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Determination of Levels of Heavy Metal in Sub-Soil Around Incinerator in University of Benin Health Centre

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ABSTRACT

Incineration of medical waste (MW) is an important alternative way for disposal of this type of hazardous waste. Samples of soil around adopted incinerator and soil within the health center were collected from University of Benin Health Center and soil samples from Capitol (before UNIBEN Chancellor residence) in the same University of Benin was also collected which served as the control site. These studies were carried out in Benin City, Edo state of Nigeria from January 2017 to December 2017. Samples were analyzed for Zn, Pb, Cd, Cr, Fe, and Mn. Samples were collected between the hours of 4pm to 7pm on Fridays of every week for one year. The mean concentrations of heavy metals (Zn, Pb, Cd, Cr, Fe, and Mn) were determined in the samples. Atomic absorption spectrophotometry was used for heavy metal analysis after digestion using standard methods. The results obtained are: 0.467±0.267mg/kg, 0.0331±0.049mg/kg, 0.003±0.005mg/kg, 0.7251±0.316mg/kg, 12.4761±0.315mg/kg, 0.922±0.073mg/kg for (Zn, Pb, Cd, Cr, Fe and Mn) respectively for the control site, 0.800±0.374mg/kg, 0.133±0.098mg/kg, 0.133±0.098mg/kg, 1.6191±0.737mg/kg, 23.467±0.861mg/kg, 2.465±0.295mg/kg (Zn, Pb, Cd, Cr, Fe, and Mn) respectively for the health center and 1.135±0.281mg/kg, 0.242±0.162mg/kg, 0.023±0.036mg/kg, 2.118±0.881mg/kg, 26.258±1.200mg/kg, 2.465±0.295mg/kg (Zn, Pb, Cd, Cr, Fe, and Mn) respectively for the incinerator site. Data obtained were analyzed using (ANOVA). A probability ¡ 0.05 was considered as significant. P-values at (probability ¡ 0.05) of (Zn - 4.2E-09), (Pb = 0.007809), (Cd - 0.21624), (Cr = 1.05E-07), (Fe - 1.13E-23) and (Mn = 1.44E-15) except for Pb and Cd, others listed were all less than 0.001, this indicates that the various site/location has a significant effect on the mean concentrations of the various heavy metals. While for Pb and Cd, the various site/location had no effects on their mean concentrations. The results from the site/locations were higher than the control site, indicating a clear case of pollution. Comparison of heavy metal 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 concentrations of heavy metals than the soils around the health center. Medical waste, when not properly disposed of, poses a serious threat to public health and should be disposed of appropriately.

Keywords: *Incineration, Medical Waste, Heavy Metal, Concentration*

1 Introduction

Municipal solid waste management is an area of research that has evolved significantly in developed countries over the years unlike what is obtainable in developing countries. Among the constituents of municipal wastes are medical wastes. Standard medical waste management protocol involves 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 on the environment through the release of hazardous combustion products, such as heavy metals, dioxins and PAHs which have environmental and public health implication. This is of great public concern (Thakur *et al.,* 2023; Tait *et al.,* 2020.). Medical waste incineration involves the burning of waste generated by hospital veterinary facilities and medical research facilities which include infectious medical wastes as well as non-infectious general housekeeping waste.

However there is usually contamination of the surrounding environment with the various release from incineration and uncontrolled disposal of ash is a common practice in the country. This leads to pollution in our environment, as a result of the various components contained in them (Kanhar *et al.*, 2020).

Incinerated hospital waste has been found to contain more heavy metals like chromium, cadmium, lead, magnesium, zinc and other metals (Ghobakhloo *et al.,* 2024). Exposure can pose public health problem such as acute respiratory syndromes, gastrointestinal abnormalities and various cancers (Winiarska *et al*., 2024)

Heavy metals are generally defined as metals with relatively high densities (¿5g/cm^3) atomic weights, or atomic numbers (Iroegbulem *et al*., 2023; Iyama *et al*., 2023). The term "Heavy metals" is used to describe more than a dozen elements that are metals or metalloids. Though they are natural constituents of the earth's crust, there are also anthropogenic sources, in small amounts, they enter the human body via food, drinking water and air.

The most common heavy metals found at contaminated sites in order of abundance are Pb, Cr, As, Zn, Cd, Cu and Hg. Medical waste is considered as a source of contamination of land and water. If not rendered harmless before it is buried in land or disposed in water (Adepoju *et al*., 2024). The harmful chemicals from biomedical waste may pollute air, water and land that in turn may cause health problems to the residents (Shabani *et al*., 2024).

Incinerated hospital waste has been found to contain more heavy metals like Chromium, Cadmium, lead, Mercury, Zinc and other metals (Ghobakhloo *et al*., 2024). Acute exposures to high levels cause nausea, 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 (Parui *et al*., 2024)

Soils are the major sink for heavy metals released into the environment by so many anthropogenic activities and most metals do not undergo microbial or chemical degradation and their total concentration in soils persist for a long time after their introduction (Corvalán *et al*., 2024). Heavy metals contamination of soil may pose risks and hazards to humans and the ecosystem through direct ingestion or contact with contaminated soil, the food chain (soil-plant-human or soil-plant-animal-human), drinking of contaminated groundwater e.t.c. (Eigbike *et al*., 2024)

Lead is causing concern in particular due to the possible impacts on children. Lead influences the nervous system by slowing down nerval response (Huang *et al*., 2024). This influences learning abilities and behaviour. Children are exposed to lead right from their birth, as children in the embryonic stage receive lead from their mothers through the blood (Chbihi *et al*., 2024). Children exposed to lead via dust and soil contaminated by deposition from air and other sources. In the environment, lead is known to be toxic to plants, animals and microorganisms. Effects are generally limited to specially contaminated areas (Debroy *et al*., 2024).

Particularly in the renal cortex of the kidneys, cadmium buildup causes renal dysfunction, including poor protein, glucose, and amino acid absorption. Renal tubular injury, or kidney damage, is most likely the major health consequence. (Bautista *et al*., 2024).

Renal stone development and hypercalciuria are other symptoms of the disruption in calcium metabolism. Cadmium is categorized as class 1 by the International Agency for Research on Cancer (IARC). (Milanković *et al*., 2024).

In general, cadmium is more accessible, more mobile in soil, and has a tendency to bioaccumulate. Animal and plant life does not require cadmium. The overall population who does not smoke is primarily exposed to cadmium through diet. Other pathways make up a very minor portion of the total intake. The human body accumulates cadmium, particularly in the kidneys. (Adamo *et al.,* 2024; Nungula *et al*., 2024; and Satarug, 2024)

2 MATERIALS AND METHODS

All chemicals used were of analytical grade and purchased from Pyrex (Nigeria). They included; nitric acid, hydrochloric acid,

2.1 THE STUDY AREA

University of Benin is situated within the Ovia North-East local Government area of Benin City, Edo state Of Nigeria. It lies between the geographical coordinates of longitude 536' and 0.53" E and of latitude 6°20' and 1.32" N.

2.2 SAMPLING LOCATION

Sampling sites used for this study is located within the premises of the University of Benin Health Center facility. An incinerator is made out of the Center's combustion pit. It is approximately 8 feet deep and well protected from ground contamination with concrete walls. It also has a metallic cover to prevent rodents from assessing the wastes in it as well as limit air contamination during wastes combustion. Due to constant burning over the years, the cover has corroded significantly leaving observable opening. Hazardous hospital wastes are usually combusted in this local incinerator during the dry seasons of the year.

2.3 SAMPLING PROCEDURE

Soil samples were collected weekly from around adopted incinerator, soil within the University of Benin Health Center and soil samples from Capitol (before UNIBEN Chancellor residence) in the same University of Benin which served as the control site. Sampling was done from January to December 2017. Composite surface soil samples were collected for the entire sampling duration.

Collected soil samples were wrapped in polyethylene bags and placed in a refrigerator.

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

2.4 SAMPLING PREPARATION

All foreign objects like roots and gravel sized materials were picked and separated from the dried samples. 10g of the samples were weighed into porcelain crucibles using chemical balance and then oven dried at a temperature of 105 °C and 1g was then weighed into a labeled 100ml conical flask (Qiu *et al.*, 2018).

2.5 Cleaning of glassware

All apparatus were washed with detergents then rinsed with distilled water. The glassware was then dried in a hot oven at 105^0C.

2.6 Soil digestion

Well mixed samples of 1g each were weighed using a Scientech Zeta series electronic balance. The samples were put into 250 ml glass beaker and digested with 24 ml of aqua regia and then evaporated to near dryness. The soil samples were then dissolved in 30ml of distilled water, filtered through a 0.45 μm membrane paper and then made up to 100 ml with distilled water prior to AAS analysis (Begum *et al.*, 2009). Duplicate samples were analyzed

The resulting solution 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, at Department of Chemistry Research Laboratory, University of Benin, Benin City, Edo State

3 RESULT AND DISCUSSION

The concentrations of the various heavy metals studied for the duration of the study are presented in Tables 1.1-1.5, and figures 1.1-1.2 below

Results obtained indicate a concentration range of 1.217±0.264 mg/kg to 0.483±0.248 mg/kg for Zn for the duration of the sampling with the highest concentration obtained in the month of March, 0.200±0.276 mg/kg to 0.083±0.041 mg/kg for Pb for the duration of the sampling with the highest concentration obtained in the month of March, 0.037±0.049mg/kg to 0.002±0.004mg/kg for Cd for the duration of the sampling with the highest concentration obtained in the month of March, 2.322±1.140mg/kg to 0.705±0.385mg/kg for Cr for the duration of the sampling with the highest concentration obtained in the month of March, 21.767±7.710mg/kg to 20.050±6.129mg/kg for Fe for the duration of the sampling with the highest concentration obtained in the month of November, 2.582±1.314mg/kg to 1.810±0.713mg/kg for Fe for the duration of the sampling with the highest concentration obtained in the month of November, as seen from table 1.2.

Results from Table 1.1 show that Fe had the highest mean concentration (across the months) of 12.476±0.315 mg/kg and Cd had the lowest, 0.003±0.005 mg/kg among the heavy metals found in soils around the Control. The descending order of metal content was Fe¿Mn¿Cr¿Zn¿Pb¿Cd. Similar trends were observed for the results for Health Centre and incinerator sites in Table 1.1 where the mean concentrations of Fe (across the months) were 23.467±0.861 mg/kg and

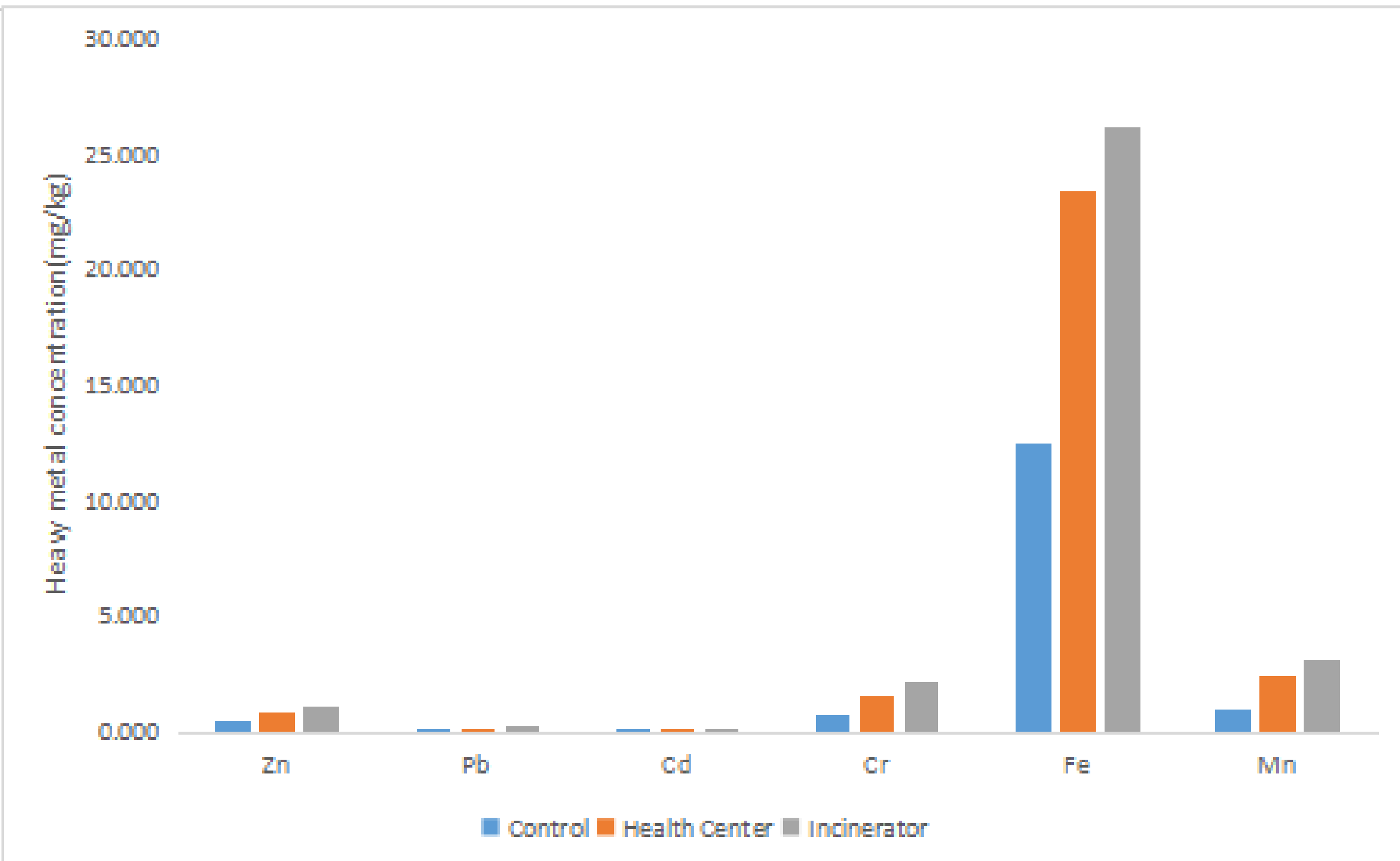

Figure 1: A bar chart showing heavy metal concentration across the three sites

Table 1: Summary of Mean Concentration of Heavy Metals in Soils across the Sites

Parameters	Control	Health Center	Incinerator	WHO Values	p-values
Zn (mg/kg)	0.467±0.267	0.800±0.374	1.135±0.281	300.000	4.2E-09
Pb (mg/kg)	0.033±0.049	0.133±0.098	0.242±0.162	100.000	0.007809
Cd (mg/kg)	0.003±0.005	0.133±0.098	0.023±0.036	3.000	0.21624
Cr (mg/kg)	0.725±0.316	1.619±0.737	2.118±0.881	100.000	1.05E-07
Fe (mg/kg)	12.476±0.315	23.467±0.861	26.258±1.200	-	1.13E-23
Mn (mg/kg)	0.922±0.073	2.465±0.295	2.465±0.295	1000.000	1.44E-15

Table 2: Correlation Matrix for heavy metals at the Control site

	Zn	Pb	Cd	Cr	Fe	Mn
Zn	1					
Pb	-0.046	1				
Cd	-0.046	0.625*	1			
Cr	0.169	-0.706*	-0.694*	1		
Fe	0.413	-0.236	-0.119	0.185	1	
Mn	0.031	-0.546	-0.521	0.454	0.407	1

Table 3: Correlation Matrix for heavy metals at the Health Center

	Zn	Pb	Cd	Cr	Fe	Mn
Zn	1					
Pb	0.049	1				
Cd	0.049	-0.437	1			
Cr	0.261	-0.602*	0.071	1		
Fe	0.333	0.379	-0.057	0.266	1	
Mn	-0.472	0.317	-0.050	0.074	0.247	1

Table 4: Correlation Matrix for heavy metals at the Incinerator

	Zn	Pb	Cd	Cr	Fe	Mn
Zn	1					
Pb	0.679*	1				
Cd	0.466	0.873**	1			
Cr	0.638*	0.895**	0.733**	1		
Fe	0.111	0.000	-0.128	0.179	1	
Mn	0.186	0.020	0.036	0.100	0.782**	1

26.258±1.200 mg/kg respectively and Cd had the lowest, 0.003±0.005 mg/kg among the heavy metals found in soil. The descending order of metal content was Fe¿Mn¿Cr¿Zn¿Pb¿Cd. The concentration of heavy metals at the three sites shows a relative decrease with distance from the source (Incinerator ¿ Health Center ¿ Control). This may be attributed to contamination of soil within the immediate vicinity of the incinerator by ash which could be aided by wind as the adopted incinerator has an observable opening due to corrosion as a result of continuous burning. The Incinerator recorded high mean concentrations of heavy metal contents in the three sites across the months.

From Table 1.2, the result shows the mean concentrations of heavy metals in the soils across the month. In the month of March, it was observed that the mean concentration of Zn, Pb, Cd, and Cr recorded higher concentrations (1.217±0.264 mg/kg, 0.200±0.276 mg/kg, 0.037±0.049 mg/kg and 2.322±1.140 mg/kg) respectively as compared to other months studied while Fe and Mn recorded higher mean concentrations (21.767±7.710 mg/kg, 2.582±1.314 mg/kg) respectively with Fe having the highest mean concentration (21.767±7.710 mg/kg) among all the metals studied. Zn had the lowest mean concentration (0.483±0.248 mg/kg) in the month of October, Pb had the lowest mean concentration (0.083±0.075, 0.083±0.041 mg/kg) in the month of September and October having approximately the same value. Cd had the lowest mean concentration (0.002±0.004 mg/kg) in the month of October, Cr had the lowest mean concentration (0.705±0.385 mg/kg) in the month of April, Fe had the lowest mean concentration (20.050±6.129 mg/kg) in the month of May and Mn had the lowest mean concentrations (1.810±0.713 mg/kg) in the month of September. All the metal concentrations in soil were below the WHO maximum allowed limits (Table 1.1-1.2). The concentrations of heavy metals in these soils were low compared to that of polluted soils as reported in the research work done by Yahaya et al. (2009) and Timothy and Olajumoke (2013). The concentration of heavy metals at the three sites shows a relative decrease with distance from the source (Incinerator

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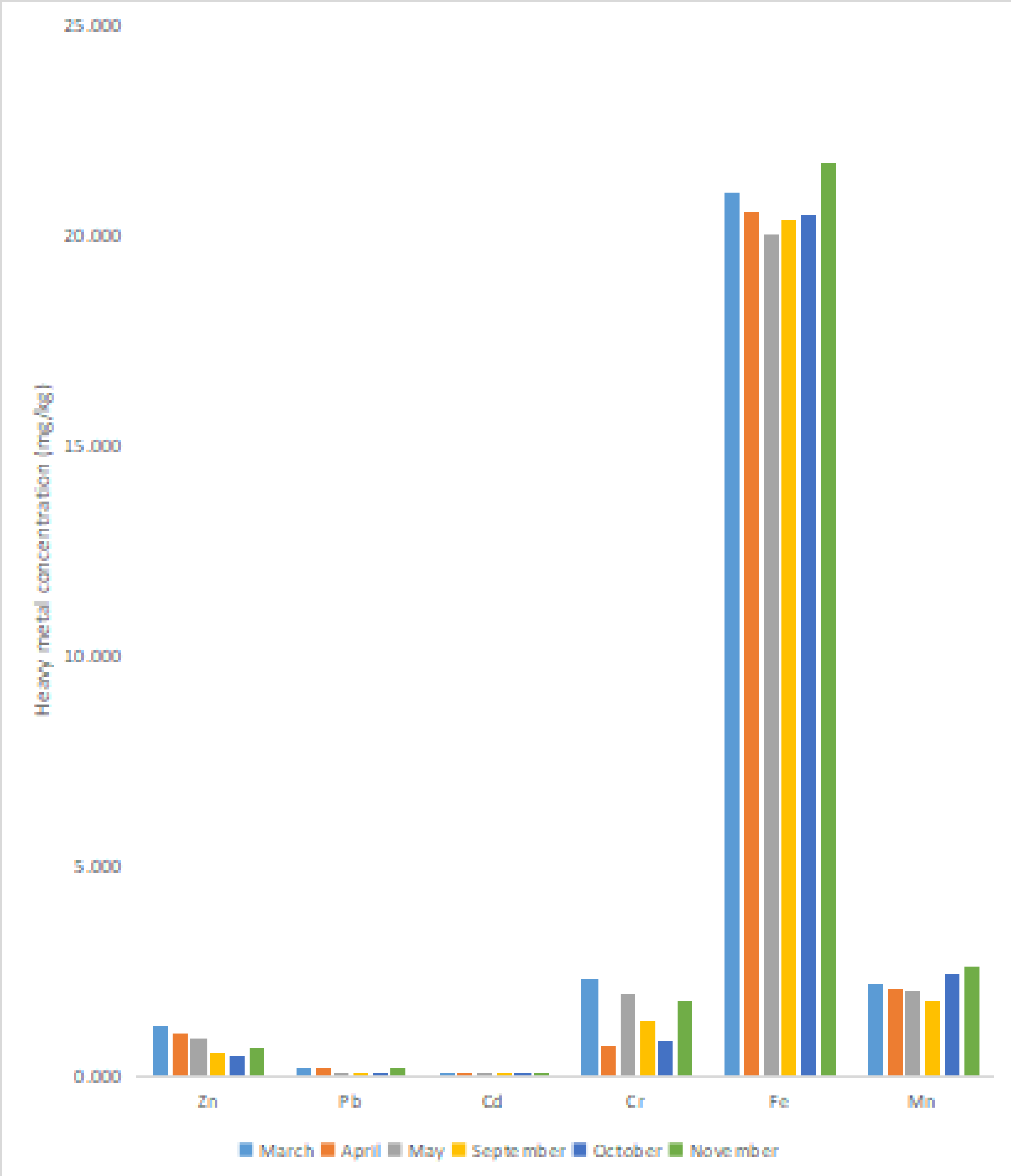

Figure 2: A bar chart showing heavy metal concentrations across the months

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¿ Health Centre ¿ Control). 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 has an observable opening due to corrosion as a result of continuous burning. The Incinerator recorded high concentrations of heavy metals studied as compared to the Health Centre and the control site which in turn had the least concentrations of heavy metals studied.

STATISTICAL ANALYSIS

Data obtained were subjected to analysis of variance (ANOVA). A probability ≤ 0.05 was considered significant. From Table 1.1, P-values at (probability ≤ 0.05) of (Zn =4.2E-09), (Pb = 0.007809), (Cd = 0.21624), (Cr = 1.05E-07), (Fe = 1.13E-23) and (Mn = 1.44E-15) except for Pb and Cd, others listed were all less than 0.001. This indicates that the various sites/location have significant effect on the mean concentrations of the various heavy metals. While for Pb and Cd, the various site/location had no effects on their mean concentrations. From Table 1.2, P-values at (probability ≤ 0.05) of (Zn =4.89E-09), (Pb = 0.303), (Cd = 0.040), (Cr = 7.54E-08), (Fe = 0.010) and (Mn = 0.00027) were all less than 0.005. This indicates that the months have significant effect on the concentration of the various metal concentrations respectively.

From Table 1.3, results of the Correlation Matrix for heavy metals at the control site, *. Correlation is significant at the 0.05 level (2-tailed). Significant positive correlations were observed between Cd and Pb, as Cd concentrations increase, concentrations of Pb also increase while significant negative correlations were observed between Cr and Pb, Cr and Cd, as concentrations of Cr increase, concentrations of Pb and Cd decrease. This indicates that they were from the same source of contamination.

The results from Table 1.4, Correlation matrix for heavy metals at the Health Center *. Correlation is significant at the 0.05 level (2-tailed). Significant negative correlation was observed for Cr and Pb, as the concentrations of Cr increase, concentrations of Pb decrease.

From Table 1.5, the results of the Correlation Matrix for heavy metals at the Incinerator *. Correlation is significant at the 0.05 level (2-tailed). **. Correlation is significant at the 0.01 level (2-tailed). Significant positive correlation was observed between Pb and Zn, Cd and Pb, Cr and Pb, Cr and Cd, Mn and Fe. Significant positive correlation indicates that as one increases the other increases. Significant negative correlation was observed Fe and Cd, negative correlation indicate that as one increases the other decreases.

Conclusion: The results from the sites/locations were higher than control site, indicating a clear case of pollution. Comparison of heavy metal 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 concentrations of heavy metals than the soils around the Health Centre. Medical waste when not properly disposed poses serious threat to public health and should be disposed of appropriately.

RECOMMENDATION

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 in the concentrations as bottom ash could increase the concentrations. This could be done by ensuring the proper sealing of the adopted incinerator.

References

Adepoju, A. O., Femi-Adepoju, A., Jalloh, A., & Faeflen, S. (2024). Soil pollution and management practices. In Environmental Pollution and Public Health (pp. 187-236). Elsevier.

Corvalán Moya, C., Bruni, C., Barbini, A., & Previtali, E. (2024). An analysis of heavy metals movements on soils from places with high level risk of flooding and different anthropogenic activities. J. Mater. Environ. Sci., 15 (1), 162, 178.

Eigbike, C., Odion, N., and Ojo-igbinosa, U. (2024). Assessment of heavy metal contamination of some designated scrap yards in Benin city, Edo State, Nigeria. African Journal of Health, Safety and Environment, 5(1), 01-10.

Ghobakhloo, S., Mostafaii, G. R., Khoshakhlagh, A. H., Moda, H. M., & Gruszecka-Kosowska, A. (2024). Health risk assessment of heavy metals in exposed workers of municipal waste recycling facility in Iran. Chemosphere, 346, 140627.

Ghobakhloo, S., Mostafaii, G. R., Khoshakhlagh, A. H., Moda, H. M., & Gruszecka-Kosowska, A. (2024). Health risk assessment of heavy metals in exposed workers of municipal waste recycling facility in Iran. Chemosphere, 346, 140627.

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Hussain, M.S., Gupta, G., Mishra, R., Patel, N., Gupta, S., Alzarea, S.I., Kazmi, I., Kumbhar, P., Disouza, J., Dureja, H. and Kukreti, N., 2024. Unlocking the secrets: Volatile Organic Compounds (VOCs) and their devastating effects on lung cancer. Pathology-Research and Practice, p.155157.

Iroegbulem, I. U., Egereonu, U. U., Ogukwe, C. E., Egereonu, J. C., Okoro, N. J., & Nwoko, C. I. A. (2023). Assessment of Heavy Metals in Rainwater from Metropolis and Suburbs, Lagos State, Nigeria. International Journal of Environment and Climate Change, 13(9), 831-857.

Iyama, W. A., Nimame, P., Egbunefu, C. O., Nakara, T., Emejuru, S., & Nwagbara, V. U. (2023). Journal of Environmental and Science Education.

Odjugo, P. A. O., et al. (2015). ”Geospatial approach to spatio-temporal pattern of urban growth in Benin City, Nigeria.” African Journal of Environmental Science and Technology 9(3): 166-175.

Parui, R., Nongthombam, G. S., Hossain, M., Adil, L. R., Gogoi, R., Bhowmik, S., ... & Iyer, P. K. (2024). Impact of Heavy Metals on Human Health. Remediation of Heavy Metals: Sustainable Technologies and Recent Advances, 47-81.

Qiu, H., Du, J., Fang, X., & Chen, M. (2018). Differences in Soil Remediation of Ecological Shelterbelt in Taihu Lake. Sustainable Forestry, 1(1), 19-28.

Shabani, T., Mutekwa, V. T., & Shabani, T. (2024). Environmental health risks associated with solid waste management at rural hospitals in Chirumanzu District, Zimbabwe. SN Social Sciences, 4(2), 20.

Thakur Palak, Anchal Thakur, Samriti Gautam, Jagdish Choudhary, Ruchika Kumari, Kirti Raina, Rohit Sharma, Ashun Chaudhary (2023). “Occurrence and formation of environmentally persistent free radicals in incineration and their impact on soil and water”. Journal of Geochemical Exploration 252, 107264

Timoithy, A. and A. M. Olajumoke (2013). ”Heavy Metal Concentrations around a Hospital Incinerator and a Municipal Dumpsite in Ibadan City, South-West Nigeria.” J. Appl. Sci. Environ. Manage 17(3): 419-422.

Winiarska, E., Jutel, M., & Zemelka-Wiacek, M. (2024). The potential impact of nano-and microplastics on human health: Understanding human health risks. Environmental Research, 118535.

Yahaya, M. I., et al. (2009). ”Seasonal Variations of Heavy Metals Concentration in Abattoir Dumping Site Soil in Nigeria.” J. Appli. Sci. Environ. Manage. 13(4): 9-13.

Zhao, L., et al. (2010). ”Typical pollutants in bottom ashes from a typical medical waste incinerator.” Journal of Hazardous Materials 173(1–3): 181–185.

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Appendix

Various concentrations of Zn

—c—c—c—c—c—c—c—

Months **March** **April** **May** **Sept** **Oct** **Nov**

Control 1.00 0.70 0.40 0.20 0.30 0.20
0.80 0.60 0.60 0.30 0.30 0.20

Health center 1.30 1.20 1.00 0.50 0.40 0.60
1.30 1.10 0.90 0.60 0.30 0.40

Incinerator (around) 1.50 1.40 1.30 0.70 0.80 1.20
1.40 1.22 1.20 0.80 0.80 1.30

Various concentrations of Pb

—c—c—c—c—c—c—c—

Months **March** **April** **May** **Sept** **Oct** **Nov**

Control 0.00 0.10 0.00 0.00 0.10 0.00
0.00 0.10 0.00 0.00 0.00 0.10

Health center 0.00 0.30 0.10 0.10 0.10 0.20
0.10 0.30 0.00 0.10 0.10 0.20

Incinerator (around) 0.50 0.20 0.20 0.10 0.10 0.20
0.60 0.10 0.30 0.20 0.10 0.30

Various concentrations of Cd

—c—c—c—c—c—c—c—

Months **March** **April** **May** **Sept** **Oct** **Nov**

Control 0.00 0.01 0.00 0.00 0.01 0.01
0.00 0.01 0.00 0.00 0.00 0.00

Health center 0.01 0.00 0.00 0.00 0.01 0.00
0.01 0.00 0.00 0.00 0.01 0.00

Incinerator (around) 0.10 0.01 0.00 0.01 0.01 0.01
0.10 0.00 0.01 0.01 0.01 0.00

Various concentrations of Cr

—c—c—c—c—c—c—c—

Months	**March**	**April**	**May**	**Sept**	**Oct**	**Nov**
Control	1.01	0.32	1.00	1.00	0.30	0.72
	1.00	0.37	1.01	0.97	0.30	0.70
Health center	2.40	0.61	2.37	1.30	0.97	2.11
	2.42	0.57	2.40	1.31	0.97	2.00
Incinerator (around)	3.54	1.20	2.50	1.57	1.31	2.58
	3.56	1.16	2.53	1.59	1.29	2.59

Various concentrations of Fe

—c—c—c—c—c—c—c—

Months	**March**	**April**	**May**	**Sept**	**Oct**	**Nov**
Control	12.80	12.40	12.20	12.70	12.90	12.20
	13.01	12.20	12.40	12.50	12.40	12.00
Health center	24.20	23.70	22.60	23.30	22.40	24.40
	24.50	23.80	22.50	23.00	22.50	24.70
Incinerator (around)	26.10	25.80	25.20	25.50	26.60	28.70
	25.80	25.60	25.40	25.30	26.50	28.60

Various concentrations of Mn

—c—c—c—c—c—c—c—

Months	**March**	**April**	**May**	**Sept**	**Oct**	**Nov**
Control	1.02	0.77	0.91	0.91	0.95	0.96
	1.00	0.80	0.93	0.90	0.96	0.95
Health center	2.24	2.41	2.39	2.10	2.55	2.97
	2.27	2.38	2.43	2.13	2.72	2.99
Incinerator (around)	3.24	3.12	3.00	2.42	3.75	3.82
	3.25	3.08	2.59	2.40	3.75	3.80

ANOVA

Zn

SoV	SS	df	MS	F	P-valu	F crit
Locations	2.696056	5	0.539211	25.71209	4.2E-	2.602987
Months	2.656056	5	0.531211	25.33061	4.89E-	2.602987
Error	0.524278	25	0.020971			
Total	5.876389	35				

Pb

SoV	SS	df	MS	F	P-val	F crit
Locations	0.268056	5	0.053611	4.058032	0.0078	2.602987
Months	0.084722	5	0.016944	1.28259	0.302	2.602987
Error	0.330278	25	0.013211			
Total	0.683056	35				

Cd

SoV	SS	df	MS	F	P-valu	F crit
Locations	0.002981	5	0.000596	1.53067	0.216	2.602987
Months	0.005381	5	0.001076	2.763195	0.040	2.602987
Error	0.009736	25	0.000389			
Total	0.018097	35				

Fe

SoV	SS	df	MS	F	P-val	F crit
Locations	1274.29	5	254.8581	453.1056	1.13E	2.602987
Months	10.95335	5	2.190669	3.894735	0.009	2.602987
Error	14.06174	25	0.562469			
Total	1299.305	35				

Mn

SoV	SS	df	MS	F	P-value	F crit
Locations	32.11669	5	6.423338	97.45652	1.44E-15	2.602987
Months	2.372556	5	0.474511	7.199404	0.00027	2.602987
Error	1.647744	25	0.06591			
Total	36.13699	35				

Cr

SoV	SS	df	MS	F	P-value	F crit
Locations	11.96103	5	2.392205	18.57903	1.05E-07	2.602987
Months	12.38289	5	2.476578	19.23431	7.54E-08	2.602987
Error	3.218958	25	0.128758			
Total	27.56288	35				