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Characterization of textile ETP sludge to assess heavy metals and their environmental impact assessment

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Abstract

Worldwide industrial solid management is a big issue. Discharging of effluent treatment plant (ETP) sludge is one of the major concerns due to containing toxic heavy metals. In this study, textile effluent treatment plant (ETP) sludge was characterized to assess the heavy metals and their impact assessment. The ETP sludge sample was collected from a renowned textile industry. The sludge was air dried, grinded and sieved. Grinded sludge was acid digested and the aliquot was analyzed by atomic absorption spectroscopy (AAS). The heavy metals content of sludge chromium (Cr), lead (Pb), and arsenic (As) were 31.8±1.2 mg/kg, 3.8±0.3 mg/kg, and 1.2±0.1 mg/kg respectively. Cadmium (Cd) was in the sludge below the detection limit. Disposing of sludge containing heavy metals could be leached in groundwater that could be a great threat for the forthcoming generation.

Keywords: Textile ETP sludge, Heavy metals, acid digestion, Environmental impact

1. Introduction

Increasing industrialization disposing of industrial solid or liquid waste including mine tailings metallurgical slags, and municipal sewage sludge are also increased [1– 4]. Growing awareness and the impact of human activities on the environment is threatening both to the nature and the forthcoming generation. Contamination of sediment, soil or water with heavy metals is a big threat to the environment. Hence, heavy metal mobilization and subsequently leaching into groundwater or surface water or enter the human food chain through various chemical and biological processes.

Textile and clothing industries are very important as they fulfill the second basic requirements of a human being for their living and Bangladesh is the second-largest garment exporter in the world [5]. The Textile and leather industries are rapidly growing industry in Bangladesh and these industries get popularity due to easy availability of labor and low labor cost. Both the industry contributes a lot to the economy of the country. Most industries are located near or on the bank of the rivers or lakes where they dump effluents directly without proper management. In the fiscal year 2013-14 total exporting was $30.18 billion where textile was $24.50 billion [6].

Although textile is a very important sector for our economy but it is one of the most polluting industries in our country. During manufacturing process it consumes 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 [7].

Unfortunately, most of the textile and leather industries have no effluent treatment plant (ETP). After production, process residues of industries are discharged directly to the rivers, canals or lakes. Wastewater for irrigation, solid waste disposal, sludge applications, vehicular exhaust and industrial activities are the major sources of soil contamination with heavy metals. Few of the industries have ETP and the produced sludge is used for land filling which contain heavy metals e.g. chromium (Cr), lead (Pb), arsenic (As) cadmium (Cd) etc. Heavy metals from the sludge subsequently leach into groundwater, which causes groundwater contamination. 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 [8].

In this study, textile effluent treatment plant (ETP) sludge was characterized to assess the heavy metals and their impact assessment. The textile ETP sludge was collected from a textile industry. After sieving, grinded sludge was acid digested and aliquot was analyzed by the atomic absorption spectroscopy (AAS).

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2. Materials and Methodology

2.1 Sample collection

The textile ETP sludge was collected in polyethylene bag from a textile industry, Dhaka. The sample was air dried, grinded with mortar and sieved with 80-mesh. After sieving, the sample was homogenously mixed (Fig. 1).

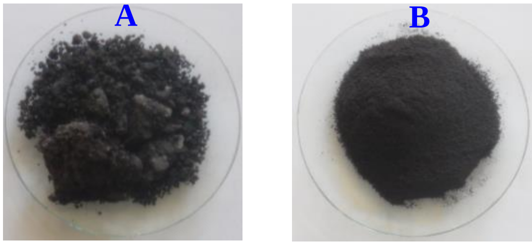

Fig. 1. Textile ETP sludge **a**) after sun dried and **b**) after grinding with sieved

2.2 Reagents

All the stock solutions were prepared from the analytical grade (AR). The sludge was acid digested with nitric (Merck KGaA, Germany) and hydrogen peroxide (Merck, India) and was collected from the Khulna scientific store. Freshly prepared double deionized water, from a quartz still, was used in all experiments. Chromium (Cr), arsenic (As), lead (Pb) and cadmium (Cd) standard solution were 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), 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 (H_2O_2 30%, Merck, India) was added. The mixture was then heated, refluxed on 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 heavy metals with AAS

Acid digested aliquot was analyzed by the atomic absorption spectroscopy (SpectrAA-220, VARIAN, Australia) for the quantitative measurement of chromium (Cr), arsenic (As), lead (Pb) and cadmium (Cd). Arsenic was measured by the hydride vapor generation method using sodium borohydride as a reducing agent, carrier gas argon (Ar) at the wavelength of 193.7 nm. Chromium (Cr), lead (Pb) and cadmium (Cd) were measured direct flame (air-acetylene) at the wavelength of 357.9 nm, 217.0 nm and 228.8 nm, respectively.

3. Results and Discussion

3.1 Physiochemical properties of sludge

The color of the sludge was dark brown due to having dyestuffs. The pH of the sludge was 6.7±0.01.

3.2 Heavy metals content in sludge

Heavy metal content in the sludge is shown in the Table 1. The heavy metal Cr, Pb and As were 31.8, 3.8, and 1.2 mg/kg respectively. The Cd was below the detection limit. The amounts of Cr were higher among the metals. It may be the reason is that metals complex dyestuffs contain Cr were used in textile dyeing process. Generally in textile and leather dyeing metal complex dyestuffs are used because it form coordination bond, which offer high fastness properties. 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.

Table 1. Heavy metals (mg/kg)

Chromium	Lead	Arsenic	Cadmium
31.8±1.2	3.8±0.3	1.2±0.06	BDL*

*BDL→ Below Detection Limit

3.3 Comparison of metals content in soil with present study

Different countries have set their standards for heavy metals content in ETP sludge or agricultural soil. The comparison of the metals content in soil is presented in Table 2

Table 2. Comparison of heavy metals content in soil with present study

	Permissible limits of heavy metals (mg/kg)				
Metals	This study	USEPA [9]	India [10]	SEPA [10]	Bangladesh [11]
Cr	31.8 ± 1.2	3000	-	250	Max. 50
Pb	3.8 ± 0.3	300	250-500	350	Max. 30
As	1.2 ± 0.06	41	-	-	-
Cd	BDL	39	3-6	0.6	Max. 5

It is clear from the Table 2 that Cr content in ETP sludge was lower than the standard level of Bangladesh. The Cr content in the sludge was 31.8±1.2 mg/kg where Bangladesh was 50 mg/kg. According to SEPA limit sets by China it is 250 mg/kg. The amount of Pb was in the sample 3.8±0.3 mg/kg, which was lower than the standard level of Bangladesh. The amount of As in the sample was determined 1.2±0.06 mg/kg and it is also below the standard limit set by the USEPA.

3.4 Heavy metals leaching from sediment/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 [12]. Cr(III) and As(V) are the least mobile. Soluble and un-adsorbed chromium complexes can leach from the sediment/soil into groundwater. The pH of the sludge was around neutral (6.7). 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 [13].

3.5 Effect of Cr, As, Pb and Cd

Chromium is associated with allergic dermatitis in humans [13]. 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 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 [14]. Children are exposed to arsenic show impaired learning and memory, sleep disturbances, abnormality and hearing problem [15]. Patients are exposed with arsenic may disorder of brain, impairments of higher neurological functions including learning, memory and attentiveness [16].

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 [17].

4. Conclusion

The study reveals that the textile ETP sludge was mostly contained with chromium. The heavy metals like arsenic and lead were in low concentration. The cadmium was too low that was below detection limit. Although metals contents were low; landfilling with this sludge could enhance leaching of chromium from sludge to groundwater in the near future. It could be better to develop a process to remove the heavy metals from the sludge so that it could be favorable to the environment and also for the future generation.

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