The influence of hospital waste dumps and incinerator ash on the receiving environment

[1]Sunday M and [2]Agbaji E. B.

[1]Department of Pre- science and Technology, Federal Polytechnic, Kaura Namoda, Zamfara State, Nigeria
[2]Department of Chemistry, Ahmadu Bello University, Zaria, Nigeria
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ABSTRACT

Samples of dump soil, incinerator ash and food crops (tomatoes, guava, and banana) were collected from Ahmadu Bello University Teaching Hospital waste dumpsite, waste incinerator and from farmland respectively within the vicinity of the study area. Samples were collected between the hours of 7:00am- 9:00am when hospital activities are high. The mean concentrations of heavy metals (Pb, Fe, Mn, Cr, and Cd) were determined in the samples. Atomic Absorption Spectrometry was used for the heavy metals analysis after digestion using standard method. The result showed the order of relative abundance as Fe> Pb> Mn> Cr> Cd. Analysis of variance with t-test indicated no significant difference for all the metal level within the study area except for iron. The levels of the metals analyzed in all the sources and food crops were within WHO tolerable limits. Therefore, the contamination of the receiving environment (soil, water, food crops) due to the discharged from the hospital dumpsite, and incinerator could be hazardous to human health over time.

Key words: Hospital waste, dump soil, incinerator ash, food crops and heavy metals.
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INTRODUCTION

Since the beginning, hospitals are known for the treatment of sick persons but are unaware of the adverse effects of the garbage and filth generated by them on human body and environment. Now it is a well-established fact that there are many adverse and harmful effects to the environment and human beings which are caused by the hospital waste generated during the patient care. Hospital waste is a potential health hazard to the health care workers, public and the flora and fauna of the area. Hospital acquired infection, transfusion transmitted diseases, rising incidences of hepatitis B, and HIV, increasing land and water pollution lead to increasing possibility of contracting many diseases. Air pollution due to emission of hazardous gases by incinerators such as furan, dioxin, hydrochloric acid etc. have compelled the authorities to think seriously about hospital waste and the diseases transmitted through their improper disposal [10], [20]. The hospital waste is classified into seven [2] comprising of both the liquid and the dissolved substance generated within the hospital environment [10], [9].

(I) General waste: This is composed largely of non-hazardous particles such as kitchen waste, paper and plastics.

(II)Infectious wastes: This includes waste which includes pathogens in sufficient concentration of quantity that could cause diseases. It is hazardous e.g. culture and stocks of infectious agents from laboratories, waste from surgery, waste originating from infectious patients.

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(III) Pathological waste: Consist of tissue, organ, body parts, human foetuses, blood and body fluid. It is hazardous waste.

(IV) Sharps: Waste which could cause the person handling it, a punch or puncture of skin e.g. needles, broken glass, saws, nails, blades, scalpels.

(V) Pharmaceutical waste: This includes pharmaceutical products, drugs and chemicals that have been spilled are outdated, expired or contaminated.

(VI) Chemical waste: This comprises discarded solid, liquid and gaseous chemicals e.g. House-keeping and disinfecting products such as waste anaesthetic gases, formaldehyde solutions.

(VII) Radioactive waste: It includes solid, liquid and gaseous waste that is contaminated with radionuclides generated from in-vitro analysis of body tissues and fluid, in-vivo body organ imaging and tumor localization and therapeutic procedures.

The modern hospitals and health care institutions including research centres use a wide variety of drugs including antibiotics, cytotoxics, corrosive chemicals, radioactive substances, which ultimately become part of hospital waste. The advent of disposables in hospitals has brought in its wake, attendant ills e.g. inappropriate recycling, unauthorized and illegal reuse and increase in the quantity of waste.

In many countries, medical waste can no longer be disposed in landfills, unless it is so thoroughly detoxified as to pose no risk to human health. This is very expensive. Burning the waste material in open air can never be complete, with small quantities of many organic and chlorinated organic compounds as well as pathogens surviving. This will lead to dispersal of dangerous diseases. Incineration is currently used to destroy hospital waste, especially biomedical waste and hazardous chemical waste by reducing the volume and destroying some harmful constituents. Disposal of hospital waste in an environmentally acceptable manner is thus a critical necessity.

One of the most serious problems facing the world today is the contamination of the environment, including surface and ground waters, with heavy metals such as arsenic (As), cadmium (Cd), chromium (Cr), lead (Pb) and mercury (Hg) [12]. Most trace elements especially the heavy metals remain in the soil nearly indefinitely. These metals remain bound to organic matter unless they are remobilized mechanically as wind-blown dusts [16]. Human exposure to metals and their compounds in the environment is through food, drinks, water. Other forms of uptake are via skin contact [8]. However, over a period of time, adverse toxic effects may occur as a result of long-term low level exposure [8]. Food crops such as cassava, tomatoes and mango constitute an important part of the human diet since they contain carbohydrate, proteins as well as vitamins, minerals and trace elements [11]. However, in recent years, their consumption is increasing gradually particularly among the urban dwellers. This is due to the increased awareness on the exposure to other culture and acquiring proper education [1]. Heavy metals are generally present in agricultural soils at low levels. Due to their accumulation behavior and toxicity, however, they have a potential hazardous effect not only on crop plants but also on human health [11]. Metals have characteristic affinities for certain organs and system. The consequences of preferential localization in certain organs of the body are not necessarily bad. As an example, lead (pb) has a great affinity for bone, more than 90% of the lead in the body is localized in bone. Yet, the toxic effect of lead are the result of its presence in much, lower concentrations elsewhere in the body, notably in the hematopoietic system and the central nervous system [5]. The major health risks posed by medical waste to the inhabitants of the terrestrial and aquatic ecosystem as audited by the WHO report of 1999 includes the following: contamination of dirty water possibly the leachate entering the aquifers. Surface water accumulation of toxic non-biodegradable hospital waste products, which could lead to the blockage of the sewage system, release of toxic substance into the air due to burning, accumulation of heavy metals and unprotected landfill as well as inefficient sorting of waste materials.

MATERIALS AND METHODS

In the preparation of solution, analytical reagent grade chemicals and distilled water were used. All glassware were washed with detergent and rinsed in water before immersion in 10% nitric acid solution. They were further rinsed with distilled water before drying in the oven.

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All samples were oven dried at 105°C to a constant weight and were sieved through a 250µm mesh [3].

Description of the sampling area: The sampling area is Ahmadu Bello University Teaching Hospital situated in Zaria, Kaduna State. The hospital began medical services at this site in a skeletal way in 2005. Hence, the hospital waste site is virtually new as medical services are just taking proper shape.

Sample collection: All samples were collected between the hours of 7:00AM – 9:00AM on 30th August, 2010 for the wet season and on the 15th March, 2010 for the dry season. Soil samples were collected from two sampling points at the hospital dumpsite at different distances away from the dumpsite at a depth of 5cm within the study area as follows:

D1 is a point on the dumpsite where the samples were collected at 0-5cm, 5-10cm deep.
D2 is a point 5m away from the dumpsite with the same depths.

Crop sample: Crop samples collected from the farmland within the vicinity of the dumpsite are tomatoes, guava, and banana fruits were collected.

Ash sample: Ash samples from the mini incinerator were taken at random in two points, designated as: A1, and A2 which are first, and second points of collection respectively.

Treatment and Preservation of Sample
Immediately the soil samples were collected they were isolated and packaged in neatly labeled plastic containers that had been washed and rinsed thoroughly with nitric acid and analytical grade pentane in order to remove all heavy metals and organic residue and transported to the laboratory.

Digestion of samples for AAS
Soil samples from each site were homogenized and air – dried in a circulating air in the oven of 30^0C to a constant weight and passed through a 2mm sieve. 0.3g of soil samples were placed in 100ml beaker. 3cm³ of 30% hydrogen peroxide was added following a procedure by Shriadah [15]. This was left to stand for 60 minutes until the vigorous reaction ceased. Thereafter 75cm³ of 0.5M solution of HCl was added and the content heated gently at low heat on hot plate for 2hours. The digest was then filtered into a 50cm³ standard flask. Duplicate digestion of each sample together with the blank (blank) was also carried out. The crop samples guava, banana and tomatoes were washed with tap water [6],[19] and thereafter with distilled water, sized in nearly uniform size to facilitate drying of the pieces at the same rate and then dried in an oven at 105°C for 24hours, until they were brittle and crisp [4]. At this stage, no micro organism can grow and care was taken to avoid any source of contamination. The dried samples were grinded into fine particles using clean acid washed mortar and pestle. The procedure according to [1] was used for digestion of plant samples. 0.3g of sieved samples was then weighed into 100cm³ beaker. A mixture of 5cm³ concentrated trioxonitrate (V) acid and 2cm³ perchloric acid was added and this was digested on low heat hot plate for 15mins, at 70°C until a light coloured solution was obtained. The sample solution was not allowed to dry during digestion. The digest was allowed to cool, filtered into 50ml standard flask. Duplicate digestion of each sample was carried out. Quantitation of metallic content of digested sample was carried out with Atomic absorption spectrophotometer.

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RESULTS AND DISCUSSION

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Ducan one way analysis of variance (ANOVA) was used to conduct a test of significance at p<0.05 i.e. 95% confidence limit between pairs of data i.e. wet season and dry season also student t-test was used to test for significance. The statistical result is as shown below:

Soil: Lead has mean concentration (Table 1) of 0.323mg/kg during the wet season and 0.344mg/kg for the dry season on the dump soil at (0-5cm) depth. The concentration of lead at another depth (5-10cm) at the same point of soil collection is 0.305mg/kg for wet season and 0.256mg/kg for the dry season see table 1. Although statistics shows that there is no significant difference in the mean concentration of the metals in the two seasons. Table 1 and 2 show the metals concentration in the soil at the dump. The concentration of lead outside the dump (5m away) at (0-5cm) depth is 0.255mg/kg for the wet and 0.260mg/g for the dry season, while at another dept (5-10cm) (Table 2) the concentration of lead is 0.171mg/kg for wet and 0.172mg/kg for dry season. This implies that the concentration

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of lead decreases as the point of sample collection get deeper into the soil, it also decreased with increased distance from the main dumpsite.

Of all the metals analyzed iron has the highest mean concentration of 0.807mg/kg for both the dry and wet seasons. Student t-test showed that there is no significant difference in the concentration of manganese, cadmium, and chromium in the two seasons. Nickel showed the lowest mean concentration of 0.040mg/kg for wet and 0.038mg/kg for dry season.

Table 1: Concentration (mg/kg) of heavy metals on the dump soil for the wet and dry seasons at 0-5cm and 5-10cm depth

Metal	Wet(0-5cm)	Dry(0-5cm)	Wet(5-10cm)	Dry(5-10cm)
Pb	0.323 ± 0.038^a	0.344 ± 0.005^a	0.305 ± 0.053^a	0.256 ± 0.002^a
Fe	0.807 ± 0.002^a	0.807 ± 0.001^a	0.764 ± 0.003^a	0.765 ± 0.001^a
Mn	0.134 ± 0.002^a	0.134 ± 0.004^a	0.091 ± 0.001^a	0.092 ± 0.002^a
Cd	0.045 ± 0.002^a	0.044 ± 0.002^a	0.027 ± 0.001^a	0.027 ± 0.001^a
Cr	0.076 ± 0.001^a	0.076 ± 0.001^a	0.019 ± 0.001^a	0.019 ± 0.001^a
Ni	0.040 ± 0.004^a	0.038 ± 0.001^a	0.015 ± 0.006^a	0.013 ± 0.001^a
Co	0.067 ± 0.001^a	0.061 ± 0.001^a	0.033 ± 0.001^a	0.032 ± 0.002^a

Values with different superscript across the row for wet and dry season pairs are significantly different (p< 0.05).
Values are mean± SD.
Mean sample size=3.14

Table 2: Concentration (mg/kg) of heavy metals outside the dump soil (5m) for the wet and dry seasons at 0-5cm and 5-10cm depth

Metal/season	Wet(0-5cm)	Dry(0-5cm)	Wet(5-10cm)	Dry(5-10cm)
Pb	0.255 ± 0.001^a	0.260 ± 0.006^a	0.171 ± 0.001^a	0.172 ± 0.002^a
Fe	0.721 ± 0.011^a	0.716 ± 0.136^a	0.681 ± 0.001^a	0.683 ± 0.002^a
Mn	0.097 ± 0.001^a	0.090 ± 0.012^a	0.073 ± 0.001^a	0.066 ± 0.002^a
Cd	0.026 ± 0.002^a	0.026 ± 0.000^a	0.027 ± 0.001^a	0.028 ± 0.002^a
Cr	0.035 ± 0.001^a	0.036 ± 0.002^a	0.026 ± 0.011^a	0.026 ± 0.011^a
Ni	0.025 ± 0.001^a	0.023 ± 0.001^a	0.018 ± 0.001^a	0.018 ± 0.002^a
Co	0.045 ± 0.001^a	0.043 ± 0.001^a	0.027 ± 0.001^a	0.025 ± 0.001^a

Values with different superscript across the row for wet and dry season pairs are significantly different (p< 0.05).
Values are mean± SD.
Mean sample size=3.14

Iron has the highest mean concentration of 0.721mg/kg and 0.716mg/kg for both wet and dry season respectively among all the metals analyzed at 0-5cm depth while at depth 5-10cm the concentration of iron is 0.681 and 0.683mg/kg for both wet and dry seasons respectively. The implication from this result is that the concentration of almost all the metals analyzed decreased as the depth and distance of sample collection increased. Nickel also has the lowest concentration of 0.018mg/kg for both seasons. Student t- test for the result recorded shows that there is no significant difference in the concentration of lead in both seasons.

Heavy metals exact a broad range of toxic effects on humans, terrestrial and aquatic life and plants. A number of these metals also have the potential to bio-accumulate, including cadmium, chromium, lead, mercury and zinc [17], [13], [14]. In addition, certain forms of cadmium and chromium have carcinogenic properties [17]. From result of these metals in Table 1 and 2 above shows that seasonal variations do not significantly affect the concentration of the heavy metals.

Table 3: Concentration (mg/kg) of heavy metals for wet and dry seasons in the incinerator ash

Season	Pb	Fe	Mn	Cd	Cr	Ni	Co
wet	0.384 ± 0.066^a	0.279 ± 0.047^a	0.115 ± 0.236^a	0.036 ± 0.010^a	0.005 ± 0.001^a	0.028 ± 0.003^a	0.043 ± 0.008^a
dry	0.382 ± 0.070^a	0.284 ± 0.048^a	0.116 ± 0.023^a	0.038 ± 0.009^a	0.002 ± 0.001^b	0.027 ± 0.004^a	0.044 ± 0.009^a

Values with different superscripts down the column are significantly different (p< 0.05).
Values are mean± SD.
Mean sample size=3.14

Incinerator Ash: Lead had the highest mean concentration of 0.384mg/kg of the entire metals analyzed (table 3). Both seasons showed high concentration of lead closely followed by iron with concentration of 0.284mg/kg. Chromium showed lowest mean concentration of 0.002mg/kg during the dry season to 0.005mg/kg for wet season. The concentration of manganese is 0.115mg/kg (wet season) and 0.116mg/kg for the dry season, while the

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concentration of cadmium 0.036mg/kg in the wet season is not significantly different from the concentration during the dry season 0.039mg/kg. The concentration of nickel was almost the same during both seasons. The concentration of cobalt ranged from 0.043mg/kg in the wet season to 0.044mg/kg for the dry season. This result is in line with the report of [7], that heavy metals are not destroyed by incineration but is simply concentrated in the remaining ashes, or released to the environment via stack emission. The concentrations of heavy metals in the ashes are dependent on the amounts of these metals in the wastes being incinerated. Heavy metals can remain in their original form during incineration or may react to form new compounds such as metal oxides, chlorides or fluorides [7]. Student t-test for the result showed that there is no significant difference in the concentration of all the metals analyzed for both the wet and dry season.

Table 4 Concentration (mg/kg) of heavy metals for wet and dry season in guava in the farmland.

Season	Pb	Fe	Mn	Cd	Cr	Ni	Co
wet	0.086±0.001[a]	0.413±0.003[a]	0.043±0.001[a]	0.061±0.001[a]	0.018±0.002[a]	0.019±0.001[a]	0.009±0.001[a]
dry	0.086±0.002[a]	0.410±0.005[a]	0.044±0.001[a]	0.061±0.001[a]	0.019±0.001[a]	0.019±0.002[a]	0.016±0.015[a]

Values with different superscripts down the column are significantly different (p< 0.05).
Values are mean ±SD.
Mean sample size = 3.14

Table 5 Concentration (mg/kg) of heavy metals for wet and dry seasons in banana in the farmland.

Season	Pb	Fe	Mn	Cd	Cr	Ni	Co
wet	0.082±0.003[a]	0.355±0.012[a]	0.047±0.001[a]	0.067±0.001[a]	0.040±0.002[a]	0.014±0.000[a]	0.033±0.001[a]
dry	0.084±0.002[a]	0.355±0.013[a]	0.047±0.001[a]	0.067±0.001[a]	0.040±0.001[a]	0.015±0.002[a]	0.032±0.001[a]

Values with different superscripts down the column are significantly different (p< 0.05).
Values are mean ±SD.
Mean sample size =3.14

Table 6 Concentration (mg/kg) of heavy metals for wet and dry season in tomatoes in the farmland.

Season	Pb	Fe	Mn	Cd	Cr	Ni	Co
wet	0.181±0.016[a]	0.467±0.043[a]	0.064±0.002[a]	0.081±0.001[a]	0.055±0.001[a]	0.033±0.022[a]	0.046±0.002[a]
dry	0.172±0.002[a]	0.468±0.043[a]	0.054±0.002[a]	0.082±0.002[a]	0.055±0.001[a]	0.046±0.002[a]	0.046±0.005[a]

Values with different superscripts down the column are significantly different (p< 0.05).
Values are mean ±SD.
Mean sample size =3.14

Metal concentration in the food crops analyzed
Tomatoes had the highest iron mean concentration of 0.467mg/kg among all the food crops analyzed (see table 6). This is closely followed by lead which has concentration of 0.181mg/kg in tomatoes. Also the concentration of manganese (0.064mg/kg), cadmium (0.081mg/kg), chromium (0.055mg/kg), nickel (0.033mg/kg) and cobalt (0.046mg/kg) in tomatoes are higher than all other metals in food crops analyzed for heavy metals(see table 4 and 5). Guava has the lowest mean concentration of cobalt (0.009mg/kg) and (0.016mg/kg) for both wet and dry seasons respectively see table 4. Banana had iron concentration of 0.355mg/kg for both seasons which is significantly higher than all the other food crops analyzed for heavy metals. Mango had lead concentration of 0.082mg/kg for wet season and 0.086mg/kg for dry season. Cobalt showed the lowest concentration of 0.020mg/kg and 0.021mg/kg for wet and dry season respectively among all the heavy metals analyzed in the mango fruit see table 5.

The mean concentration and seasonal level of lead in all the sources/fruit analyzed are below WHO and USEPA recommended maximum permissible level. Heavy metals exact a broad range toxic effects on humans, terrestrial and aquatic life and plants. A number of these metals also have the potential to bio-accumulate, including cadmium, chromium, lead, mercury and zinc [17], [13], [14]. In addition, certain forms of cadmium and chromium have carcinogenic properties [17].

Even though the concentration of all the heavy metals analyzed fall below the critical permissible concentration level, consumption of such fruit will accumulate over time and consequently cause harm to human health.

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CONCLUSION

Higher levels of iron metals were observed for the soil samples and food crops in the vegetation located within the vicinity of the hospital waste dumpsite, which as mentioned before, can be explained due to the soil's natural composition.

All values were within the accepted levels by the concerning regulatory agencies.

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