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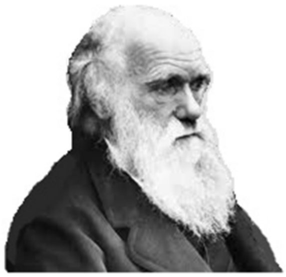

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Heavy Metal Concentration in Fields Used as Urban Waste Dump Site in Owerri, Imo State, South-Eastern Nigeria

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ABSTRACT

The concentration of heavy metals in fields used as urban waste dump sites in Owerri, Imo state Nigeria was evaluated. Three dumpsites were selected from Avu (along Port Harcourt Road), Mechanic village (opposite Tipper Park) and Egbeada housing (along Onitsha Road). Site selection was based on the presence of the dumps for at least 10 years. Soil samples were collected from the dumpsites and 100 m away from the dumpsite as control, using soil auger at depth of 0 –15 cm and 15–30 cm. Cassava crops were planted on all the sites and the cassava roots were sampled alongside the soil for the study of heavy metal contents in plant roots. Routine soil analysis and plant root analysis were carried out to determine the physio-chemical characteristics and heavy metal contents of the soil and plant roots. Results showed that heavy metal contents of soils and plants are significantly ($p = 0.05$) higher in the dumpsites than the control except for Cd which did not show significant difference. Also results showed that Cd and Pb content of soil and plants are higher (4.17 and 3.17 mg/kg, respectively) for soil and (0.2 and 0.1 mg/kg, respectively) for plant roots. It is therefore recommended that farmers should avoid growing crops in urban waste dumpsites to avoid food contamination and health hazard.

Keywords**:** Dumpsite, urban waste, soil, heavy metals, plants

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1. INTRODUCTION

Wastes are materials ranging from household, market, agricultural and industrial operations for which there is no immediate economic demand and which must be disposed of. Waste can also be defined as those materials which, though may no longer be needed here but may become useful elsewhere either as feedstock, raw materials, or manure. The World Health Organization (WHO) described waste as useless, unwanted or discarded materials that arise from man's activities. There are three basic forms of waste, namely solid, liquid and gaseous wastes. Solid waste, which will form a major part of this study, was described by Dengiz, O. (2010) as communities as well as the more homogeneous accumulations of agriculture, industrial and mineral wastes. The author explained that solid waste is otherwise called refuse and it is found in the human environment. Antoniadis, and Alloway, (2003) reported that solid wastes also include residuals from homes, business and institution wastes, trash, garbage, rubbish, refuse discards that may be in the form of wrapped papers, tins, cans, plastic containers, old refrigerators, stones, lanterns etc. Chang *et al.*, (1984) Solid waste generation is increasing more rapidly than the growth of our population because it is dependent only upon waste generated by each person in his day-to-day activities. Also, the greater the population density, the more the impact of waste on public health and on the environmental quality. When toxic waste is dumped on the soil, the decomposed materials and toxins released mixed intimately with the soil, thereby affecting the soil's physical, chemical and biological properties (Dengiz, and Sarioglu, 2011; Dowdy et al., 1991). Esu *et al.*, (2008) reported the chemical reactions may promote or reduce the soil's potential for agricultural productivity as well as other uses of the soil.

In Imo state, the handling of solid waste is controlled by three different bodies, namely Imo state ministry of petroleum and Environment Owerri: Imo state Environmental Protection Agency and the Imo state Bureau for sanitation and Transport. The agencies have specific locations and sites designated for disposal of solid waste. Some of these sites are also farmlands which can be used for farming after the site has been abandoned. Studies have shown (Anikwe and Nwobodo, 2001) that continuous disposal of municipal wastes in soils may lead to increase in metal concentration in the soil.

These metals may have harmful effects on soil, crops, and human health. Idoga and Azagaku, (2005) reported the use of old waste dumpsites by the rural farmers for cultivation of vegetables and other crops and according to Anikwe and Nwobodo (2001). The long term dumping of untreated municipal wastes and increasing toxicity of urban refuse due to rapid industrialization make the use of Municipal wastes potentially hazardous for Agricultural purposes (Agbim, 1981; Higgins, 1984; Nuga *et al.*, 2008; Oguike *et al*., 2006).

In Owerri, the population is rapidly increasing thereby reducing the areas for cultivation. Urban residents in Owerri are fond of farming the municipal dumpsites due to shortage or unavailability of farmlands. Given the dangers that may arise from high level of heavy metals concentration in soils used or in use of waste dumps and which may be transferred into food chain when the areas are used to grow crops, it is therefore necessary to investigate the heavy metal concentration in these soils as well as the crops planted within the areas. Many heavy metals are toxic to plants or animals if absorbed in excessive amounts and these include the essential ones like copper and, to some extent, manganese, and zinc (Ololade, *et al.*, 2010; Onweremadu *et al*., 2007c). Traces of these heavy metals as well as others are present in most solids, but their minerals are relatively rare.

Plant uptake of heavy metals differs depending on the metal source. Wang et al., (2001) reported that the total content of heavy metals in soil-sludge mixtures may not reflect their bioavailability. Higher contents of heavy metals in the soils do not always mean higher plant contents (Silver *et al.,* 1994; Onweremadu *et al.,* 2007d; Shelme, 2011; Victoria *et al.,* 2023). Factors that enhance mobility of the heavy mobility of the heavy metals to the groundwater include, the properties of the metals, the quality and type of soil binding sites, soil pH, the concentration of complexing anions (organic and inorganic) and competing cations in soil solution (Tyler *et al*., 1981; Silreira *et al.,* 1999; Borowski, 2008).

The question of whether plants cultivated in polluted soils are safe human consumption is of great interest to public especially now that environmental quality of food production is of major concern (Nwachokor, and Uzu, 2008). Soils with high concentration of metals can present a health risk to human life by exposing us to contaminants that do rest in its different layers. Indirectly people drink water containing pollutants leaching from the ground and eat meat raised in contaminated soils (Tomasz et al., 2004; Shelme, B (2011)). Ali *et al.,* 2010) stated that soils having appreciable concentration of heavy metals constitute a major environmental problem. Farmers make use of abandoned waste dump soils for crop production due to lack of resources to acquire fertilizers for getting meaningful harvest (Tomer, and Anderson, 1995; MC Bride,1995). Tomlin *et al.,* (1993) reported that the Heavy metal might accumulate in the soil and therefore enter the food chain.

This study aims to assess the concentration of heavy metals such as lead (Pb), Cadmium (Cd), Chromium (Cr), Nickel (Ni), Zinc (Zn), Iron (Fe), Copper (Cu) and manganese (Mn) in soils and crops grown in municipal waste dump sites in Owerri, Imo state, Nigeria. This involves an investigation of the danger or otherwise that may result from the concentration of heavy metals in soils and crops of these dump sites. Also, recommend continued use or otherwise of the dumpsites for crop products.

2. MATERIALS AND METHODS

The study was carried out in Owerri agro-ecological zone in Imo state. Owerri is located within latitude 5°6’E (Ismlsd, 1990). The area is characterized by a lowland geomorphology, and is of humid tropical climate, with an average annual rainfall of about 2238 mm with a bimodal rainfall pattern (April-July) and (September-November) with a short break in August. It has a mean annual temperature of 280 °C and a relative humidity range of 63-80%. The vegetation is mostly dominated by trees and shrubs. The soil is derived mainly from coastal plain sand which is highly weathered and acidic. Three sites were selected from different locations in Owerri, Imo state including Owerri west, Owerri North and Owerri municipal. Cassava (Manihot esculenta) was used as the test plant for the study.

The plant root was harvested from various sites. Soil was collected alongside the harvest of plant roots. Soil sampling and the root harvest was done only once with the use of cutlass, hoe, and auger. Both soil and root samples were prepared and got ready for laboratory determination of the heavy metals. Soils and root samples were prepared before taking them to the laboratory. Some physical and chemical properties were analyzed such as; Texture, Bulk density, soil pH, organic carbon, Available P, total N, Ca^{2+}, Na^{+}, Mg^{2+}, K^{+}, Al^{3+}, H^{+} etc. where analyzed. Particle size distribution was determined using hydrometer method. The textural classes were obtained by using textural triangle.

Organic carbon was determined by walkley-Black method. Soil pH was determined in 1:2.5 soils to water using the glass electrode pH meter. Nitrogen was determined by Microkjedahl method (Bremmier and Malvoney, 1982). Available phosphorus was determined using the procedure of Olson and Sommes (1990). Exchange cation (Ca^{2+} + Mg^{2+} + K^+ + Na^+) were determined by using Ammonium Acetate extraction and atomic absorption spectrometer was used for Ca^{2+} and Mg^{2+} determination while flame photometer was used for Ca^{2+} and Mg^{2+} determination while flame photometer was used to determine Na^+ and K^+ . Routine analytical methods were used to determine the heavy metal contents of the soil and plants samples. They were determined by the atomic absorption spectrophotometer (AAS) of UNICAM model. Data obtained were subjected to statistical analysis using the studentized t-test for paired observations.

3. RESULTS AND DISCUSSIONS

3. 1. Physical and Chemical Characteristics of Dump and Control Sites

Results of soil physical and chemical characteristics are shown in Tables 1 and 2 for dump and control sites at range; 0-15 cm and 15-30 cm. The soils of the dump sites at both depths have sandy clay loam texture while the control sites at both depths have loamy sand texture. The bulk density at both depths is similar in the dump and control sites and ranged from 1.19-1.22 g/m^3. The pH of the soil at both depths and for the dump and control sites is moderately acid (pH =5.4-5.77). The organic carbon content of soils is higher (0.75-1.58%) at 0-15 cm for both dump and control sites than 15-30 cm (0.58-0.74%). Available P was also higher at 0-15 cm depths for both dump and control sites (6.25-8.67 mg/kg) than 15-30 cm (4.83-5.5 mg/kg). More so, the total nitrogen, exchangeable cations (Ca^{2+}, Na^+, Mg^{2+}, and K^+) and the exchangeable acidity (Al^{3+} and H^+) are all higher at the 0-15 cm depth for both dump and control site than 15-30 cm depth.

Physical and chemical characteristics of dump and control sites at 0-15 cm are shown in Table 1 below. Note in the table below that; OC = Organic Carbon, OM = Organic Matter, TN = Available Nitrogen, AP = Available Phosphorus, TEB = Total Exchangeable Base, TEA = Total Exchangeable Acidity, ECEC = Effective Cation Exchangeable Capacity, B sat = Base saturation, Al^{3+} sat = Aluminum Saturation, K^+ = potassium, H^+ = Hydrogen, Ca^{2+} = Calcium

Table 1. Physical and chemical characteristics of dump and control sites at 0-15 cm

S/N	Site	Dump	Control
1	Sand %	71.00	82.00
2	Silt %	1.33	6.00
3	Clay %	20.69	36.00
4	AC	SCL	LS
5	B.D g/cm^3	1.19	1.20

6	pH	5.4 0	5.77
7	OC %	1.58	0.74
8	AP (mg/kg)	8.67	5.50
9	TN %	0.28	0.17
10	Ca^{2+} cmol/kg	0.33	0.19
11	Na^{+} cmol/kg	0.32	0.18
12	Mg^{2+} cmol/kg	1.99	1.12
13	K^{+} cmol/kg	0.36	0.23
14	Al^{3+} cmol/kg	1.65	1.41
15	H^{+} cmol/kg	0.78	0.65

Table 2. Physical and chemical characteristics of dump and control sites at 15-30 cm

S/N	**Site**	**Dump**	**Control**
1	Sand %	73.67	80.67
2	Silt %	6.67	9.00
3	Clay %	19.67	11.00
4	AC	SCL	LS
5	B.D g/cm^3	1.22	1.22
6	pH	5.14	5.50
7	OC %	0.75	0.58
8	AP (mg/kg)	6.25	4.83
9	TN %	0.22	0.10
10	Ca^{2+} cmol/kg	0.28	0.14
11	Na^{+} cmol/kg	0.18	0.13
12	Mg^{2+} cmol/kg	1.10	0.60
13	K^{+} cmol/kg	0.34	0.19
14	Al^{3+} cmol/kg	1.32	1.09
15	H^{+} cmol/kg	0.61	0.51

3. 2. Heavy Metal Contents of Soil

Heavy metal contents of soil are shown in Table 3 for both soil depths (0-15 cm and 15-30 cm depths) and sites (dump and control). Note that LSD is least significant difference.

Table 3. Heavy Metal concentrations in dump and undump sites

0-15cm Depth

SITE	Pb	Cr	Ni	Cd	Zn
DUMP	3.17	2.52	3.16	4.17	2.38
UNDUMP	0.40	0.42	0.41	0.11	0.75
L.S.D(0.05)	1.48	0.90	0.79	1.01	0.79

15cm – 30cm depth

SITE	Pb	Cr	Ni	Cd	Zn
DUMP	1.77	0.89	1.13	1.07	1.04
UNDUMP	0.11	0.14	0.10	0.08	0.19
L.S.D(0.05)	N.S	N.S	N.S	0.53	0.60

In Table 3 above, at 0-15 cm, the soil content of heavy metal is 3.17, 2.52, 3.16, 4.17 and 2.38 mg/kg for Pb, Cr, Ni, Cd, and Zn respectively for dump sites while heavy metal content at the same depth are 0.4, 0.42, 0.41, 0.11 and 0.75 for Pb, Cr, Ni, Cd and Zn respectively. All heavy metal content of soils is significantly higher (p <0.05) in the dump sites at 0-15cm than control sites.

At 15-30 cm, heavy metal content of soil followed similar pattern with higher values occurring in the dump sites than control. However, except for Cd and Pb where differences are significant (P<0.05) for dump and control sites , all other heavy metals are not significantly different in the two sites. Heavy metal content of cassava root for dump and control sites are shown in Table 4. Heavy metal content of cassava roots is significantly (P<0.05) higher in the dump sites except for Cd where the difference is not significant (P<0.05). The value of heavy metal range from 0.12-0.65 cm/kg in dump and 0.03-0.08mg in the control sites.

From the result, it appeared that refuse dumping has no effect on soil physical properties especially the bulk density since the bulk densities of the studied sites are similar for both dump and control sites at all depths. This, however, does not mean that other physical properties may not be affected by the refuse dump. Bride (1995) reported that heavy metals are immobile in the soil and can affect soil properties such as colour, pores etc. Again, most chemical properties of the soils were higher for dump than control sites especially at 0-15cm depth except soil Ph.

This indicates that refuse dumping increased these chemical properties such as organic, exchangeable bases etc. This finding agreed with the speculation that dumping increases fertility status as reported by Osuji and Onojake, (2004).

For heavy metal content of soil, results showed that concentrations are significantly higher in the dump sites at 0-15cm than control sites. This result agreed with other authors who stated that heavy metals are strongly bound in the topsoil and accumulate little or none in the sub soil (Filep, 1999; Rasulov *et al.*, 2020). Results further revealed significant differences in the soil content of cadmium and lead in the dump sites which may pose danger for use of such areas for food productions.

Table 4. Heavy metal concentration in the plants (cassava) root for dump and control sites

Site	Pb (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Cd (mg/kg)	Zn (mg/kg)
Dump	0.65	0.57	0.49	0.48	0.12
Control	0.08	0.06	0.04	0.03	0.04
L.S.D (0.05)	0.43	0.51	0.35	N.S	0.24

However, from the findings of this research, cadmium content of cassava roots in the dump and control sites are not significantly (P=0.05). It is rather worrisome to discover from this work that the level of heavy metals in the dump soils and plant root harvested (Tables 3 and 4) especially for cadmium and lead in the top soil (0-15 cm) are above the critical levels documented by Isirima (2004).

Cadmium concentration in the soil (Table 3) was 4.17 mg/kg while critical level of the heavy metal for soil ranged from 0.01-7 mg/kg. In the plant root of this study, cadmium content was 0.48 mg/kg, while critical level ranged from 0.2-0.8 mg/kg. Lead concentration in the soil (Table 3) was 3.17 mg/kg while the critical level for soil ranged from 2.0-200 mg/kg and in the plant root of cassava of this study (Table 3), lead content was 0.65 mg/kg while the critical level for plants ranged from 0.1-10 mg/kg.

These results indicate planting of crops on the dump sites can be dangerous as there may be accumulation of cadmium and lead in the food chain. In line with this observation, Agbim (1985) reported waste sites as good sources of plant nutrients, but Chaney and Rayan, (1993) cautioned that use of such sites for production of foods is dangerous due to possible accumulations of heavy metals, which can find ways into food chain.

4. CONCLUSIONS

The study on the heavy metal concentration of dump and control sites in Owerri revealed that dumping did not affect some of the physical soil properties especially the bulk density of the studied sites. Some chemical properties do not change significantly between dump and control sites especially at 0-15 cm soil depths although in some cases, values are higher in the dump than the control sites. All heavy metal content of soils is significantly higher in the dump sites at 0-15 cm soil depth than control sites. At 15–30 cm depth, a similar higher trend, though not significant was observed except cadmium and zinc that were significantly higher in the dump sites. For cassava roots, heavy metal contents are significantly higher in the dump sites than control except for cadmium where the differences are not significant. It is however a thing to worry about that the levels of cadmium and lead in the study exceed the critical levels established as safe in food. It is therefore concluded that dump sites contain heavy metals and planting food crops in such sites can be dangerous as heavy metals may accumulate in food and create health hazard.

The results of the study suggest that farmers should desist from planting on dump sites to avoid eating or selling food crops contaminated heavy metals. Meanwhile, Imo state environmental sanitation/protection Authorities should as a matter of urgency provide/designate an avenue for the deposit of urban waste rather than on Agricultural lands.

Imo state Government should also implement/enforce all environmental pollution laws in Owerri and its environs. More so, dumpers should desist from indiscriminate dumping of urban wastes.

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APPENDIX IA: SOIL ANALYSIS, (0-15 cm) Depth

Dump Site	**A**	**B**	**C**	**MEAN**
Sand %	77.00	70.00	66.00	71.00
Silt %	6.00	10.00	9.00	8.33
Clay %	17.00	20.00	25.00	20.67
TC	SL	SCL	SCL	
B.D g/cm^3	1.16	1.22	1.20	1.19
pH	5.50	5.42	5.30	5.40
OC %	1.57	1.72	1.45	1.58
AP (mg/kg)	7.50	10.00	8.50	8.67
TN %	0.27	0.29	0.28	0.28
Ca^{2+} cmol/kg	0.37	0.30	0.32	0.33
Na^{+} cmol/kg	0.26	0.32	0.37	0.32
Mg^{2+} cmol/kg	2.11	1.92	1.95	1.99
K^{+} cmol/kg	0.35	0.42	0.32	0.36
Al^{3+} cmol/kg	1.62	1.72	1.62	1.65
H^{+} cmol/kg	0.85	0.66	0.82	0.78
Pb mg/kg	3.50	4.50	5.50	4.5
Cr mg/kg	2.75	3.62	3.00	3.12
Ni mg/kg	3.68	4.25	4.27	4.07
Cd mg/kg	5.20	6.25	6.20	5.88
Zn mg/kg	2.50	2.65	2.00	2.38

APPENDIX IB: SOIL ANALYSIS, (15 cm – 30 cm) depth for Dump Site

Dump Site	A	B	C	MEAN
Sand %	82.00	72.00	67.00	73.67
Silt %	6.00	6.00	8.00	6.67
Clay %	12.00	22.00	25.00	19.67
TC	LS	SCL	SCL	
B.D g/cm^3	1.20	1.25	1.22	1.22
pH	5.20	5.22	5.00	5.14
OC %	0.75	0.52	0.68	0.75
AP (mg/kg)	5.50	7.00	6.25	6.25
TN %	0.22	0.20	0.25	0.22
Ca^{2+} cmol/kg	0.42	0.28	0.14	0.28
Na^{+} cmol/kg	0.16	0.20	0.17	0.18
Mg^{2+} cmol/kg	1.22	1.05	1.03	1.10
K^{+} cmol/kg	0.40	0.32	0.30	0.34
Al^{3+} cmol/kg	1.42	1.40	1.15	1.32
H^{+} cmol/kg	0.57	0.60	0.67	0.61
Pb mg/kg	0.62	3.20	1.50	1.77
Cr mg/kg	0.21	1.25	1.20	0.89
Ni mg/kg	1.20	0.65	1.33	1.13
Cd mg/kg	1.22	0.95	1.05	1.07
Zn mg/kg	1.15	1.11	0.85	1.04

APPENDIX IC: SOIL ANALYSIS, (15cm – 30cm) depth for undump site

UnDump	A	B	C	MEAN
Sand %	80.00	80.00	82.00	80.67
Silt %	12.00	8.00	7.00	9.00
Clay %	10.00	12.00	11.00	11.00
TC	SL	SL	LS	
B.D g/cm^3	1.20	1.22	1.24	1.22
pH	5.62	5.42	5.47	5.50
OC %	0.62	0.62	0.50	0.58
AP(mg/kg)	4.20	5.10	5.20	4.33
TN %	0.00	0.10	0.12	0.10
Ca^{2+} cmol/kg	0.13	0.19	0.10	0.14
Na^{+} cmol/kg	0.11	0.16	0.12	0.13
Mg^{2+} cmol/kg	0.62	0.62	0.55	0.60
K^{+} cmol/kg	0.16	0.26	0.16	0.19
Al^{3+} cmol/kg	1.20	1.05	1.02	1.09
H^{+} cmol/kg	0.52	0.52	0.50	0.51
PB mg/kg	0.14	0.13	0.07	0.11
Cr mg/kg	0.16	0.22	0.05	0.14
Ni mg/kg	0.10	0.11	0.08	0.10
Cd mg/kg	0.05	0.09	0.09	0.08
Zn mg/kg	0.11	0.22	0.23	0.19

APPENDIX 1D: PLANT ANALYSIS (PLANT UPTAKE)
DUMP SITE

Parameter	Pb (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Cd (mg/kg)	Zn (mg/kg)
A	0.72	0.52	0.50	0.78	0.12
B	0.72	0.60	0.42	0.33	0.12.
C	0.52	0.60	0.34	0.34	0.11
MEAN	0.65	0.57	0.49	0.48	0.12

Undump SITE

Parameter	Pb (mg/kg)	Cr (mg/kg)	Ni (mg/kg)	Cd (mg/kg)	Zn (mg/kg)
A	0.06	0.05	0.03	0.02	0.03
B	0.10	0.07	0.04	0.06	0.03
C	0.07	0.05	0.06	0.02	0.07
MEAN	0.08	0.06	0.04	0.03	0.04