proper treatment which contain considerable amount of heavy metals. Though as per the policy, government the Hatirjheel Lake was cleaned in 2012-2013, but till impact of previously introduced heavy metals is continuous.

In this study, investigation has been attempted to determine the heavy metal content in soil near Hatirjheel area at different points. The collected samples were acid digested and aliquots were analyzed by the atomic absorption spectroscopy for the quantification of arsenic (As), chromium (Cr), cadmium (Cd), lead (Pb) and manganese (Mn).

2. METHODOLOGY

2.1 Sampling

The soil samples were collected at a depth of 30cm from the existing ground surface from the points of Hatirjheel Lake, Dhaka, Bangladesh (Table 1) in polyethylene bag and brought back to the laboratory at the Department of Leather Engineering, Khulna University of Engineering & Technology (KUET), Khulna, Bangladesh. The samples were air dried, grinded with mortar and sieved with 80-mesh. After sieving, the sample was homogeneously mixed (Fig. 1).

Table 1: Locations of sample collection

Point	Latitude	Longitude	Location
A	23°46’26.3”	90°23’50.2”	Near Jamuna Garments
B	23°46’26.2”	90°23’50.5”	Joint of Hatirjheel and Gulshan lake
C	23°46’05.2”	90°25’23.5”	Near Rampura bridge
D	23°46’06.1”	90°25’22.5”	Near Rampura bridge
E	23°46’14.3”	90°24’08.4”	Near Hatirjheel first bridge

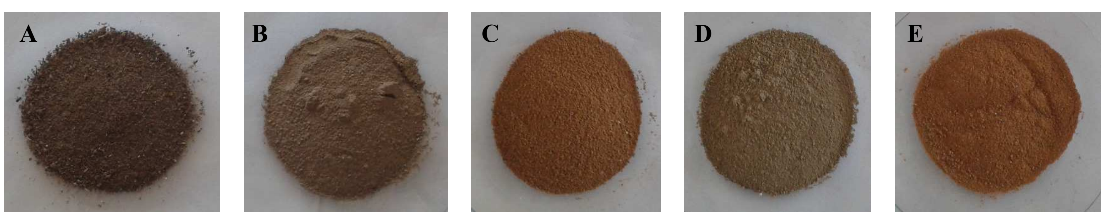

Figure 1: Soil samples after grinding and sieving

2.2 Reagents

All the stock solutions were prepared from the analytical grade (AR). The soil was acid digested with nitric (Merck KGaA, Germany) and hydrogen peroxide (Merck, India) which was collected from the Khulna scientific store. Freshly prepared double deionized water, from a quartz still, was used in the all experiments. Chromium (Cr), arsenic (As), lead (Pb), manganese (Mn) and cadmium (Cd) standard solution were obtained from the Fluka-Analytical, Switzerland. To reduce As(V) to As(III) 20% potassium iodide (Sigma-Aldrich, USA) solution was used. Arsenic trihydride (AsH_3) generation was performed with 5M HCl (Sigma-Aldrich, USA) and 0.6% sodium borohydride solution (Sigma-Aldrich, USA).

2.3 Acid Digestion

The homogeneously mixed sample was acid digested following the EPA Method 3050B. About 2.0 g sample was acid digested with nitric acid (HNO_3 65%, Merck KGaA, Germany). The acid mixed samples were heated, refluxed on hot plate for several hours and occasionally nitric acid was added until no brown fumes was given off. Then the mixture was cooled and hydrogen peroxide (30% H_2O_2, Merck, India) was added. The mixture was then heated, refluxed on a hot plate and hydrogen peroxide was added until the effervescence was minimal or the mixture appearance was unchanged. The mixture was heated continuing until the volume had become 5 mL. Then 50 mL deionized water was added and again heated for another one hour. The mixture was then cooled, filtrate through filter paper (Whatman No.1) and the solution was made up 100 mL with deionized water. The filtrate (aliquot) was preserved in high-density polyethylene (HDPE) bottle at 4°C until to complete metals analysis.

2.4 Analysis of Heavy Metals with AAS

Acid digested aliquot was analyzed by the atomic absorption spectroscopy (SpectrAA-220, VARIAN, Australia) at the Department of Public Health Engineering, Zonal Laboratory, Khulna, for the quantitative measurement of Cr, As, Pb, Mn and Cd. Arsenic was measured by the hydride vapour generation method using sodium borohydride as a reducing agent, carrier gas argon (Ar) at the wavelength of 193.7 nm. Cr, Pb, Mn and Cd were measured direct flame (air-acetylene) at the wavelength of 357.9 nm, 217.0 nm, 279.5 nm and 228.8 nm, respectively.

3. RESULTS AND DISCUSSION

3.1 Heavy Metals Content in Soil

Concentrations of the heavy metals were examined from the soil samples. The results of AAS analysis, shows the various concentrations of Cr, As, Pb, Mn and Cd in samples of collecting soil which are shown in the Table 2. The heavy metals were contained in the soil: Cr 21.8–43.1 mg/kg, Pb 9.5–74.9 mg/kg, As 2.7–33.3 mg/kg and Mn 138.3–222.7 mg/kg. The amount of Cd was in the soil below detection limit. Among the various concentrations of heavy metals, Mn was in higher level. The presence of heavy metals follows the series: Mn > Cr > Pb > As > Cd.

Table 2: Heavy metals content in the soil

Point	As (mg/kg)	Pb (mg/kg)	Cd (mg/kg)	Mn (mg/kg)	Cr (mg/kg)
01	2.708	75	BDL*	141.036	43.14
02	33.291	31	BDL	138.249	33.29
03	21.824	12	BDL	218.189	21.82
04	32.743	18	BDL	221.004	32.74
05	25.197	10	BDL	222.696	25.20

* BDL → Below detection limit

The industries located at the investigated area were used various types of metals incorporate with different chemicals. After processing metals are discharged from the industries in the wastewater stream. Finally it mixes with the Hatirjheel Lake. It may be the reason is that the contamination of soil with heavy metals near Hatirjheel area. The most commonly used metal in dyestuffs production is Cr. However, the source of arsenic is from the source of reagents or chemicals used for the textile process.

3.2 Leaching of Heavy Metals from the Soil

Many factors are responsible for leaching of heavy metals from the sediment/soil. pH is one of the most important factors for leaching of heavy metals from the sediment/soil into groundwater. At low pH, the solubility of Pb and Cd are increased whereas Cr and As forms different compound or complexes at different pH. Higher the pH, solubility of Cr(VI) and As(III) are increased. The mobility of As(III) compounds is 4-10 times higher than the As(V) compounds (McLean and Bledsoe, 1992). Cr(III) and As(V) are the least mobile. Soluble and un-adsorbed chromium complexes can leach from the sediment/soil into groundwater. If the pH changes for any causes, it will be horrible for our mankind as well as for the ecology. Other different factors e.g. temperature, amount of organic matter in soil, residual time of the sludge and soil texture and pore structure plays an important role in leaching the heavy metals (Sherene, 2010).

3.3 Potential risk of Cr, As, Pb, Mn and Cd

Chromium is associated with allergic dermatitis in humans (Sherene, 2010). Cr(III) has a toxic effect upon daphnia, thus disrupting the food chain for fish life and possibly inhibiting the photosynthesis even in low concentration. Dichromate is toxic to fish life since they swiftly penetrate into the cell wall.

Arsenic compounds are adsorbed strongly to sediment/soil. It transports only over short distances into groundwater as well as surface water. It is associated with skin damage, increased risk of cancer, and problems with circulatory system (Scragg, 2006). Children are exposed to arsenic show impaired learning and memory, sleep disturbances, abnormality and hearing problem (Yadav et al., 2011). Patients are exposed with arsenic may disorder of brain, impairments of higher neurological functions including learning, memory and attentiveness (Rodrıguez et al., 2003).

Inhalation and ingestion are the two routes of Pb exposure and effects from the both are same. Pb accumulates in the body organs (brain), which may lead to poisoning or even death. Children exposed to lead are at risk for impaired development; lower IQ, shortened attention span, hyperactivity, and mental deterioration, etc. with children under the age of six being at a more substantial risk. Cadmium is poisonous metal and it is very bio-persistent but has few toxicological properties (Järup, 2003).

4. CONCLUSIONS

The study reveals that the soil was contaminated with manganese, chromium, arsenic and lead. The cadmium was too low that was below the detection limit. The wastewater from the industries is discharged without accomplishing any recovery/reuse system which is rich with heavy metals. The discharged wastewater containing high heavy metals increased the heavy metals content in sediment/soil of the adjacent area of Hatirjheel Lake. The heavy metals may leach from the sediment/soil to groundwater in the near future that could be a great threat for the human. It could be better to develop a process to remove the heavy metals from the wastewater and sludge so that it could be favourable to the environment and also for the next generation.

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