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HEAVY METAL POLLUTION POTENTIAL IN SOILS AROUND A REFUSE DUMPSITE LOCATED IN JATTU, EDO STATE, NIGERIA

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ABSTRACT: *The concentration of the heavy metals, Copper, Chromium, Lead, Nickel and Cadmium was determined using the Atomic Absorption Spectrometer (AAS). This was to ascertain the level of their contributory pollution effect on the soils around a refuse dumpsite located in Jattu, Etsako west local government area of Edo state, Southern Nigeria. Samples were obtained at the centre of the dumpsite and at lateral intervals of 50meters, and 100meters away from the centre of the dumpsite in the North, East and West directions and at 0-15cm and 15-30cm vertical intervals at each of the sampled points. The results obtained were subjected to a one-way analysis of variance (ANOVA) statistical treatment at $P < 0.05$ at 95% confidence level. Results show that there was significant decrease from top soil to subsoil within the dumpsite and as well as a corresponding decrease at each sampled point laterally at 50meters and 100meters away from the centre of the dumpsite. The concentration of the heavy metals in the soils was in the order Ni > Cu > Pb > Cr > Cd. Concentration values for copper ranged between 0.70mg/kg and 1.78mg/kg, while values for chromium were between 0.11mg/kg and 0.42mg/kg. Recorded value for lead was between 0.08mg/kg and 0.90mg/kg in the study area. Also, Nickel had a concentration value of between 3.76mg/kg and 8.54mg/kg and Cadmium concentration value ranged from 0.07mg/kg to 0.19mg/kg. In Comparism of the heavy metals concentrations from this study with the Department of Petroleum Resources (DPR) target and intervention values (2002) guideline, all the concentration values obtained in this study were below the target and intervention values of the Department of Petroleum Resources guideline. Results from the Analysis of variance and the correlation analysis both suggests that the metals are not site dependent and are therefore of similar origin. Results for the relative pollution potential of the investigated heavy metals gave positive values for all the metals at all sampled points, indicating that the soils were contaminated at the point of impact, which is at the dumpsite.*

KEYWORDS: Heavy Metals, Analysis of Variance, Pollution Potential, Target and Intervention Value, Dumpsite.

INTRODUCTION

Waste handling facilities are lacking in most highly populated areas in many developing and undeveloped countries due to cost and lack of enforcement of relevant laws and edicts on waste disposal and management. Lack of organized land fill site contribute to the presence of dumpsite within living areas in developing nations, this results in discharge of household sewage and refuse into the environment untreated (Abdu-Salam et al, 2011).

Specifically, heavy metals are naturally occurring elements that have a high atomic weight and a density at least 5 times greater than that of water (Jarup, 2003). Some heavy metals are either essential nutrients (typically iron, cobalt, and zinc), or relatively harmless (ruthenium); but can be toxic in larger amounts or in certain forms. Other heavy metal such as cadmium, mercury, and leads are highly poisonous. Potentials sources of heavy metals poisoning include mining, tailings, industrial waste, agricultural runoff, paints and treated timber. This research is focused on the evaluation of the distribution of some heavy metals in a waste dumpsite located in Jattu, Etsako West Local Government Area, Edo State, Nigeria.

LITERATURE REVIEW

Heavy metals and persistent organic pollution are of concern due to their potential harmful effects to humans and the environment. Wong et al, (2002) showed that heavy metals are potentially toxic to crops, animals and humans when contaminated soils are used for crop production. Pollution of the biosphere with heavy metals induced by industrial, agricultural and domestic activities posses' serious problems for safe use of agricultural land (fytianos et al, 2001). Similarly, other researcher has reported elevated levels of heavy metals in different types of contaminated soils, (Iwegbue et al, 2013).

The proliferation of open and unsafe dumpsites containing multiple deposits of domestic, municipal industrial and medical waste is common practice in most cities in Nigeria. These dumpsites have become feeding ground for diseased breeding animals especially rats, birds, and stray animals, thereby contributing greatly to their nourishment and growth. This posses a great challenge to the well being of city residents, particularly to those living adjacent to dumpsite due to the potential of the contamination of the waste to their sources of water, land, vegetation, and air. The improper disposal and handling of waste thus lead to environment degradation, destruction of the ecosystem and may cause great risk to public health. The resultant accumulation of waste poses a health hazard to urban habitant and also threatens the surrounding environment (UNEP, 2005).

METHODOLOGY

Study Area

This experimental study was conducted and carried out in and around a refuse dumpsite located in Jattu. It is situated close to Jattu market at Uzairue in Estako West local government area of Edo state, Nigeria. Its geographical coordinates are latitude 7^0 05' 0'' North and longitude 6^0 17' 0'' East.

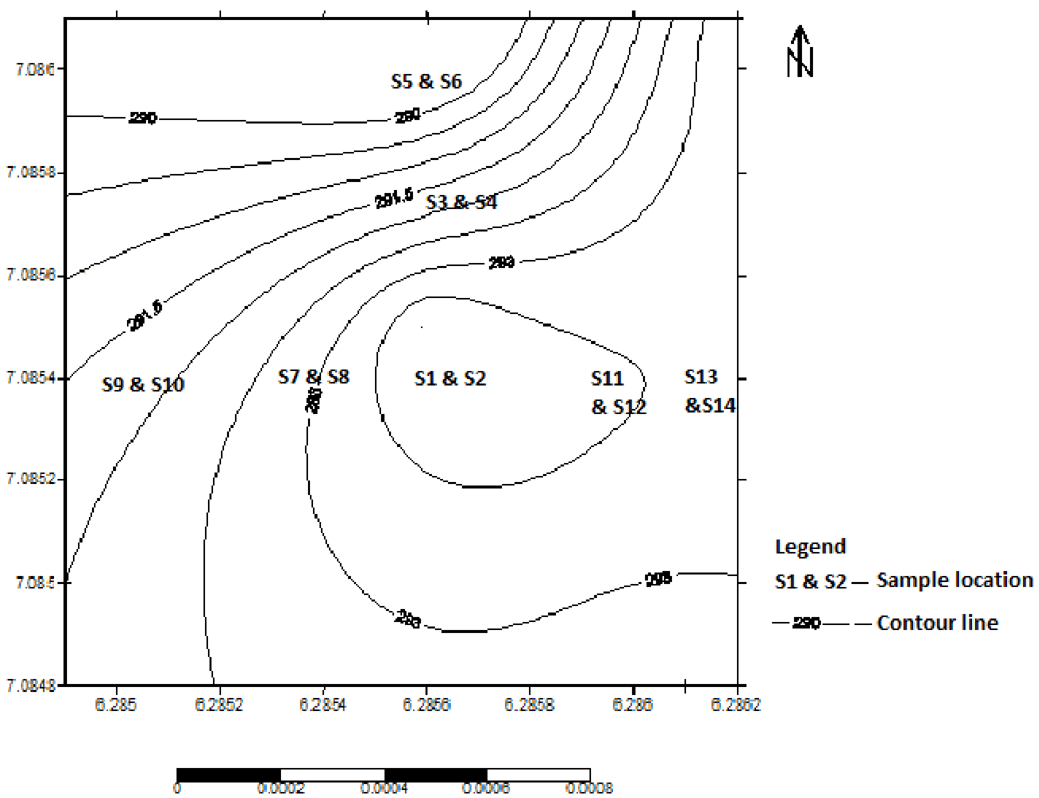

Figure 1: Topographical Map Showing the Study Location and the Sampling Points.

Source: Authors, 2020.

The study location lies within the Ajali formation of the Anambra basin. It is maestrichtian in age and consists of fine to coarse, poorly to moderately sorted, angular to sub-angular and friable sandstone with sparse cement of white clay and cross beddings, (Reyment, R. A. 1965).

Samples Collection and Analysis

The Field sample collection was preceded by a reconnaissance of the area to establish, the location and its boundary extent. This was then followed by a detailed geological survey of the study area. A total of 14 samples were collected in all at 0-15cm and 15-30cm vertical depth and same at 50m and 100m vertical distance away in the north, west and east directions. The equipment used for samples collection includes Hand auger, measuring tape, Global Positioning System (GPS) and polyethylene bags were used for storage of samples for onward transmission to the laboratory for relevant analysis.

The soil samples were obtained with a hand auger starting from top soil between depths of 0-15cm and 15-30cm vertical intervals at the centre of the dumpsite designated as point 0. This sampling procedure was repeated at 50m and 100m away from the centre of the dumpsite in the north, east and west directions so as to properly establish the source direction of the

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targeted heavy metals. The sample were then collected and stored in plastic bags, and properly labeled before transporting them to the laboratory for further analysis.

Laboratory analysis procedure includes air drying of the soil samples for three days and then removing large debris, stones and plant remains by hand picking while; soil lumps were grinded in an agate mortar and pestle to achieve homogeneity. The ground soil samples were sieved through a 2mm nylon sieve. With the aid of an electrical weighing balance, 0.5g of each sample was weighed and put into a conical flask, after which 10ml of Nitric acid (HNO_3) and 5ml of parchloric acid ($HClO_4$) was added for digestion. The mix was then heated for 50 minutes on an electrical heater till a colour change to white was observed. After this, the whole solution was allowed to cool for 30minutes, after which 20% dilute Hydrochloric acid (HCl) was added. The content was then filtered into a 100ml container. The content was properly mixed by shaking. Distilled water was then added to dilute it to volume as recommended by (Allen, et al, 1974). The Atomic Adsorption spectrophotometer (AAS) MODEL Solaar 969 unicam series with Air acetylene flame was used in determining the elemental composition of metals in the sample under investigation. This method was chosen because of the aim of the analysis which is to determine the elemental composition of the soil samples, (Helaluddin, et al, 2016).

RESULTS

The analytical results were subjected to Analysis of Variance (ANOVA) with Scheffe post hoc test and the student t-test were used for the statistical analyses of the results obtained at 95% confidence level using Dunca Multiple Range SPSS. The statistical results for this work are presented below. Table 1 shows the variation of the concentration of the heavy metals with distance as one move away from the centre of the dumpsite as well as variation with vertical distance of 0-15cm and 15-30cm at each sampling point.

Table 1: Showing the Effect of Distance and Depth of Soil on the Concentration of Heavy Metals in and Around the Dumpsite.

Sampling Point	Depth	Copper	Chromium	Lead	Nickel	Cadmium
	Cm	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
POINT 0	0 – 15	1.78	0.42	0.90	8.54	0.19
POINT 0	15 – 30	1.12	0.34	0.31	5.93	0.12
NORTH 50M	0 – 15	1.59	0.29	0.33	6.39	0.16
NORTH 50M	15 – 30	0.89	0.16	0.22	4.22	0.08
NORTH 100M	0 – 15	1.38	0.39	0.32	5.92	0.08
NORTH 100M	15 – 30	0.83	0.26	0.09	4.31	0.07
EAST 50M	0 – 15	1.47	0.41	0.40	7.76	0.17
EAST 50M	15 – 30	0.95	0.37	0.14	5.63	0.14
EAST 100M	0 – 15	1.59	0.33	0.37	7.91	0.15
EAST 100M	15 – 30	0.85	0.24	0.08	5.45	0.13
WEST 50M	0 – 15	1.31	0.20	0.38	7.07	0.14
WEST 50M	15 – 30	0.88	0.14	0.27	4.78	0.09
WEST 100M	0 – 15	1.12	0.14	0.11	4.94	0.10
WEST 100M	15 – 30	0.70	0.11	0.08	3.76	0.07

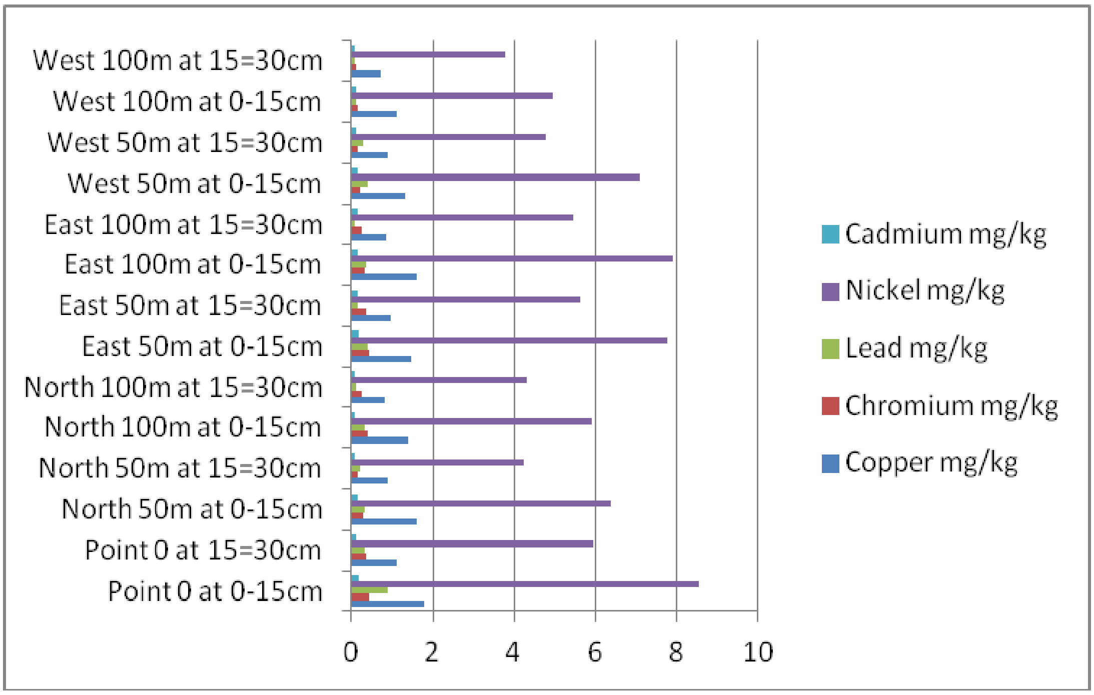

Figure 2: Bar Chart Showing the Effect of Distance and Depth of Soil on the Concentration of Heavy Metals in and Around the Dumpsite.

The guidelines of the department of petroleum resources (DPR) target and intervention values for metals in soil (2002) employed for this research work is presented in table below.

Table 2: Department of Petroleum Resources (DPR, 2002) Target and Intervention Values for Metals in Soil

Metals	**Target value**	**Intervention value**
Cd	0.8	17
Cr	100	380
Cu	36	190
Pb	85	530
Ni	35	210
Zn	140	720
Mn	850*	-
Fe	4.7**	-

**Derived from crustal abundance value. ** Value in %. Modified after Iwegbue, et al (2013).*

Table 3 shows the lateral distribution of the heavy metals in soils 50m away from the centre of dumpsite in all sampled direction, while Table 4 is a table of the relative pollution potentials of the heavy metals under investigation as computed after (Egharevba and Odjada, 2002).

Given: $Y = \frac{A-B}{A}$

Where Y = Relative Pollution Potential.
A = Metal concentration at impacted point.
B = Metal concentration at point away from the impacted point.

Table 3: Lateral Distribution of the Heavy Metals in Soils 50m Away from the Centre of Dumpsite in all Sampled Directions.

Metals	Sampled Point/Direction	Point of Impact (A)	50m Away (B)
Cu	North	1.78	1.59
	East	1.78	1.47
	West	1.78	1.31
Cr	North	0.42	0.29
	East	0.42	0.41
	West	0.42	0.20
Pb	North	0.90	0.33
	East	0.90	0.40
	West	0.90	0.38
Ni	North	8.54	4.22
	East	8.54	7.76
	West	8.54	7.07
Cd	North	0.19	0.16
	East	0.19	0.17
	West	0.19	0.14

Table 4: Relative Pollution Potentials of the Heavy Metals under Investigation.

Sampled Points/Direction	Copper	Chromium	Lead	Nickel	Cadmium
North	0.11	0.31	0.63	0.51	0.16
East	0.21	0.02	0.55	0.09	0.11
West	0.26	0.52	0.58	0.17	0.26

Table 5: A Summary of One-Way Analysis of Variance (ANOVA) Carried Out for the Different Heavy Metals at Different Sampling Points.

Element	Source of Variation	SS	DF	MS	P	F
Copper	Bet ss	364.3665	13	28.0282	0.9999	0.1088
	With ss	3607.743	14	257.6959		
	Total	3972.109	27			
Chromium	Bet ss	389.6264	13	29.9713	0.9999	0.1088
	With ss	3856.792	14	275.4852	0.9998	0.1087
	Total	4246.418	27			
Lead	Bet ss	381.8949	13	29.3765	0.9999	0.1065
	With ss	3860.516	14	174.6507		
	Total	4242.411	27			
Nickel	Bet ss	299.6055	13	23.0467	0.9996	0.1320
	With ss	2445.11	14	174.6507		
	Total	2744.715	27			

Cadmium	Bet ss With ss Total	391.5851 3901.762 4293.347	13 14 27	30.1220 278.6973	0.9999	

Table 6: Correlation Matrix for the Heavy Metals within the Study area.

	Copper	Chromium	Lead	Nickel	Cadmium
Copper	1				
Chromium	0.661427	1			
Lead	0.815138	0.572647	1		
Nickel	0.905015	0.723858	0.809668	1	
Cadmium	0.766796	0.628345	0.687800	0.890682	1

DISCUSSION

A study of the distribution and accumulation of heavy metals in soils is very important especially in a developing country like Nigeria due to the fact that there are no proper waste management guidelines and procedures in place and where there are, these guidelines are not properly or well implemented and so all manner of indiscriminate dumping of refuse takes place on a daily basis unrestricted. The sampling site for this study was considered as it plays hosts to the biggest market in the whole of the Edo north district and is located right at the heart of residential dwellings. Not much data on soil heavy metal content is available in this part and considering the complex, porous nature of soil in retaining and releasing pollutant into the groundwater (Liu et al, 2006). This work aims to study the heavy metal content around the vicinity of the dumpsite and objectively study how they are distributed vertically and horizontally in the soil and assess anthropogenic contributions associated with it if any.

The influence of lateral distance and depth of soil on the concentration of heavy metal in and around the study site is presented in table 1. The metal, copper had a concentration of 1.78mg/kg at the centre of the dumpsite (point 0) at 0-15cm vertical interval and 1.12mg/kg at 15-30cm vertical distance at the centre of the dumpsite. At a distance of 50m away from the centre of the dumpsite in the north direction, Copper concentration values were 1.59mg/kg at 0-15cm vertical interval and 0.89mg/kg at 15-30cm depth. Similarly, at a distance 100m from the centre of the dumpsite in the north direction, copper concentration values were 1.38mg/kg at 0-15cm interval and 0.83mg/kg at 15-30cm vertical depth. This reflects a decrease in concentration values of the investigated heavy metal both vertically and horizontally across sampled points in this study. A similar reduction in heavy metal concentration with distance, laterally and vertically was recorded in other sampled points in the north, east and west directions for chromium, Lead, Nickel and Cadmium metals.

Concentration values for copper ranged between 0.70mg/kg-1.78mg/kg as against DPR target value of 36mg/kg. Values for chromium were between 0.11mg/kg-0.42mg/kg. Target value for chromium in soil is 100mg/kg. Recorded value for lead was between 0.08mg/kg-0.90mg/kg in the study area as against a target value of 85mg/kg for lead. Nickel had a concentration value of between 3.76mg/kg-8.54mg/kg and a target value of 35mg/kg. Also, Cadmium concentration value ranged from 0.07mg/kg to 0.19mg/kg and its target value from the DPR standards is 0.8mg/kg. In Comparism of the heavy metals concentrations from this study with the Department of Petroleum Resources (DPR) target and intervention values (2002) in table 2, it can be seen that all the values obtained in the study are below the target and intervention values of the DPR guidelines and so suggest that there isn't much cause for concern for now regarding their concentration the soils in the vicinity of the studied location.

According to Ololade, A.I. (2014) and Zou, et al. (2015), correlation can reflect association between elements and similarity of their population sources. From table 6, which is a correlation matrix for the investigated heavy metals, it is seen that there is a strong positive correlation among the different heavy metals investigated, indicating similar association of source or origin.

Analysis of variance to determine the significant difference existing between the heavy metals investigated at different sampled points was carried out. Sources of variance between different sampled locations for each of the metals was evaluated based on the sum of squares between different sampling points (bet ss) and the sum of squares within the different sampling points (with ss) as well as total sum of squares (Total ss), Mafuyai, et al, (2015). The analysis showed that differences exist significantly in the mean value for all the elements investigated across all sampled points (0.94-2.36). The P-values were between (0.9996-0.9999), much higher than a significance level of (0.05). This implies there is significant difference in the mean values. This would suggest a similar origin for the elements investigated and that they are not site dependent but likely of anthropogenic source. This further corroborates the result of the correlation matrix.

Results for the relative pollution potential of the investigated heavy metals gave positive values for all the metals at all sampled points, an indication that the soils were contaminated at the point of impact, (Osakwe, 2014).

CONCLUSION

The results of the research show that all the concentration value for all metals investigated in this study were lower than the target and intervention value of the department of petroleum resources guidelines used for this study. Results from the Analysis of variance and the correlation analysis both suggests that the metals are not site dependent and are therefore of similar origin or source, and in this case brought about as a result of anthropogenic activity of refuse dumping at the dumpsite. Results for the relative pollution potential of the investigated heavy metals gave positive values for all the metals at all sampled points, indicating that the soils were contaminated at the point of impact, which is at the dumpsite, that is, the contamination of the soils at the sampled points are actually from the dumpsite.

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