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Studies in the Heavy Metal Content in Soil Hospital Waste Dumpsite

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Abstract

Soil samples were collected from the University of Benin Teaching Hospital (UBTH) dumpsite and from Edo Development and Property Agency (EDPA) dumpsite which served as the control site. Samples were analyzed for Zn, Pb, Cd, Cr, Fe andMn. Samples were collected every week for six months (January- June). The values mean concentrations of heavy metals: Zn, Pb, Cd, Cr, Fe and Mn determined using AAS are 8.223±0.621 mg/L, 1.435±0.302 mg/L, 0.547±0.133 mg/L, 2.788±0.212 mg/L, 108.608±18.317 mg/L, 4.418±0.566 mg/L for the control site, 18.727±1.397 mg/L, 2.093±0.236 mg/L, 0.772 ±0.134 mg/L, 4.972±0.552 mg/L, 191.337±29.524 mg/L, 8.052±1.078 mg/L for the dumpsite and 46.008±6.463 mg/L, 4.062±0.861 mg/L, 1.985±0.409 mg/L, 12.747±1.661 mg/L, 1833.667±364.014 mg/L, 19.797±2.980 mg/L for the incinerator site. Analysis of variance (ANOVA) was used for analysis of data, a probability of <0.05 was considered as significant. P-values of Zn=0, Pb=0, Cd=0, Cr=0, Fe=0 and Mn = 0.40897. With the P-values <0.05. The various site/location have significant effect on the mean concentrations of the various heavy metals except for Mn, the various site/location had no effect on the mean concentration of Mn. There is a clear case of pollution since the results from the site/locations were higher than control site. Heavy metal concentrations in soil were lower than WHO maximum allowed limits. The soil at the adopted medical incinerator (dumpsite) had higher concentrations of heavy metals than the soil around the dumpsite.

1.0. Introduction

Soil from medical dumpsites has been analyzed as an area of research that has evolved significantly in developed countries over the years unlike what is obtainable in developing countries. There are many standard medical wastes management protocols, but the one frequently practiced in Nigeria is incineration, while this has the advantage of killing pathogens in the waste stream and reducing waste volume and reactivity, incineration has been found to impact the environment through the release of hazardous combustion products, such as heavy metals, dioxins and PAH's which has environmental and public health implications. This is of great public concern [1,2]. Medical waste incineration involves the burning of waste generated by hospital veterinary facilities and medical research facilities which include [red bag] medical wastes as well as non-infectious general housekeeping waste [3]. Hospital waste incineration is known to not completely destroy the metallic components of the waste stream but rather concentrate heavy metals into the bottom ash and surrounding soils [4], thus incinerated hospital waste bottom ash has more heavy metals and other elements (potassium, calcium, chromium, manganese, iron and lead) as well as organic compounds (PCBs, dioxins, benzene and other cancer causing organics) which if not well disposed of can pollute the environment and pose public health problems such as acute respiratory syndromes , gastro intestinal abnormalities and various cancers [5,6]. Because of these environmental concerns incinerator bottom ash management has been under continuous scrutiny and control [7] in recent times, according to Ghana's health care waste management guideline waste incineration is approved for use for infectious and hazardous waste. It stipulates that incineration bottom ash should be disposed of at land fill sites and should not be deposited or scattered on surface of open dumps and must be protected against access to scavengers [8]. Pollution is a worldwide problem and its potential in influencing health of human population is great [9]. Excessive levels of pollution are causing a lot of damage to human and animal health, plants including tropical rain forests as well as the wider environment [9]. Pollution is the cause of many diseases which affect not only the old but also the young and the energetic and all animals and plants [10]. These wastes include both infectious (red bag) medical wastes as well as non-infectious, general housekeeping wastes. University of Benin Teaching Hospital, has a semi - combustion pit which it adapts as an incinerator. It is a large open space. It is to be noted that the site is very far from human settlements. Hospital wastes are usually combusted in this large expanse of open space during the periods of relatively less rainfall and dry season of the year. Improper disposal of medical wastes, especially contaminated sharp objects (syringes and needles) that are scavenged and often reused may lead to significant numbers of hepatitis B, hepatitis C, HIV and possibly other infections. Other infectious medical wastes could be a major source of pollution in the environment if not properly disposed. options for safe waste disposal in developing countries are often limited. However, combustion of plastics and other materials containing polyvinyl and heavymetals and other air pollutants that are toxic, persistent in the environment and bio-accumulative. These emissions may pose chronic risks. There is a need to assess the risks attributable to toxic emission of this adopted waste burning by the University of Benin Teaching Hospital and policy makers involved with medical waste management and to document "best management practices" to minimize risks should this adopted waste incinerator be used. However, this study was conducted to examine the current concentrations of some selected heavy metals in the environmental matrices collected in the vicinity of the medical dumpsite and the control site of the medical dumpsite and control, to evaluate the principle cause of contamination, to determine the variation of the levels to the pollutants before, during and after the combustion and between the three sites of focus, to use analysis of variance and source identification of the obtained heavy metals from both sites as source markers and diagnostic ratio.

2.0 Materials and methods

All the reagents used in this study were of analytical grade.

2.1 Study area

University of Benin Teaching Hospital is located in Ugbowo, Benin-city, Edo state of Nigeria. It lies between the geographical coordinates of longitude $5^0$36\` and 0.44" E and of latitude $6^0$23\` and 0.26" N. The origin of the school is dated back to 1973 and it have 910 beds (recent data). It is affiliated to the University of Benin Nigeria. Benin-City the capital of Edo state in Nigeria, has a topography that can be described as low and sloping gently from about 105m above sea level in the north east to about 55m in the south west part. Temperature is usually high with an annual mean of 28^0c and also annual range of 3^0c. The city experiences an annual rainfall of above 2000mm with mean relative humidity of above 80%. The rainy season in Benin begins on March/April and ends October/November. Rainfalls are of high intensity and usually double maxima with a dry little spell in "August break". The city lies within the tropical rain forest belt of Nigeria and has therefore some to several forest products including timber, oil palm and rubber [11].

2.2 Sampling location

Sampling sitesused for this study is located outside the premises of the University of Teaching Hospital, an open site where University of Benin Teaching Hospital disposes their waste and at BDPA use as control site. The sampling site other than the control site is an open site also subjected to wild fire where the refuse is burnt. Plastics mainly polyvinylchloride (PVC) products and adsorbents which are major sources of air pollution constitutes about 70% of the waste being generated in the hospital. It is to be noted that the site is very far from human settlement.

Soil samples were collected in the month of January 2021 to June 2021, once every Friday in the hours of 5-7pm composite surface soil were collected from around the dumpsite as well as within the dumpsite for each of the six months. Within the dumpsite, soil samples were collected around the burnt medical waste. At each sampling point, four samples were collected at different directions and mixed to obtain a composite sample. Representative samples were picked to represent the entire samples collected.

Collected soil samples were wrapped in polythene bags and placed in a refrigerator. The samples were stored in labelled polythene bags and taken to the laboratory for treatment and preservation. These were stored in separate polythene bags, appropriately labelled and stored for digestion and analysis.Data obtained were subjected to analysis of variance (ANOVA).

2.3 Soil digestion

Well mixed samples of 1g each were weighed using ScienTech Zeta series electronic balance. The sample were put into 250ml glass beaker and digested with 10ml of aqua regia and then evaporated to near dryness. The soil samples were then soaked in 30ml of distilled water, filtered and then made up to 100ml with distilled water prior to AAS analysis [12]. Duplicated samples were analyzed.

The resulting filtrate was stored in a pre-cleaned polyethylene bottle until time for analysis.

All the soil samples were analyzed for Zn, Pb, Cd, Cr and Mn using AAS, using appropriate lamps and resonance wavelength of the metals.

Data obtained were subjected to analysis of variance (ANOVA). Correlation matrix was also conducted for the various data.

3.0 Result and Discussion

The results obtained from the analysis are presented in the Tables below:

Table 1: Summary of the mean concentration of the heavy metals in soils across the site.

Parameters	Control	Dumpsite	Incinerator	WHO values	P–values
Zn(mg/L)	8.223±0.621	18.727±1.397	46.008±6.463	300.000	0
Pb(mg/L)	1.435±0.302	2.093±0.236	4.062±0.861	100.00	0
Cd(mg/L)	0.547±0.133	0.772±0.134	1.985±0.409	3.000	0
Cr(mg/L)	2.788±0.212	4.972±0.552	12.747±1.661	100.000	0
Fe(mg/L)	108.608±18.317	191.337±29.524	1833.667±364.014	-	0

Mn(mg/L)	4.418±0.566	8.052±1.078	19.797±2.980	1000.000	0.40897

Table 2: Summary of mean concentration of heavy metals in soils across the months in comparison

Month	Zn(mg/L)	Pb(mg/L)	Cd(mg/L)	Cr(mg/L)	Fe(mg/L)	Mn(mg/L)
January	21.587±15.242	3.053±2.098	0.970±0.435	6.313±4.707	674.437±850.554	10.183±6.496
February	23.317±18.133	2.310±0.798	1.137±0.827	7.493±6.513	693.363±981.803	12.190±8.485
March	27.810±22.625	2.903±1.605	1.007±0.669	7.320±5227	951.273±1381.665	12.153±10.436
April	22.230±16.250	2.327±1.248	1.450±1.043	7.30±6.167	692.62±952.91	10.13±7.804
May	24.673±20.823	2.093±1.080	0.933±0.781	6.580±4.546	600.96±819.175	10.827±9.033
June	26.390±24.005	2.493±1.431	1.110±0.903	6.003±4.326	654.57±852.183	9.05±6.039
P-values	0	0	0	0	0	0.1544
WHO values	300.000	100.000	3.000	100.00	-	1000.000

Table 3: Correlation matrix for heavy metal at the control site

Heavy metal	Zn	Pb	Cd	Cr	Fe
Zn	1.0000				
Pb	0.3192	1.0000			
Cd	0.1884	-0.2930	1.0000		
Cr	0.4571	0.8803	-0.1249	1.0000	
Fe	0.514	0.0013	0.1009	-0.2595	1.0000

Table 4: Correlation matrix for heavy metal at the dumpsite

Heavy metal	Zn	Pb	Cd	Cr	Fe
Zn	1				
Pb	-0.1292	1			
Cd	0.2291	0.4363	1		
Cr	0.6689	-0.0957	-0.2173	1	
Fe	-0.2716	0.8735	0.3291	-0.3122	1

Table 5: Correlation matrix for heavy metals at the incinerator site

Heavy metal	Zn	Pb	Cd	Cr	Fe
Zn	1.0000				
Pb	-0.0511	1.0000			
Cd	-0.0721	-0.5917	1.0000		
Cr	-0.3813	-0.3823	0.4769	10000	
Fe	0.3893	0.3219	-0.1293	0.3764	1.0000

The concentrations of the various heavy metals studied for the duration of the study are presented in Table 1 -5.

Results obtained indicate a concentration range of 21.587±15.242 mg/L to 26.39±24.005 mg/L for Zn for the duration of the sampling with the highest concentration in the month of march, 3.053±2.098 mg/L to 2.493±1.431 mg/L for Pb for the duration of sampling with the highest concentration obtained in the month of March, 0.97±0.435 mg/L to 1.11±0.903 mg/L for Cd for the duration of the sampling with the highest concentration obtained in the month of march 6.313±4.707 mg/L to 6.003±4.326 mg/L for Cr for the duration of sampling with the highest concentration obtained in the month of March 674.437±850.554 mg/L to 654.57± 852.183 mg/L for Fe for the duration of the sampling with the highest concentration obtained in the month of March 10.183±6.496 mg/L to 9.05±6.039 mg/L for Mn for the duration of the sampling with the highest concentration obtained in the month, as seen from Table 2. Results from Table 1 show that Fe had the highest mean concentration (across the months) of 108.608±18.317mg/L among the heavy metals found in soils around the control. The descending order of heavy metals content around the control was Fe>Zn>Mn>Cr>Pb>Cd. Similar trend were observed for the result from dumpsite and incinerator site were the mean concentration of Fe (across the months) are 191.337± 29.524 mg/L and 1883.667± 364.014 mg/L respectively. Cd had the lowest mean concentration (across the months) 0.547± 0.133 mg/L among the heavy metals found in the soil for control. The concentration of heavy metals at the site shows a relative decrease with distance from the source (Incinerator > Dumpsite> Control). This may be attributed to contamination of soil within the immediate vicinity of the semi-incinerator by ash which could be aided by wind as adopted incinerator has an observable opening due to the corrosion as a result of continuous burning. The semi-incinerator recorded high mean concentrations of heavy metals contents in the three sites across the months.

From Table 2, the result shows the mean concentration of heavy metals in the soil across the month. The months of January- June, it was observed that the mean concentration of Zn, Pb, Cd, Cr, Fe and Mn are 21.587±15.242 mg/L to 26.390±24.005 mg/L, 3.053±2.098 mg/L to 2.493±1.431 mg/L, 0.970±0.450 mg/L to 1.110±0.903 mg/L, 6.313±4.707 mg/L to 6.003±4.326 mg/L, 674.437±850.554 mg/L to 654.570±852.183 mg/L and 10.183±6.496 mg/L to 9.050±6.039 mg/L respectively. Comparing the months studied Fe and Zn recorded higher concentrations among all the heavy metals studied.

Cd had the lowest mean concentration 0.933±0.781 mg/L in month of May. Fe had the highest mean concentration 951.273±1381.665 mg/L in the month of March.

All the heavy metal concentrations in soil were below the World Health Organisation (WHO) maximum allowed limits. The concentrations of heavy metals in these soils are very low compared to that of polluted soils as reported in the research work done by [13,6]. The concentration of heavy metals at the three sites shows a relative decrease with distance from the source (incinerator site> dumpsite > control site) This may be attributed to contamination of soil within the immediate vicinity of the incinerator by ash which could be aided by the wind as the adopted incinerator site has an observable opening due to corrosion as a result of continuous burning. The incinerator site recorded high concentrations of heavy metals studied as compared to dumpsite and the control site which in turn had the least concentrations of heavy metals studied.

3.1 Statistical analysis :

Data obtained were subjected to analysis of variance (ANOVA). A probability ≤ 0.05 was considered as significant.

From Table 1, P values at (probability ≤0.05) of Zn=0, Pb=0, Cd=0, Cr=0, Fe=0 and Mn=0.40897, this indicate that the various site / location have significant effect on the mean concentrations of the various heavy metal except for Mn which has no significant effect on the mean concentration.

From Table 2, P-values at (probability ≤ 0.05) of Zn=0, Pb=0, Cd=0, Cr=0, Fe=0 and Mn=0.1544 were less than 0.005, this indicate that the months have significant effect on the concentration of the various heavy metal concentrations respectively.

4. Conclusion and Recommendation

The results from the site/location were higher than control site, indicating a clear case of pollution. Comparison of heavy metals concentration in soil with WHO maximum allowed limits showed that they are all below the set limits. The soils at the adopted medical incinerator had higher concentration of heavy metals than the soils around the dumpsite. Medical waste when not properly disposed poses serious threat to public health and should be disposed appropriately.

Comparing current study with WHO maximum allowed limits showed that the heavy metals concentrations were below. Appropriate care should be taken to avoid further increase the concentration. This could be done by ensuring the proper ceiling of the adopted incinerator.

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