World Journal of Analytical Chemistry, 2013, Vol. 1, No. 4, 59-62
Available online at http://pubs.sciepub.com/wjac/1/4/3

DOI:10.12691/wjac-1-4-3

Impact Assessment of Contamination Pattern of Solid Waste Dumpsites Soil: A Comparative Study of Bauchi Metropolis

D. S. Buteh, I.Y. Chindo*, E. O. Ekanem, E. M. Williams

Chemistry Programme, Abubakar Tafawa Balewa University, Bauchi
*Corresponding author: istifanuschindo@yahoo.com

Received August 21, 2013; Revised September 09, 2013; Accepted September 16, 2013

Abstract Soils samples from four different dumpsites namely Makama Housing Estate (MHE), Gwallaga (GW), Rafin Makaranta (RM), and Yelwa Makaranta (YM) in Bauchi metropolis were collected and analysed for some heavy metals (Cr, Cd, Pb and Cu) using complexometric method. The results of the analyses showed that the four dumpsites have the following range of mean concentrations: Cd 0.21-1.21 mg/kg; Cr 5.04-8.31 mg/kg; Pb 4.31-10.63 mg/kg and Cu 0.79-2.07 mg/kg. The dumpsite soils were significantly different from those obtained from control sites. The contamination intensities of chromium and lead pollution were strong at Rafin Makaranta using geoaccumulation classification. These may suggested that solid waste dumpsite contributes to heavy metals contamination of the environment.

Keywords: *complexometric method, geoaccumulation classification, dumpsites, contamination, Bauchi*

Cite This Article: D. S. Buteh, I.Y. Chindo, E. O. Ekanem, and E. M. Williams, "Impact Assessment of Contamination Pattern of Solid Waste Dumpsites Soil: A Comparative Study of Bauchi Metropolis." *World Journal of Analytical Chemistry* 1, no. 4 (2013): 59-62. doi: 10.12691/wjac-1-4-3.

1. Introduction

Metals are known to be present in soil in different chemical forms, which influence their reactivity and hence their mobility and bioavailability [1]. Heavy metals concentrations in soil are associated with biological and geochemical cycles and are influenced by anthropogenic activities such as agricultural practices, industrial activities and waste disposal methods [2]. Wastes degradation leads to the pollution of soils by many pollutants through leachate seepage. The soils under and around the landfills are therefore subjected to different types of pollution including those caused by trace elements [3]. The risks associated with the presence of heavy metals are varied and depend on their chemical forms (metal, oxide, and organometallic). The impact of these metals in soils is their possible transfer into water or plants, which is defined in term of bioavailability. Cd, Cr and Pb are considered as the most important environmental pollutants in agricultural soils because of the potential harmful effects they may have on food quality and health of soil [4]. Copper which is an active ingredient of fungicides is reported as one of the most toxic metals to soil microorganisms and soil health [5]. The disposal of solid waste is a practice that still brings serious impacts to the environment generating pollution by-products derived from waste [6]. The toxicity and impact provoked from waste on microflora and microfauna is very strong and they are influenced by various factors such as organic matter, heavy metals and nitrogen concentrations as well as mass flux of contaminations being transported [7].

Studies have shown that soil at refuse dumpsites contain different kinds and concentrations of heavy metals, depending on the age, contents and location [8]. In recent times, it has been reported that heavy metals from waste dumpsites can be accumulated and persist in soils at an environmentally hazardous level [9]. In Nigeria, leachate from refuse dumpsites constitutes a source of heavy metal pollution to both soil and aquatic environment [10]. Nevertheless, most abandoned waste dumpsites in Nigeria have been used extensively as fertile ground for cultivating variety of vegetables. Identifying compounds that cause the toxicity in the soil is not easy because the physical-chemical characteristics of soil is highly variable and dependant on the following factors; local environmental conditions, time elapsed after waste disposal and landfill characteristics as well [6]. Toxicity tests are bioassays used in pollution control for determining the maximum permitted concentrations of a given chemical agent for the development/survival of certain living organisms [11]. Toxic compounds can have two different effects on living organisms; acute toxicity, which is possible to evaluate in the short term upon the death of the organism, and chronic toxicity, whose evaluation takes longer time, in this case, sub-lethal effects must be analysed [11]. This paper is focused at assessing the levels of heavy metals contamination at different dumpsites soils in Bauchi metropolis.

2. Materials and Methods

2.1. Study Areas and Site Location

The study was conducted on four dumpsites in major residential areas of Bauchi metropolis viz:- RafinMakaranta (RM); Gwallaga ward (GW), Makama Housing Estate (MHE) and YelwaMakaranta (YM).

2.2. Sample Collection

Soil samples were randomly taken from each dumpsite and control sites at a depth of 0-15 cm. Two replicate soil samples at each dumpsite were taken and thoroughly mixed together; from which two representative samples were collected for the study. The control soil samples were obtained at 10 m radius away from the dumpsites. The samples were labeled and stored in polythene bags and transported to the laboratory. The soil samples were air-dried between 24-48 hours and sieved through a 2-mm mesh and stored for subsequent analysis. The samples were collected between November-December 2010. The analyses were done in accordance with WHO 1996 standard procedure and guidelines for heavy metals [12].

2.3. Preparation of Sample Solution and EDTA Determination of Heavy Metals

Soil sample (1.0g) was digested with 20 cm^3 of (2:12:1 v/v) HNO_3: $HClO_4$: H_2SO_4 acid mixture and heated at a temperature of 120-250°C for a period of 1.0 hr until colourless (no brown fume given off). It was cooled and distilled water was then added to the digest and decanted until a 50 ml solution was obtained. A 5 cm^3 portion of the digest was then made up to 25 cm^3 with distilled water followed by addition of Xylenol Orange as indicator for each metal determination.

2.4. Samples Analysis

2.4.1. Determination of Lead Using Xylenol Orange Indicator

Soil sample (25.0 cm^3) was pipetted into a 250 cm^3 volumetric flask, diluted with about 25 cm^3 of distilled water and 3 drops of the indicator solution were added. The solution turned red, hence dilute nitric acid (0.5 M) was added cautiously and with stirring, until the solution acquired a yellow colour. 0.7g of hexamine (hexamethylentriamine) powder was added until the colour was intensely red. This was to ensure that the solution has attains a pH of 6. The solution was titrated with standard EDTA solution (0.05 M) until the colour changed to lemon-yellow and the concentration of the lead ion was calculated.

2.4.2. Determination of Cadmium Using Xylenol Orange Indicator

Soil sample (25.0 cm^3) was pipetted and diluted with distilled water (50 cm^3), and three drops of the indicator solution were added followed by a drop of dilute H_2SO_4 (0.05 M) and the solution turned yellow. 0.5g of hexamine was then added and shaken vigorously, until the colour turned deep red. The solution was then titrated with EDTA solution (0.05 M) slowly near the end point to a colour change from red to yellow and the concentration of Cadmium was then calculated.

2.4.3. Determination of Chromium Using Xylenol Orange Indicator

Soil sample (25.0 cm^3) was pipetted into 250 cm^3 conical flask and diluted with distilled water (25 cm^3). Xylenol orange indicator (three drops) was added to obtain yellow solution. 0.5g of powdered hexamine was added and the solution became red. The resulting solution was titrated with EDTA solution (0.05M) and the solution turned purple which indicated the end point. The concentration of cadmium was then calculated.

2.4.4. Determination of Copper using Xylenol Orange Indicator

Soil sample (25.0 cm^3) was pipetted into 250 cm^3 conical flask and diluted with distilled water (50 cm^3) followed by the addition of three drops of xylenol orange indicator to obtain a blue solution. 0.7g of hexamine powder was added and the solution turned red. The solution was then titrated with EDTA solution (0.05 M) to purple colour end point and the concentration of copper was then calculated.

3. Results and Discussion

The results of heavy metal analysis of soil from the four dumpsites in Nov-Dec, 2010 are presented in Table 1 as shown below:

Table 1. The mean heavy metal analysis of dumpsites soil (Nov-Dec 2012)

Location	Cd (mg/kg)		Cr (mg/kg)		Pb (mg/kg)		Cu (mg/kg)	
	S	**C**	**S**	**C**	**S**	**C**	**S**	**C**
MHE	0.85 ± 0.02	0.06 ± 0.00	5.04 ± 0.02	0.31 ± 0.02	4.13 ± 0.11	0.08 ± 0.01	0.79 ± 0.03	0.29 ± 0.05
GW	0.77 ± 0.02	0.03 ± 0.03	7.03 ± 0.05	1.89 ± 0.02	6.25 ± 0.01	0.17 ± 0.02	1.16 ± 0.11	0.17 ± 0.02
RM	0.21 ± 0.08	0.04 ± 0.00	7.94 ± 0.15	0.13 ± 0.02	10.63 ± 0.74	0.03 ± 0.00	2.07 ± 0.06	0.22 ± 0.03
YM	1.21 ± 0.03	0.08 ± 0.02	8.31 ± 0.03	0.21 ± 0.03	6.67 ± 0.06	0.16 ± 0.04	1.70 ± 0.01	0.29 ± 0.05
WHO STD	3.00		10.00		11.00		7.00	

MHE →Makama Housing Estate, GW →Gwallaga, RM →Rafin Makaranta, YM→Yelwa Makaranta, S→Soil, C→Control

3.2. Contamination Index: (Igeo)

To quantify the degree of pollution in the refuse dump soils the Geoaccumulation index Igeo was calculated by using the relationship below;

$$Igeo = \ln\left(Dn\right)/1.5 \times Cn$$

Dn = measured concentration of heavy metal in the refuse dump soil (ppm);
Cn = measured concentration of heavy metal in the control soil (ppm), and 1.5 = background matrix correction factor.

Table 2. Geoaccumulation Index of Heavy Metals for Nov-Dec, 2010

Locations	Igeo			
	Cd	Cr	Pb	Cu
Makama Housing Estate	2.24	2.40	4.35	5.20
Gwallaga	2.83	0.90	3.19	1.51
Rafin Makaranta	3.50	3.71	5.46	1.84
Yelwan Makaranta	2.31	3.27	3.32	1.36

Table 3. Geoaccumulation Classification

Geoaccumulation Index I_{geo}	I_{geo} Class	Contamination intensity
>5	6	Very strong
>4-5	5	Strong – very strong
>3-4	4	Strong
>2-3	3	Moderate-strong
>1-2	2	Moderate
>0-1	1	Uncontaminated-moderate
<0	0	Practically uncontaminated

(Agyarko et al, 2010)

Cadmium is a toxic metal having functions neither in human body nor in animals or plants. It is present in fossil fuel such as coal and oil. This present study indicates the mean concentrations range of cadmium in dumpsites soils at 0.21-1.21 mg/kg. These concentrations are considerably lower than those reported by David, *et al (2009).* [13] (1.28-21.31 mg/kg), but higher than those reported by Agyarko, *et al. (2010).* [14] (0.14-0.90 mg/kg), and within the range reported by David, *et al. (2009) [13]* as (1.64-2.50 mg/kg). These low cadmium concentrations may associated with the absent of fossil fuel in the area [17] The contamination intensity calculated with Geoaccumulation Index, shows moderate intensity at Makama Housing Estate, Gwallaga and Yelwan Makaranta. Chromium being a toxic heavy metal occurs naturally in soil at a normal range of 5-15 mg/kg WHO 1996 [12]. In this study, the mean concentrations of chromium in the dumpsites soils were found to range from 5.0-8.31 mg/kg. These concentrations were lower than those reported by Agyarko, *et al. (2010).* [14] as (13.00-24.20 mg/kg) but within the range reported by Oviasage, et al. (2008). [15] as (3.50-9.00 mg/kg). The pollution intensity calculation using the geoaccumulation index showed a moderate intensity for Makama Housing Estate, moderate to strong intensity for Rafin Makaranta and Yelwan Makaranta respectively while Gwallaga dumpsite showed practically uncontaminated intensity. Increased lead concentrations in soils are usually attributed to industrial activities [16]. Lead is mostly found in automobile battery in sufficient amount [17]. The results of this study showed that the lead mean concentrations in the dumpsites soils to range within 4.13-10.63 mg/kg. These concentrations were below the normal soil lead concentrations (15-25 mg/kg) reported by Eddy, *et al. (2006)* [16]. And below the concentrations (8.59-9.20 mg/kg) reported by Agyarko, *et al. (2010)* [14]. The concentrations of lead obtained in this study indicate that the soils at these sites may not be polluted perhaps due to low automobile activities in the area [17]. The result of the geoaccumulation index computed showed that the pollution intensity was strong at MHE, moderate-Strong at Gwallaga and Yelwan Makaranta and strong-very strong at rafin Makaranta.

Copper is an essential micronutrient required by plants for their healthy growth. The soil normal range of copper falls within (7- 8.0 mg/kg) [16], the concentrations of copper for the dumpsites soil samples ranges from 0.79-2.07 mg/kg. These concentrations were lower than those reported by Agyarko and Berlinger, 2010 [14] and David *et al.*, 2009 [13]. The implication of the lower concentrations of copper reported in this study when compared to those reported [13,14] in literatures may suggest that the soils at these dumpsites are not polluted. This observation was further confirmed by the geoaccumulation index calculation, which showed uncontaminated - moderate pollution intensity at Gwallaga, Rafin Makaranta and Yelwan Makaranta.

4. Conclusion

The results of analysis indicated that the concentrations of the heavy metals analysed are within the WHO permissible limits in all dumpsites soils. The geoaccumulation index showed that the pollution intensity was strong at Makama housing estate, moderate-Strong at Gwallaga and Yelwan Makaranta and strong-very strong at rafin Makaranta.

References

[1] Östman, M., Wahlberg, O., Agren, S., Martensson, A.Metal and matter contents in a combined household and industrial landfill. Waste Management, 26, 29-40. International Journal of Environmental Research, 3, No. 3, 353-358. (2006).

[2] Zauyah, S. B., Julian Noorhafizh, R., Fauzih, C. I. and Rosemani, B.). Concentration and speciation of Heavy Metals in some cultivated Utisols and Inceptisls in peninsular Malaysia Supersoil (2004).

[3] Park, J. H., Shin, W.S. Immobilization of Pb contamined soil using Modified clay. Water Practice and Technology, 1(2), 1-10. (2006).

[4] Onweremadu, E. U., Duruigbo C. I. Assessment of Cd concentration of crude oil pollution in arable soils. Int. J. Environ. Sci. Tech., 4 (3), 409-412 (2007).

[5] Dussault, M., Bécaert, V., François, M., Sauvé, S., Deschênes L. Effect of copper on soil functional stability measured by relative soil stability index (RSSI) based on two enzyme activities. Chemosphere 72, 755-762. (2008).

[6] Bertazzoli, R., & Pelegrini, R. Photoelectrochemical discoloration and degradation of organic pollutants in aqueous solutions.Quimica Nova (2002).

[7] Isidori, M. M., Lavorgna Nardelli A., & Parella A. Toxicity Identification Evaluation of Leachates from Municipal Solid Waste Landfills, and approach to *chemosphere* 85-94 (2003).

[8] Odukoya, O. O., Bambose, O., Avowolo, T. A. Heavy Metals in topsoil of Abeokuta dumpsites. Global J. Pure Applied Sci., 7: 467- 472. (2009).

[9] Amusan Charles, K.., & Ojo, S. J. Determination of Heavy Metals in Soil in the Vicinity of a Dumpsite in Ketaren Gwari Minna. International Journal of Science and Nature. @ 2004-2011 Society for Science and Nature SFSN (2005).

[10] Ande, O. T., & Onajobi, J. Assessment of Effects of controlled land use types on soil quality using inferential method. African journal of Biotechnology 8 (22), 6267-6271. 16 November, (2009).

[11] Buratini, S. V., Bertolleti, E., Zagatto, P. A. Evaluation of daphnia simillis as A test species in ecotoxicological assays. Bulletin of Environmental Contamination and Toxicology, 73(5), 878-882 (2004).

[12] W.H.O. The world health report 1996-fighting disease,fostering Development (1996).

[13] David, N. O., Benjamin, L.K., & Patrick O. Y. Some physicochemical and heavy metal levesl in soils of waste dumpsites in Port Harcourt Municipality an *Environs J. Appl. Sci. Environ. Manage* 13(4) 65-70 (2009).

[14] Agyarko, K.., Darte, E. & Berlinger, K.. Metal levels in some refuse dumpsite soils and plants in Ghana-Journal of Plant Soil Environ, 56, (5): 244-251 (2010).

[15] Oviasogie, P. O., & Ndiokwere, C. L. Fractionation of lead and cadmium in refuse dump soil treated with cassava mill effluent.The journal of agriculture and environment Vol. 9, Jun. 2008 technical paper (2008).

[16] Eddy, N., Odoemelem, S. A., & Mbaba, A. Elemental composition of soil in some dumpsites Electron J. Environ. Agric Food . 5(3) 2006. ISSN: 1579-4377.

[17] Buteh, D. S., Chindo, I. Y., Ekanem, E. O. and Williams. E. M. Elemental Composition Study of Leachate in some dumpsites in Bauchi Metropolis. A Journal of Environmental and Earth Science 3(5), 28-31. 30th May, 2013.

[18] WHO., Guidelines for Soil and Drinking water Quality 3rd Edition (1): Recommendations. World Health Organisation, Geneva.