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Evaluation Of The Distribution Of Some Heavy Metals In A Waste Dumpsite Located In Aviele, Edo-State, Nigeria

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***Abstract:** A study of the concentrations of the heavy metals (Copper, Chromium, Lead, Nickel, Arsenic and Cadmium) was undertaken at a dumpsite located in Aviele, Edo State, Nigeria, to determine the concentration of the heavy metals in the soils around the site. The results from the analysis were compared to the world health organization standards (2004) to ascertain the levels of their contributory pollution effect on the environment. Sampling was done at vertical intervals of 0-15cm and 15-30cm and at a horizontal distance of 0m, 50m and 100m away from the center of the dumpsite. The Atomic Absorption Spectrometer (AAS) was used for the analysis. 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 at distances away. From the results, it is seen that the heavy metals were from same anthropogenic source. The concentration of the heavy metals in the soils was in the order Ni > Cu > Pb > Cr > Cd > As .All the concentrations of heavy metals in the sampled soil were higher than threshold values used for-this work and as such renders the soils unusable unless a level of remediation is first carried out on it.*

***Keywords:** Heavy metals; Concentration; Dumpsite.*

I. INTRODUCTION

Population explosion has led to a very large quantities of solid waste being generated from various household, industrial and commercial activities on a daily basis and if not well managed can result in a serious environmental and health impact on the populace.

The environmental impact of solid waste sewage sludge and contaminated sediments are greatly influenced by their heavy metals content. Assessment of the kind or type of heavy metals present in the soil enables the evaluation of the metal bioavailability and the tendency of the suitability of the decomposed waste as compost or cover material (Usman, 2012). Hence the need to carry out research to determine the concentration of heavy metals in the soils of dumpsites as a high occurrence of concentration of these heavy metals in soil is undesirable for the intended land use. According to Bowen (1977), many of the heavy metals have long residence time between 1000-3000 years in temperate regions of the world. Generally, soil react much slowly to external influences than water and air as it is able to bind substances into complexes; this is carried out mainly with the help of clay mineral and humic acids which are capable of binding ions shallowly. In this process, soils accumulate both organic and inorganic substances and acts as a nutrient reservoir for plants and micro-organisms (Bloemen *et al*, 1995).

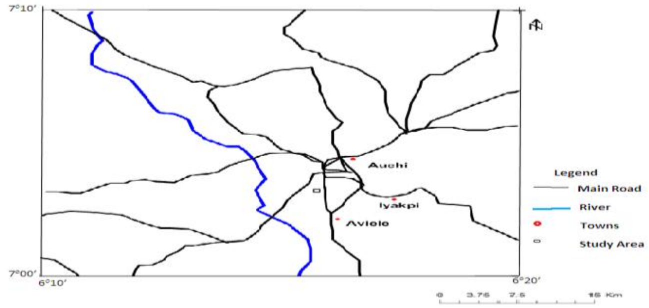
Heavy metals are those metals with densities greater than 5gm/cm^3, (Rodier, 1975). Some of the known metals are Vanadium(V), chromium (Cr), iron (Fe), cobalt(co), Nickel (Ni) mercury(Hg) copper(Cu) zinc (Zn) lead (Pb) silver(Ag), Cadmium (Cd), uranium(u) among others, out of these metals mentioned above a few of them are very important in environmental studies and they include, Mercury (mg), lead(Pb), copper(Cu) Nickel (Ni), chromium (Cr) vanadium (v), cadmium(Cd) zinc (Zn) and iron (Fe). Some of these heavy metals when present in trace amount are beneficial. Ingestion of or exposure to excess quantities is always toxic. However insufficient amounts in plants cells or animals tissue can lead to disease condition, (Murray *et al*, 2009).

It is important to note that not all heavy metals are specifically toxic as some are essential such as iron, which means some metals are toxic and also harmful to health and are known as toxic heavy metals. Some of these metals are useful in body metabolism when taken in beneficial or small doses.

Sources of these heavy metals are released through mining and industrial activities; where effluents are not properly treated before they are released into environment in streams and rivers. Others are by burning of fossils fuels like coal, environmental waste, burning of refuse and by applying fertilizer. According to Brown, (1998), heavy metals can also be released into the environment though pest control activities and from exhaust fumes of automobiles and other industrial plants and activities such as production of paints, thermometers, soldering materials, batteries, cable coverings, ammunitions, pencils, plastics, x-ray shields, crystal glass production and thinners.

Waste handling facilities are lacking in many high populated areas in most 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 (Abdus-salam *et al*, 2011). Heavy metals and persistent organic pollution is of concern due to their potential harmful effects to humans and the environment. Wong et al, (2002) in their work supported the fact 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).

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). Furthermore, the random, deposition of these waste, consequently lead to adjacent land getting enriched in traces of heavy metals. Thus dumpsite soils eventually become the repository for heavy metals. Heavy metals once introduced to the environment by one particular method may spread to various environmental components which may be caused by the nature of interaction occurring in this particular natural substances, which may increase or decrease mobility, (Bukar *et al*, 2012). In some dumpsites, wastes are burnt in the open and ashes abandoned at the sites, with no regards to the environmental implications. The burning of waste gets rid of the organic materials and oxidizes the metals, leaving the ash richer in the metal contents. After the processes of oxidation and corrosion, these metal gets dissolved in rain water and are then relocated into soil from where they are picked up by growing plants thereby entering the food chain (Harrison and Chirgrawi 1989, Benson and Ebong, 2005). Studies done on soil at dump site shows that the soils contain different kinds and concentration of heavy metal depending on the age, contents and location (Udosen, *et al*, 1990). This research work is focused on determining the levels of Arsenic (As), Lead (Pb), Cadmium (Cd), Copper (Cu), Chromium (Cr), and Nickel (Ni) present in the soils around the refuse dumpsites located at Aviele near Auchi, with a view to compare the relative levels of the concentration and distribution in the soil around the dumpsites.



Source: Authors, 2018.

Figure 1: Map of Study Area

II. MATERIALS AND METHODS

The study was conducted at and around a major refuse dumpsite located in Aviele, Edo state. Aviele is a gateway town to Auchi when coming from Benin City. Geologically, the area belongs to the Ajali Formation of the Anambra basin. The formation is maestrichtian in age and has a thickness of about 400-450m. It extends from Ajali River in Enugu area to part of Edo North as well as Northern parts of Delta state. Ajali formation consists of fine to coarse, poorly to moderately sorted, angular to sub-angular and friable sandstone with sparse cement of white clay. It is characterized by cross beddings and it is generally overlain by considerable thickness of red earth formed by direct weathering of formation.

Fourteen (14) samples were collected within and around the dumpsite. Sampling was done at vertical intervals of 0-15cm, 15-30cm and horizontal distances of 50m and 100m away from the centre of the dumpsites. The soil samples were collected with the aid of hand auger, trowel and were carefully labeled and stored in polythene bags before being taken to the laboratory where they were air dried for three (3) days. The

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soil samples were then grinded in an agate mortar and sieved through a 2mm sieve. Using an electrical weighing, 0.5g of each sample was weighed and put into a conical flask and 10ml of HNO_3, 5ml of $HClO_4$, and 5ml of HF was added. The mix was then heated for about an hour in a fume cupboard and observed for a colour change to white. The whole solution was allowed to cool down for 30 minutes, after 20% dilute HCl was added. The contents then filtered into a 120ml container, with distilled water added to make up the volume according to Allen, *et al* (1974). The content was properly mixed. The concentrations of the heavy metals; Arsenic (As), Lead (Pb), Cadmium (Cd), Copper (Cu), Chromium (Cr), and Nickel (Ni) were determined with the aid of the Atomic Absorption Spectrophotometer (AAS), model Solaar 969 Unicam Series with Air Acetylene flame.

III. STATISTICAL ANALYSIS

An analysis of variance (ANOVA) was carried out on the results obtained to determine if there were significant differences between the metals assessed using the SPSS software at $P < 0.05$ (95%) confidence level. A correlation of the heavy metals was also carried out in order to ascertain if the metals assessed are from similar source.

IV. RESULTS AND DISCUSSION

The analytical results were further 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 and discussions for this work are presented below.

Sampling Points	**Depth (cm)**	**Copper**	**Chromium**	**Lead**	**Nickel**	**Arsenic**	**Cadmium**
		mg/kg					
POINT 0	0 - 15CM	3.03	0.86	1.13	12.54	0.06	0.41
POINT 0	15 - 30CM	2.56	0.74	0.97	10.33	0.05	0.32
NORTH 50M	0 - 15CM	2.12	0.59	0.73	7.44	0.03	0.25
NORTH 50M	15 - 30CM	1.71	0.51	0.61	6.08	0.02	0.20
NORTH 100M	0 - 15CM	2.71	0.72	0.97	9.60	0.04	0.33
NORTH 100M	15 - 30CM	2.23	0.62	0.73	7.92	0.03	0.27
EAST 50M	0 - 15CM	2.66	0.74	1.01	9.84	0.04	0.33
EAST 50M	15 - 30CM	1.79	0.53	0.62	6.24	0.02	0.21
EAST 100M	0 - 15CM	2.30	0.64	0.70	9.24	0.04	0.28
EAST 100M	15 - 30CM	1.78	0.52	0.59	6.92	0.03	0.20
WEST 50M	0 - 15CM	2.43	0.68	0.90	10.20	0.05	0.40
WEST 50M	15 - 30CM	1.87	0.54	0.67	8.11	0.03	0.30
WEST 100M	0 - 15CM	1.52	0.41	0.49	6.72	0.03	0.25
WEST 100M	15 - 30CM	1.07	0.33	0.31	4.72	0.02	0.18

Table 1: Shows the various concentrations of heavy metals under investigation in and around the refuse dumpsite

Samples from the Aviele dumpsites show that copper had values of between 1.07mg/kg to 3.03mg/kg. These values exceed the safe limit for copper in soils as recommended by the world health organization, used for this work. Chromium has value range of 0.33mg/kg to 0.86mg/kg. The threshold value for chromium recorded is above the permissible limit of 0.1mg/kg. This renders the soil unusable as recommended by the world health organization, except remediation work is carried out. Furthermore, Cr^{3+} is less damaging to health due to their absorption by the body (<1%), but Cr^{6+} is acutely poisonous and on contact with the skin, it triggers dermatitis, allergies and irritations and is thus considered as carcinogenic to humans (Asemave *et al*, 2012). Values for lead ranged between 0.31mg/kg and 1.13mg/kg, also exceeding the set values limits of the world health organization for lead. The presence of lead laden wastes at the dumpsite which are eventually leached to the underlying soils of the dumpsite can be attributed to presence of lead laden waste being dumped in the study area. Nickel values ranged between 4.72mg/kg and 12.54mg/kg. All values recorded were observed to be higher than the prescribed limit of 0.05mg/kg by the world health organization. The very high Nickel values recorded in the study area can be attributed to anthropogenic activities at the dumpsite, as there are no related waste generating industrie s or smelting activities in the study area, releasing their effluen ts directly into the environment.

Arsenic values obtained ranged between 0.02mg/kg and 0.06mg/kg. The values recorded were above the prescribed limit of 0.02mg/kg for soil by the world health organization standard for soil, except for a few points that were exactly 0.02mg/kg.

Cadmium had value range of between 0.18mg/kg and 0.41mg/kg in the soils sampled at Aviele study area. The values for cadmium were found to be above the recommended limit of 0.003mg/kg set by the world health organization standard for soils used for this research work.

Heavy metals	Maximum Permissible Level in Irrigation Water(µg/ml)	Maximum Permissible *Level in Soils(Mg/kg)	Maximum Permissible Level in Vegetables(µg/g)
As	0.10	0.02	__
Cd	0.01	0.003	0.10
Co	0.05	0.05	50.00
Cr	0.55	0.1	__
Cu	0.017	0.1`	73.00
Fe	0.50	50	425.00
Mn	0.20	2	500.00
Ni	1.40	0.05	67.00
Pb	0.065	0.1	0.30
Se	0.02	0.01	__
Zn	0.20	0.3	100

Table 2: The maximum allowable limits of heavy metals in soils and vegetables as established by World Health Organization (WHO), Food and Agricultural Organization (FAO), in Ewers, U (2014)

Correlation can reflect the association between elements and the similarity of their pollution source, (Zou *et al*, 2015). Tables 3 show a strong positive correlation among the different heavy metals under investigation and were all highly significant indicating a similar source of provenance.

	Copper	Chromium	Lead	Nickel	Arsenic	Cadmium
Copper	1					
Chromium	0.9998	1				
Lead	0.9999	0.9996	1			
Nickel	0.9999	0.9998	0.9998	1		
Arsenic	0.9914	0.9920	0.9914	0.9912	1	
Cadmium	0.9993	0.9996	0.9989	0.9992	0.9926	1

Table 3: Correlation table for the heavy metals investigated

A one way analysis of variance was carried out so as to ascertain the significant differences if any between the metals under investigation and the different sampling points. Sources of variance between different locations for each of the investigated elements was calculated base on the sum of squares between different sampling points (Bet ss), sum of squares within the different sampling points (with ss) and the total sum of squares (Total SS).

Source of variation		SS	Df	MS	P	F
Copper	Bet ss	0.780	1	0.780	0.844	0.041
	with ss	192	10	19		
	Total	192.780	11			
Chromium	Bet ss	0.343	1	0.343	0.825	0.052
	with ss	67	10	7		
	Total	67.343	11			
Lead	Bet ss	0.551	1	0.551	0.829	0.049
	with ss	112	10	11		
	Total ss	112.551	11			
Nickel	Bet ss	2.262	1	2.262	0.641	0.231
	with ss	98	10	9.804		
	Total ss	102.262	11			
Arsenic	Bet ss	0.822	1	0.822	0.802	0.067
	with ss	124	10	12		
	Total ss	124.822	11			
Cadmium	Bet ss	0.689	1	0.689	0.725	0.131
	with ss	50	10	5		
	Total ss	50.689	11			

Table 4: Analysis of Variance (ANOVA) for the different heavy metals is different sampling points

The output of the analysis shows clearly that differences exist significantly in the mean value for all the elements across the sampling points. The p-values for the different elements were seen to be between (0.641 - 0.844) much higher than the level of significance (0.05). This means there is significant difference in the mean values of the elements, implying that the elements are not site dependent, but from anthropogenic source and as such of similar origin.

V. CONCLUSION

The results of the research shows that all the metals under investigation were higher than the permissible limit stipulated by the world health organization guideline, 2004. The data analyzed shows that the heavy metals concentration in the study area are not site dependent, but has come about as a result of anthropogenic influences of dumping activities at the dumpsite. It is recommended that speciation studies be carried out in this site so as to determine the forms in which these heavy metals are available in the soil.

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