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Heavy Metal Concentrations around a Hospital Incinerator and a Municipal Dumpsite in Ibadan City, South-West Nigeria

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Key words: Hospital incinerator, municipal dumpsite, heavy metals, Bottom ash.

ABSTRACT: Studies to determine the concentrations of heavy metals in the surrounding soils and bottom ash of a hospital incinerator and a municipal dumpsite were carried out in Ibadan City, South-West Nigeria from November 2010 to January 2011. Samples were analyzed for Pb, Fe, Cu, Zn, Cr and Ni using Flame Atomic Absorption Spectrophotometry. Data obtained were analyzed using ANOVA, Students T-test and Pearson correlation. Mean concentrations of heavy metals in the sampled soils at the incinerator were 185.22±72.88, 16.22±13.13, 69.11±54.26, 2.33±2.53, 22.48±21.00 and 0.58±0.30 for Fe, Cu, Zn, Cr, Pb and Ni respectively, mean concentrations in the incinerator bottom ash were 5357.52±4671.89mg/Kg, 938.2±428.42mg/kg, 10670±3852.44mg/kg, 72.96±15.14mg/kg, 427.2±197.69mg/kg and 34.78±11.69mg/kg for Fe, Cu, Zn, Cr, Pb and Ni respectively and mean concentrations in sampled soils of municipal dumpsite were 290.67±78.66mg/Kg, 7.86±1.68mg/kg, 132.87±39.40mg/kg, 2.58±1.48mg/kg, 14.52±6.76mg/kg and 0.79±0.26mg/kg for Fe, Cu, Zn, Cr, Pb and Ni respectively. ANOVA showed that Fe (F = 11.254), Cu (F = 5.678), Zn (F = 20.399) and Pb (F = 3.679) had significant variations with sampling site, with bottom ash having the highest concentrations. The concentrations of heavy metals from both locations were higher than in the control site, indicating pollution. The heavy metal contents of the soils analyzed were all below the USEPA standard limits. However, the bottom ash contained high levels of Zn and Pb, that exceeded the standard limits. There is a need to appropriately dispose off the bottom ash from incinerators.. @ JASEM

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Human activities create wastes and it is the way these wastes are handled, stored, collected and disposed that constitutes risks to the environment and public health. In the urban areas, especially, in the rapidly urbanizing cities of the developing world, problems and issues of solid waste management are of immediate importance. This has been acknowledged by most governments. However, rapid population growth overwhelms the capacity of most municipal authorities to provide even the basic services. When wastes are collected, they are disposed-off in uncontrolled dumpsites and/or burnt, polluting water resources, air and soil (Onibokun, 1999).

Heavy metal soil contamination is particularly problematic because they are not degraded in soil. Heavy metals in soil cannot be permanently eliminated. At best they can be locally reduced by redistribution in the eco-system or removed from circulation by immobilization (Baker, *et al*., 1996). Heavy metals and their compounds have different physical and chemical characteristics and pose diverse toxicological characteristics. Human beings are poisoned through inhalation, ingestion and skin absorption. Acute exposures to high levels cause nausea, anorexia, vomiting, gastrointestinal abnormalities and dermatitis. Chronic exposures to heavy metals cause cumulative toxic effects, which affect various systems in the body depending on the heavy metal involved (Mahoney and Moy, 2005).

This research aimed at determining the heavy metals present in soils around a municipal dumpsite and the University College Hospital incinerator and also in the bottom ash samples in the incinerator.

MATERIALS AND METHODS

Soil samples were collected around the University College Hospital (UCH) incinerator, Bashorun market dumpsite and from an open field in the University of Ibadan (Control) in Ibadan city, south-west Nigeria. Ibadan is reputed to be the largest indigenous city in Africa, south of the Sahara. Ibadan city comprises of 11 local government areas (5 urban and 6 sub-urban) and has a population of 2,550,593 according to 2006 census results covering an area of 128 km² (National Population Commission, 2007).

The medical incinerator is the incinerator being currently used in Nigeria's oldest Teaching Hospital - University of Ibadan College Hospital (UCH). This incinerator handles close to 300 kg of biomedical wastes daily (Coker *et al*, 2000). Plastics mainly Polyvinylchloride (PVC) products and absorbents which are major sources of air pollution constitute about 70% of the wastes being generated in this hospital. The incinerator is a locally - made earth - brick furnace type with a kaolin - brick refractory (Coker, *et al*., 2000).

Surface soil samples were obtained at three different points; 10 metres apart starting from the base of the UCH incinerator and Basorun market dumpsite and at one point from the control site, for three consecutive months, November 2010 to January 2011. At each sampling point, four samples were collected at

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different directions and mixed to obtain a composite sample. The ash samples were obtained from the bottom of the incineration facility at different directions to make a composite sample. The samples were stored in labelled polythene bags and taken to the laboratory for treatment and preservation.

The soil and ash samples obtained were air-dried at ambient temperature in the laboratory for 5 days. The samples were then crushed using a porcelain mortar and pestle, then sieved through a 2mm screen, then through a 0.2mm screen to obtain a homogenous particle size. These were stored in separate polythene bags, appropriately labelled and stored for digestion and analysis

The samples were dissolved with 5-mL of 6M HNO_3. The solution was boiled for 20 minutes on a hot plate to reduce the volume of the acid to about 2-mL. The digest was diluted with 10-mL distilled water, and then filtered through Whatman No. 42 filter paper into a 50-mL volumetric flask. The residue was washed several times until volume was made up to 50-mL. The resulting solution was stored in a pre-cleaned polyethylene bottle until time for analysis All the soil and ash samples were analyzed for Pb, Fe, Cu, Zn, Cr and Ni using Flame Atomic Absorption Spectrophotometer, Buck Scientific Model 200-A, using appropriate lamps and resonance wavelength of the metals, at National Institute of Science and Laboratory Technology (NISLT), Ibadan.

Data obtained were subjected to analysis of variance (ANOVA) and Students' T-test analysis. A probability ≤ 0.05 was considered as significant.

RESULTS AND DISCUSSION

Results show that Fe had the highest mean concentration of 185.22mg/kg and Ni had the lowest, 0.58mg/kg among the heavy metals found in soils around the UCH incinerator. The descending order of metal content was Fe > Zn >Pb> Cu > Cr > Ni. All the metal concentrations in soil were below the USEPA regulation limits (Table 1). The concentrations of heavy metals in these soils are very low compared to that of polluted soils in the works of Yahaya *et al. (2009*). The concentration of heavy metals at the incinerator shows a relative decrease with distance from the source. This may be attributed to contamination of soil within the immediate vicinity of the incinerator by ash, which recorded high concentrations. Results revealed that iron (F=6.370), copper (27.043), zinc (F=3.956), and Lead (34.546) had significant mean variations with distance from the incinerator *i.e.* at the base, 10metres and 20metres away (Table 2).

Results obtained for heavy metals analyzed in bottom ash collected from the UCH incinerator, showed Zn having the highest mean concentration of 10670mg/kg while Ni had the lowest mean concentration of 34.78 mg/kg. The descending order of metal content was Zn > Fe > Cu >Pb> Cr > Ni (Table 1). Concentration of Zn in ash was relatively higher than the concentration reported by Zhao *et al.,* (2010). The ash contains much higher amount of Zn than other metals, this is because Zn is found present in most of the items used in medical facilities: for example, metal alloys containing Zn and Ti are widely used in medical instruments (Zhao *et al.,* 2010).

Table1: Summary of Concentration of Heavy Metals in Soils and Bottom Ash Samples Collected from and around UCH Incinerator, Basorun market Dumpsite and UI football field (Mean ± Standard deviation) and USEPA Upper Limit for Heavy Metals in Soil

Parameter	UCH (Incinerator)	Bottom Ash (UCH Incinerator)	BASORUN (Dumpsite)	U.I. (Control)	USEPA (2002)
Fe (mg/kg)	185.22± 72.88	5357.52±4671.89	290.67 ± 78.66	116.77 ± 96.00	-
Cu (mg/kg)	16.22 ± 13.13	938.2 ± 428.42	7.86 ± 1.68	3.98 ± 3.76	1500
Zn (mg/kg)	69.11 ± 54.26	10670 ± 3852.44	132.87 ± 39.40	16.41 ± 2.35	2800
Cr (mg/kg)	2.33 ± 2.53	72.96 ± 15.14	2.58 ± 1.48	1.71 ± 1.22	1200
Pb (mg/kg)	22.48 ± 21.00	427.2 ± 197.69	14.52 ± 6.76	6.13 ± 2.15	300
Ni (mg/kg)	0.58 ± 0.30	34.78 ± 11.69	0.79 ± 0.26	0.53 ± 0.41	420

Table 2: Mean Variation of Heavy Metal Concentrations in soil samples at different sampling points around the Incinerator at UCH

Parameter	A (Base)	B (10meters)	C (20meters)	F value
Fe (mg/kg)	265.33^{a}	144.0^{b}	146.33^{b}	6.370^{*}
Cu (mg/kg)	32.1^{a}	12.51^{b}	4.05^{b}	27.043^{*}
Zn (mg/kg)	105.9^{a}	85.6^{ab}	15.82^{b}	3.956^{*}
Cr (mg/kg)	2.76^{a}	3.09^{a}	1.15^{a}	0.437
Pb (mg/kg)	49.33^{a}	8.57^{b}	9.53^{b}	34.546^{*}
Ni (mg/kg)	0.35^{a}	0.70^{a}	0.68^{a}	1.451

Mean values along the same row with same alphabet are not significantly different
**Values are significantly different ($\alpha = 0.05$)

The t-test analysis of heavy metal concentrations for the soils collected around UCH incinerator and bottom ash samples collected from the incinerator all showed significant mean variation, Ca (t=3.1525), Fe (t=3.8345), Cu (t=7.4503), Zn (t=9.5310), Cr

(t=15.8710), Pb (t=7.0392) and Ni (t=10.1336) (Table 3).

Fe had the highest mean concentration (290.67 mg/kg), while Ni (0.79mg/kg) had the lowest mean concentration among all the heavy metals in soils from Basorun dumpsite (Table 1). The descending order of metal contents is Fe > Zn >Pb> Cu > Cr > Ni. Soil sample 10m away from the dumpsite had relatively higher concentration of heavy metals than that from the base of the dumpsite. This may not be unconnected with the activities of butchers around that point. These butchers burn tires for roasting killed animals and mostly deposit the waste of animal parts generated such as horns and bones around that point. The relative low concentration at the base of the dumpsite may also be attributed to the presence of a flowing stream and sandy nature of the soil, which make leaching of soil components easier. When compared to USEPA regulation limits, all the metals at this site are below the specified limits (Table 1). The concentrations of heavy metal in these soils are also very low compared to that of polluted soils (Yahaya*et al.* 2009). The results obtained from the analysis of mean variance of the various concentrations of the heavy metals considered indicated that Fe (F = 4.480), Cu (F = 4.531), Cr (F = 12.888) and Pb (F = 4.400) differ significantly at the three points of sampling with distance away from the dumpsite for heavy metals (Table 4).The general relatively higher concentration of heavy metals in soils at Basorun MSW dumpsite than in soils around UCH medical wastes (MW) dumpsite contradict reports by other researchers (Kuo *et al.,* 1999, Ibanez, *et al.,* 2000 and Zhao *et al.,* 2010), who reported that heavy metals in medical residue are significantly higher than those in municipal solid waste. The results from the present study may not be unconnected with the fact that wastes are not allowed to be decomposed at the UCH incinerator, the point only serves as a collection point after which the wastes are moved to a designated, and government reserved dumpsite at Apete. At Basorun market dumpsite, the wastes are gathered there with no plan of moving them to another site. This implies that the soils at Bashorun market dumpsite poses more hazard to public health than the soils around the UCH incinerator

When compared to the report of Nwajei *et al.* (2007), the Cr levels are high in this study. Chromium functions in mammalian glucose metabolism and appears to be essential to man and animals (Yahaya*et al.* 2009). Higher concentration of Fe was recorded in this study than the concentration reported by Zhao *et al,* (2010).

The Pb levels in soil were similar to the amount reported by Ogbonna *et al.* (2009) and Yahaya*et al.* (2009) but lower than the levels reported by Meneses *et al.* (1999) and Schuhmacher *et al.* (1997). The levels obtained in this work are high when compared to that reported by Nwajei *et al.* (2007). Higher concentration of Pb was recorded from ash than the concentration reported by Zhao *et al.,* (2010). Ni levels in soil are lower than reported concentrations from the works of Meneses *et al.* (1999), Schuhmacher *et al.* (1997) and Yahaya *et al.* (2009). Concentration of Ni in ash was low compared to reports by Zhao *et al.* (2010).

Table 3: Mean Variation of Heavy Metal Concentration between Bottom Ash and Soil Samples Collected at UCH

Parameter	Soil Sample	Ash Sample	T-value
Fe (mg/kg)	185.22	5357.52	3.8345*
Cu (mg/kg)	16.22	938.2	7.4503*
Zn (mg/kg)	69.12	10670	9.5310*
Cr (mg/kg)	2.33	92.96	15.8710*
Pb (mg/kg)	22.48	427.2	7.0392*
Ni (mg/kg)	.58	34.78	10.1336*

Mean variations along the same row with same alphabet are not significantly different
**Values are significantly different (α = 0.05)

Table 4: Mean variation of Heavy Metals in Soils from the different sampling points at Basorun dumpsite

Parameter	A (Base)	B (10metres)	C (20metres)	F value
Fe (mg/kg)	254.67[b]	245.67[b]	371.67[a]	4.480*
Cu (mg/kg)	6.96[b]	9.61[a]	7.03[b]	4.531*
Zn (mg/kg)	113.4	172.5	112.7	3.965
Cr (mg/kg)	2.40[b]	1.13[b]	4.20[a]	12.888*
Pb (mg/kg)	10.87[b]	11.23[b]	21.47[a]	4.400*
Ni (mg/kg)	0.77[a]	0.79[a]	0.81[a]	0.012

Mean variations along the same row with same alphabet are not significantly different
**Values are significantly different (α = 0.05)

The results recorded at University of Ibadan football field, which served as the control site showed that Fe (116.77 mg/kg) had the highest mean concentration while Ni (0.53mg/kg) had the lowest mean concentration among the heavy metals. The descending order of metal content is Fe > Zn >Pb> Cu > Cr > Ni. When USEPA regulation limits are considered all the metals are under the specified limits (Table 1).These concentrations were lower than the concentrations in both soils at the incinerator and municipal dumpsite.

The analysis of variance results obtained for the period of study among the three sites showed that Fe (F = 11.254), Cu (F = 5.678), Zn (F = 20.399) and Pb (F = 3.679) had significant variations with sampling site.

Conclusion*:* The results from both locations were higher than their control site, indicating a clear case of pollution. Comparison of heavy metal concentration in soil with USEPA standards showed that they are all below the set limits. The soils at the Basorun municipal dumpsite had higher concentrations of heavy metals than the soils around the medical waste incinerator. Medical waste bottom ash is contaminated with high levels of heavy metals, with levels of Zn and Pb, exceeding the USEPA standard limits. This type of waste ash poses serious threat to public health and should be disposed of appropriately.

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