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Heavy Metal (Pb, Cd, Zn, Cu, Cr, Fe and Mn) Content in Textile Sludge in Gazipur, Bangladesh

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Abstract: The present research was carried out with eight specimens of sludge from Apex Weaving and Finishing Mills Ltd. Gazipur, Bangladesh, to determine the concentration of heavy metals (Pb, Cd, Zn, Cu, Cr, Fe and Mn) in the sludge samples and an assessment was made with the heavy metal content in agricultural soil. Atomic Absorption Spectrometry (AAS) method was employed for the analysis of Pb, Cd, Cr, Zn, Cu and UV-Spectrophotometric method was used for Fe and Mn, respectively. The mean concentration of lead (Pb), cadmium (Cd), chromium (Cr) was 79.13, 6.27, 4.35 mg kg^{-1} and for zinc (Zn), copper (Cu), iron (Fe) and manganese (Mn) it was 7.90, 1.34, 195.2 and 3.97 g kg^{-1}, respectively. All the heavy metal concentrations except chromium in the sludge samples were higher than that of in agricultural soil. In addition, the study concluded that pre-treatment process for reducing the amount of heavy metal is mandatory before the sludge can be used as a soil conditioner or fertilizer in the agricultural soil.

Key words: Textile waste, contaminated soil, toxic trace metal, wastewater management

INTRODUCTION

The textile industry, the flagship of Bangladesh-now earns more than 70% of the country's total export income. A recent report also revealed that Bangladesh's RMG (Ready Made Garments) exports to the world markets reached an all time high value of over USD 9.35 billion in the end of 2007 (BGMEA, 2008). This textile and dyeing industries now viewed as a major environmental threat in the industrial area of Bangladesh and they contribute huge amounts of sludge in wastewater treatment processes (Karim *et al*., 2006). Although characteristics of sludge depend on the wastewater treatment process and sludge stabilization methods, it contains substantial amounts of toxic heavy metals (Chen *et al*., 2005; Singh *et al*., 2004). Another recent investigation reported that elevated levels of heavy metals in vegetables are found from the areas having long term uses of treated or untreated wastewater (Sharma *et al*., 2006, 2007).

Heavy metals are very harmful because of their non-biodegradable nature, long biological half-lives and their potential to accumulate in different body parts (Manaham, 2005; Wilson and Pyatt, 2007). Excessive accumulation of heavy metals in agricultural soils through wastewater irrigation, may not only result in soil contamination, but also affect food quality and safety (Muchuweti *et al*., 2006). Some research also confirmed that heavy metals such as Cd, Pb, Cu, Zn and Ni have carcinogenic or toxic effects on human beings and environment (Trichopoulos, 2001; Turkdogan *et al*., 2002; Kocasoy and Sahin, 2007).

The management of sludge is becoming increasingly difficult due to the presence of heavy metals (Zorpas *et al*., 2008). It is now established that application of sludge into land can increase soil water-holding capacity, decrease soil bulk density, increase soil aeration and root penetrability and stimulate

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soil microorganism activity (Kvarnstrom *et al*., 2000). In addition, land utilization of sludge could represent a step forward to more sustainable farming practices and municipal waste management. Achieving this purpose it is pivotal to know the heavy metal content in textile sludge as without investigating toxic substances it is not feasible to use sludge as a soil conditioner or fertilizer in agricultural land.

MATERIALS AND METHODS

Sludge Sample Collection

The sludge samples were collected from Apex Weaving and Finishing Mills Ltd. Gazipur, Bangladesh in mid-January, 2004. The collected samples were stored into separate plastic container and stored at ambient temperature prior to treatment. The sludge samples were homogenized by manual mixing, air-dried for 24 h, disaggregated using a pestle and mortar made by porcelain to pass through a 2 mm mesh sieve.

Digestion of Sample with Aqua-Regia

An aliquot of 0.200 g of powdered sludge of each sample was taken in a silica crucible (150 cm^3). Then 1M concentrated hydrochloric acid (9 cm^3) was added followed by 1 M concentrated nitric acid (3 cm^3). The content of the crucible was carefully heated in sandbath nearly to dryness in fumehood. After cooling the crucible at room temperature, deionized water was added to the sample and was filtered through a filter paper (Whatman No. 42). The filtrate was collected in a measuring flask and was preserved for the determination of Pb, Cd, Zn, Cu, Cr, Fe and Mn. All regents used were Merck, Analytical Grade (AR) including standard stock solutions of known concentrations of different heavy metals.

Heavy Metal Analysis

Heavy metals analysis were carried out using AAS (Perkin Elmer AAnalyst 400). The AAS was calibrated for all the metals by running different concentrations of standard solutions. Average values of three replicates were taken for each determination. The detection limits for Pb, Cd, Zn, Cu and Cr were 3.0, 1.60, 1.60, 3.0 and 3.0 mg L^{-1}, respectively. Iron determination was carried out by hydroxylamine and with 1, 10 phenanthroline at pH 3.2-3.3. At pH between 2.9 and 3.5, rapid color was formed in the presence of an excess phenanthroline and the reddish-orange iron (II) complex absorbs at 515 nm (Greenberg *et al*., 1998). A quantitative estimation of Mn in the digested samples was carried out using a UV Spectrophotometer (Sequoia-Tuner, Model-390) following permanganate oxidation method at 522 nm. Because of its distinctive color and stability, permanganate ion is preferably used as the determination form for manganese.

RESULTS AND DISCUSSION

The present study found that the average concentration of lead in the sludge samples was 79.13 mg kg^{-1} although the content of lead in the eight sludge samples ranged from 73.61-86.02 mg kg^{-1} in Table 1. This result revealed that examined sludge samples contained relatively higher amount of Pb than that of agricultural soil. Threshold natural background of Pb in agricultural soil in China is $\leq$35 mg kg^{-1} (Wong *et al*., 2002). Kabata-Pendias and Pendias (2000) reported that the maximum content of Pb was 50 mg kg^{-1} in light soils used for cultivation.

Usually, sludge contains high concentration of cadmium, because wastewater discharged from mill contains cadmium from dyes. The average concentration of cadmium of the sludge samples was 6.27 mg kg^{-1} in Table 1. The permissible level of Cd in agricultural soils set by Dutch authorities is

Table 1: The concentrations of heavy metals in all sludge samples

Sludge sample	Pb	Cd	Cr	Zn	Cu	Fe	Mn
	------(mg kg^{-1})------			------(g kg^{-1})------			
1	86.02	6.24	4.68	8.32	1.20	187.6	4.19
2	75.13	5.91	4.12	7.16	1.70	201.4	4.31
3	70.73	7.11	3.65	8.42	1.51	173.1	3.28
4	85.20	6.51	4.93	7.91	1.12	221.2	4.68
5	79.15	4.38	3.52	7.72	1.23	157.2	3.96
6	82.27	6.21	5.11	8.51	1.58	168.5	3.72
7	73.61	8.27	3.93	8.11	1.06	256.7	3.05
8	80.93	5.51	4.85	7.07	1.34	195.7	4.57
Mean	79.13	6.27	4.35	7.90	1.34	195.2	3.97
SD	5.53	1.13	0.61	0.55	0.23	32.0	0.58

Table 2: A comparison of heavy metal content (mg kg^{-1}) in soil from other regional study with present study

Heavy metal	Present study	Permissible limit in India[a]	Range in uncontaminated soil in India[b]	SEPA limit in China[c]
Pb	79.13	250-500	2-200	350
Cd	6.27	3-6	0.01-0.7	0.6
Cr	4.35	NA	5-3000	250
Zn	7906.5	300-600	10-300	300
Cu	1347.7	135-270	2-100	100
Mn	3974.1	NA	100-4000	NA

NA: Not Available, [a]Source: Awashthi (2000), [b]Source: Bowen (1966), [c]SEPA (1995)

1 to 5 mg kg^{-1} (Chen *et al*., 1997). Natural background level of Cd in agricultural soil in China is $\leq$0.20 mg kg^{-1} (Wong *et al*., 2002). The values of Cd found in the present investigation were higher than those of above critical value set by other researchers. In addition, some cadmium compounds are able to leach through soils to ground water. When cadmium compounds bind the sediments of rivers, they can be more easily bioaccumulated or re-dissolved when sediments are disturbed, such as during flooding. Therefore, the use of sludge as a soil conditioner or fertilizer in arable soils can cause severe pollution with Cd and the production of crops and vegetables may be at a risk.

The maximum Zn value in light soil used in cultivation in India given by Kabata-Pendias and Pendias (2000) was 100 mg kg^{-1}. The threshold natural background value of Zn in crop soils and paddy soils in China is $\leq$100 mg kg^{-1}. In Table 2, the concentration of Zn was found 7906.5 mg kg^{-1} in the sludge samples, which was higher than those of permissible levels given by different nations. Similarly, the Cu content in the sludge samples was 1347.7 mg kg^{-1} which was also extremely higher than that of in China ($\leq$35 mg kg^{-1}) and India (20-30 mg kg^{-1}). Some well documented studies disclosed that heavy metals such as zinc (Zn) and copper (Cu) are the principal elements restricting the use of sludge for agricultural purposes (Su and Wong, 2003; Udom *et al*., 2004; Dai *et al*., 2007).

The average concentration of chromium (Cr) in these samples was 4.35 mg kg^{-1}. The maximum content of Cr reported by Kabata-Pendias and Pendias (2000) in soil used in cultivation was 100 mg kg^{-1}. Natural background of Cr in agricultural soils in China is $\leq$ 90 mg kg^{-1}. The Cr content in soils obtained from the present study was lower than the permissible levels recommended by the above sources.

Long term exposure of iron from the sludge into soils may contaminate it and change the soil structure and thus make it harmful for cultivation. Kisku *et al*. (2000) found the concentrations of Fe in agricultural soils in India varying from 289.3-338.5 mg kg^{-1} dry weight. Samantaray *et al*. (2001) reported that the Fe content ranged from 1422.5-1593.0 mg kg^{-1} in agricultural soils near a metalliferous chromite mine spoil in India. The Fe contents found in the sludge samples were higher than that of the study by above two researchers. However, the safe limit for iron is not available in Indian and Chinese standard. The average amount of manganese (Mn) in the sludge samples was 3974.1 mg kg^{-1} which was very higher than the range of uncontaminated soil in India (Table 2).

CONCLUSION

The concentrations of Cd, Zn, Cu and Mn in the sludge samples were exceed the safe limit set by India and China whereas Pb and Cr found within the safe limit (Table 2). The present study failed to compare the results with Bangladesh standard as the Department of Environment; Government of Bangladesh has not yet established any standard for heavy metal content in agricultural soil. Therefore, it is very necessary to establish a safe or standard limit for the concentration of heavy metal in sludge that can be used as a fertilizer as well as soil conditioner.

REFERENCES

Awashthi, S.K., 2000. Prevention of Food Adulteration Act no 37 of 1954. Central and State Rules as Amended for 1999. 3rd Edn., Ashoka Law House, New Delhi.

BGMEA, 2008. Bangladesh Garments Manufactures and Exporters Association Statistical Report, 2(2) April, 2008. http://www.just-style.com/factsheet.aspx?id=276.

Bowen, H.J.M., 1966. Trace Elements in Biochemistry. 1st Edn., Academic Press, New York, ISBN-13: 9780003686463.

Chen, T.B., J.W.C. Wong, H.Y. Zhou and M.H. Wong, 1997. Assessment of trace metal distribution and contamination in surface soils of Hong Kong. Environ. Pollut., 96: 61-68.

Chen, Y., C. Wang and Z. Wang, 2005. Residues and source identification of persistent organic pollutants in farmland soils irrigated by effluents from biological treatment plants. Environ. Int., 31: 778-783.

Dai, J.Y., M.Q. Xu, J.P. Chen, X.P. Yang and Z.S. Ke, 2007. PCDD/F, PAH and heavy metals in the sewage sludge from six wastewater treatment plants in Beijing. China Chemosphere, 66: 353-361.

Greenberg, A.E., L.S. Clesceri, R.R. Trussell, M.A. Franson, 1998. Standard Methods for the Examination of Water and Wastewater. 20th Edn., American Public Health Association, Washington, DC., ISBN: 0875531318.

Kabata-Pendias, A. and H. Pendias, 2000. Trace Elements in Soils and Plants. 3rd Edn., CRC Press Inc., Boca Raton, USA., ISBN: 9780849315756.

Karim, M.M., A.K. Das and S.H. Lee, 2006. Treatment of colored effluent of the textile industry in Bangladesh using zinc chloride treated indigenous activated carbons. Anal. Chim. Acta, 576: 37-42.

Kisku, G.C., S.C. Barman and S.K. Bhargava, 2000. Contamination of soil and plants with potentially toxic effluents irrigated with mixed industrial effluent and its impact on the environment. Water Air Soil Pollut., 120: 121-137.

Kocasoy, G. and V. Sahin, 2007. Heavy metal removal from industrial wastewater by clinoptilolite. J. Environ. Sci. Health Part A, 42: 2139-2146.

Kvarnstrom, E., C. Morel, J. Fardeau and J. Morel, 2000. Changes in the phosphorus availability of a chemically precipitated urban sewage sludge as a result of different dewatering processes. Waste Manage. Res., 18: 249-258.

Manaham, S.E., 2005. Environmental Chemistry. 8th Edn., Lewis Publisher, Boca Raton, Florida, ISBN 1566706335.

Muchuweti, M., J.W. Birkett, E. Chinyanga, R. Zvauya, M.D. Scrimshaw and J.N. Lester, 2006. Heavy metal content of vegetables irrigated with mixture of wastewater and sewage sludge in Zimbabwe: Implications for human health. Agric. Ecosyst. Environ., 112: 41-48.

Samantaray, S., G.R. Rout and P. Das, 2001. Heavy metal and nutrient concentration in soil and plants growing on a metalliferous chromite minespoil. Environ. Technol., 22: 1147-1154.

SEPA, 1995. Environmental quality standard for soils. State Environmental Protection Administration, China. GB15618-1995.

Sharma, R.K., M. Agrawal and F.M. Marshall, 2006. Heavy metals contamination in vegetables grown in wastewater irrigated areas of Varanasi, India. Bull. Environ. Contamin. Toxicol., 77: 311-318.

Sharma, R.K., M. Agrawal and F.M. Marshall, 2007. Heavy metals contamination of soil and vegetables in suburban areas of varanasi. India. Ecotoxicol. Environ. Safety, 66: 258-266.

Singh, K.P., D. Mohan, S. Sinha and R. Dalwani, 2004. Impact assessment of treated/untreated wastewater toxicants discharged by sewage treatment plants on health, agricultural and environmental quality in the wastewater disposal area. Chemosphere, 55: 227-255.

Su, D.C. and J. W.C. Wong, 2003. Chemical speciation and phytoavailability of Zn, Cu, Ni and Cd in soil amended with fly ash-stabilized sewage sludge. Environ. Int., 29: 895-900.

Trichopoulos, D., 2001. Epidemiology of Cancer. In: Cancer: Principles and Practice of Oncology, DeVita, V.T. (Ed.). Lippincott Company, Philadelphia, ISBN: 0-781-72229-2, pp: 231-258.

Turkdogan, M.K., F. Kilicel, K. Kara and I. Tuncer, 2002. Heavy metals in soil, vegetables and fruits in the endemic upper gastrointestinal cancer region of Turkey. Environ. Toxicol. Pharmacol., 13: 175-179.

Udom, B.E., J.S.C. Mbagwu, J.K. Adesodun and N.N. Agbim, 2004. Distributions of zinc, copper, cadmium and lead in a tropical ultisol after long-term disposal of sewage. Environ. Int., 30: 467-470.

Wilson, B. and F.B. Pyatt, 2007. Heavy metal dispersion, persistence and bioaccumulation around an ancient copper mine situated in anglesey. UK. Ecotoxicol. Environ. Safety, 66: 224-231.

Wong, S.C., X.D. Li, G. Zhang, S.H. Qi and Y.S. Min, 2002. Heavy metals in agricultural soils of the pearl river delta, South China. Environ. Pollut., 119: 33-44.

Zorpas, A.A., V.J. Inglezakis and M. Loizidou, 2008. Heavy metals fractionation before, during and after composting of sewage sludge with natural zeolite. Waste Manage., 28: 2054-2060.