Journal of Applied Sciences

ISSN 1812-5654

Journal of Applied Science 5 (8): 1399-1401, 2005
ISSN 1812-5654

Assessment of Heavy Metal Compositions in Glen Valley Dry Sludge

E. Nkegbe
Gaborone City Council, Glen Valley Wastewater Treatment Plant Laboratory, Private Bag 0089, Gaborone

Abstract: This study was undertaken to assess heavy metal compositions in the sludge produced at the Glen Valley Wastewater Treatment Plant. Arsenic (Ar), Nickel (Ni), Lead (Pb) and Zinc (Zn) were monitored using methods by the USA EPA and using Shimazu Atomic Absorption Spectrophotometer. Heavy metals composition ranges obtained in the sludge were 0.75-1.23, 27.3-33.1, 445-482.1 and 291-446.1 mg kg^{-1}, respectively for Ar, Ni, Pb and Zn. These levels were within the composition of heavy metals concentrations documented for sludge in, use and disposal of municipal sludge in the United States of America. More research must be done to ascertain the levels of heavy metals concentrations in sludge that will trigger bioaccumulation in crops to hazardous levels and because all the metals studied were identified in the sludge, disposal methods must be adequate to prevent environmental pollution since at their present levels, they are potential pollutants.

Key words: Sludge, wastewater, heavy metals, atomic absorption spectrophotometer

INTRODUCTION

The heavy metals of most concern to human health are Mercury (Hg), Cadmium (Cd) and Lead (Pb) because they can cause cancer[1].Over a billion human beings are currently exposed to high concentrations of these metals and metalloids in the environment and is also estimated that several other million people might at the same time be suffering from sub-clinical metal poisoning.

Series of environmental incidents through industrial effluent discharges in Japan in the 1950s opened the global studies into hazards to human health by heavy metals.

Some of the known diseases as a result of heavy metal poisoning apart from cancer are; speech disturbance, nervouse conditions, derilium and difficulty in walking as well as death, severe back and joint pain, kidney lesions, protein and sugar in the urine and decalcification of bones leading to multiple fractures[1,2].

Sources of contamination of the environment by these metals are mostly from industrial effluent discharges into water sources which invariably find their usage in agriculture as well as bioaccumulation in aquatic food chains. Indeed the menace of environmental pollution by heavy metals is pronounced in the advanced economies like the USA, Japan etc. Botswana is not heavily industrialised country, however, it is an arid and semi-arid country where, the provision of drinking water and water for agricultural production is increasingly becoming scarce and expensive. Therefore, it is imperative to encourage systems that can augment the available sources of water or measures that can reduce the demand on potable water such as the Gaborone city council wastewater treatment plant[3]. Re-generated water and sludge are the major bi-products of the treatment. So far, the government of Botswana in a policy document called National Master Plan for Arable Agriculture and Dairy Development (NAMPAADD), proposals are underway to effectively utilise the bi-products of the wastewater treatment facility for horticultural irrigation at the Glen Valley Irrigation Project. The sludge produced is already the toast of many gardeners who intend using it as soil conditioner for their gardens and market gardens for the cultivation of vegetables. Ultimately therefore, the quality of the regenerated water and the sludge must be within acceptable levels. This study was therefore to ascertain the levels of Arsenic (Ar), Nickel (Ni), Lead (Pb) and Zinc (Zn) in the sludge and its suitability for agricultural purposes.

MATERIALS AND METHODS

Dry sludge (2.0 g) was sampled from each of the 24 (18x12 m) drying cells and from discarded sludge deposited around the vicinity of the drying beds over a period of one year, March 2003 to April 2004. The 2.0 g mass was equivalent to the suspended solids load in 50 mL of secondary digester effluent of average suspended solids load composition of 20000 mg L^{-1}. The weighed 2.0 g sludge sample was transferred into a 250 mL conical flask, 10 mL of 1:1 concentrated HNO_3 was added and the slurry mixed completely by shaking and then covered with a watch glass and heated to 95°C on a laboratory hot plate. The sample was then refluxed for 15 min without boiling and allowed to cool to laboratory temperature. Next, 5 mL concentrated HNO_3 from a 10 mL measuring cylinder was added. The watch glass was replaced and the samples refluxed for 30 min again. During the refluxing, the slurry was allowed to evaporate gradually to a bout 5 mL volume by maintaining watch glass half way. After this process, the samples were cooled to laboratory temperature. Next, 2 mL distilled water and 3 mL of 30% H_2O_2 were added to each sample and they were then returned to the hot plate and heated till effervescence occurring became minimal, the samples were cooled again to laboratory temperature. The heating was repeated with 1 mL addition of 30% H_2O_2 till effervescence was minimal and samples appearance remained unchanged. The samples were removed from the hot plate and cooled to laboratory temperature again. Finally, 5 mL of concentrated HCl and 10 mL distilled water were then added to the samples again, returned to the hot plate and refluxed for additional 15 min, cooled and filtered through 2.0 μm filter paper and diluted to 100 mL. The concentrations were then determined using Shimadzu atomic absorption spectrophotometer Model AA 6650.

RESULTS AND DISCUSSION

The concentration ranges determined were based on the means and the Standard Deviations calculated for each heavy metal.

Table 1 shows the results obtained after 45 different samples were analysed for the various heavy metals. All the metals were found to be within acceptable composition ranges expected of use and disposal of municipal wastewater sludge (Table 2).

Arsenic concentration was 0.75-1.23 mg kg^{-1} in the dry sludge samples analysed (Table 2). Compared to the documented US EPA range of 1.1-230 mg kg^{-1}, the sludge composition of Ar was safe (Table 2). Major sources of Ar to the environment are ore smelting, refining and from pesticides. It is mostly found in the air and water. The composition in the effluent has not been determined. Ar poisoning, when occurs, results in gastrointestinal disorders and lower-limb paralysis.

Gaborone presently does not have any of the above sources of pollution except through the importation of pesticides for agricultural purposes. Therefore, the source

Table 1: Heavy metal compositions in Glen Valley sludge

Metal	Composition (mg kg^{-1})
Arsenic	0.75-001.23
Nickel	l27.50-033.10
Lead	445.00-482.10
Zinc	291.00-446.10

Table 2: Typical heavy metals contents in wastewater sludge

Metal	Composition (mg Kg^{-1})
Arsenic	1.1-230
Nickel	l2.0-5300
Lead	13.0-26000
Zinc	101.0-49000

Source: US Environmental Protection Agency: Environmental Regulations and Technology, Use and Disposal of Municipal Wastewater Sludge, EPA 625/10-84-003, September 1984

of this metal could be testing laboratories and agriculture runoffs into storm drains that finds its way into sewers.

The level of Ni detected ranged from 27.5-33.1 mg kg^{-1} (Table 1) and was within the acceptable range as shown in Table 2. Ni as a metal is very deleterious resulting in some of the diseases mentioned above, especially cancer. Sources of Ni to the environment include electro plating industries which are not in Botswana presently however such products are readily available.

Pb levels monitored were 445-482.1 mg kg^{-1} (Table 2) and was within the expected range of 13-26000 mg kg^{-1} (Table 2).

Pb may be present in food and water as well as in the air that we breath. Until the advent of unleaded fuel, the combustion of lead gasoline was the largest source of Pb pollution in the atmosphere. Raw water supply can be contaminated by lead from the discharge of sewage treatment plants and from agricultural runoff. Exposure to relatively low levels of lead has been associated with metabolic and neuropsychological disorders, which include anaemia and lowered IQ level especially in children.

Zn concentration detected from sludge samples was in the range 291-446.1 mg kg^{-1} (Table 1) and was within the US EPA range of 101-49000 mg kg^{-1} (Table 2). Zn is one of the trace elements needed for proper plant growth in agriculture. Zn concentrations lower than 2.0 mg L^{-1} is recommended for irrigation water.

The heavy metals studied except Cd are not known to cause any adverse effect on crops cultivated using sludge since they do not accumulate in the edible portions of the plants[4].

Heavy metals taken up by vegetables exposed to heavy metals tend to be distributed almost equally in roots and leaves with same level reaching the fruit[5]. Also, there is evidence of accumulation of heavy metals such as Zn, Ni and Cr in the food chain[6] when sludge is used as a fertilizer for growing crops. Because most heavy metals in effluent end up in sludge rather than in the wastewater[7], much attention be paid to food chain heavy metal accumulation when sludge is used rather than wastewater.

Accumulation of heavy metals in sludge could lead to accumulation in crops using the sludge as soil conditioner or fertiliser. It is however good for the cultivation of lawns and other non edible horticultural products. The levels of Ar, Ni, Pb and Zn compositions in Glen Valley sludge even though within the acceptable ranges for use and disposal of municipal sludge in the United States of America can not be recommended for agricultural usage until more work is done on each specific heavy metal and crop accumulative indices. At present levels detected in the sludge, it is obvious the metals are potential pollutants and therefore, efforts must be made to control their entry in to Gaborone environment as well as adoption of the most efficient sludge disposal mechanism in Gaborone.

REFERENCES

1. Mason, C.F., 1996. Biology of Freshwater Pollution. 3rd Edn., Longman, England, pp: 167-175.
2. Glynn, J.H. and W.H. Gary, 1996. Environmental Science and Engineering. Prentice Hall. London, pp: 292-301.
3. Emongor, V.R., E.B. Khonga, G.M. Ramolemana, K. Marumo, S. Machacha and T. Motsamai, 2005. Suitability of treated secondary sewage effluent for irrigation of horticultural crops in Botswana. J. Applied Sci., 5: 451-454.
4. Polprasert, C., 1996. Organic Waste Recycling: Technology and Management. John Willey and Sons. Chichester, England, pp: 374-375.
5. Biziuk, M., J. Namiesnik and L. Zaslawska, 2001. Heavy Metals in Food Products and Biological Samples from the GDANSK District In: Frontasyeva, M.V, V.P. Perelyain and P. Vater (Eds.). Radionuclides and Heavy Metals in Environment. Kluwer Acad. Publ., Netherlands, pp: 209-216.
6. Lue-Hing, C., D.R. Zenz, T. Prakasam, R. Kuchenrither, F.J. Malina, Jr. and B. Sawyer (Eds.), 1998. Municipal Sewage Sludge Management: A Reference Text on Processing, Utilisation and Disposal. Technomic. Lancaster, USA, pp: 777-780.
7. Toumi, A., A. Nejmeddine and B. EI Hamouri, 2000. Heavy Metal Removal in WasteStabilisation Ponds and High Rate Ponds. In: Pearson, H.W., D.D. Mara and Y. Azov, (Eds.).Water Sci. and Technol., Waste Stabilisation Ponds, Technol. Environ., IWA, London, Bristol, UK., pp: 17-21.