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Heavy Metals Concentration of Dumpsites and Their Influence on the Soil Physical Properties in Three Major Cities of South Eastern Nigeria

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ABSTRACT

This research was carried out to determine the concentration of heavy metals in soils of major dumpsites and their influence on soil physical properties in three major Cities in Southeastern Nigeria, namely; Owerri, Aba and Onitsha. Soil samples were collected randomly at depths 0 to 15cm, 15 to 30cm, 30 to 45cm. The samples were taken to the Laboratory for routine analysis to determine the soil physical properties while the concentration of Ni, Pb, Cr, Cd, Zn, Fe and Mn were determined using atomic absorption spectrophotometer. The data generated were subjected to the following statistical analysis: Analysis of variance and least significant differences (LSD) in means, co-efficient of variation and correlation showing the relationship between soil physical properties and heavy metals. Results showed that soils irrespective of location have high sand fraction ranging from 617.8± 1.63g/kg while silt and clay have very low values when compared with sand. This could allow large quantities of leachates from dumpsites to permeate ground water table. The soils were generally acidic. Concentration variation across the locations was observed to be low. The mean values of the concentrations of the heavy metals across all locations are as follows; Ni 13.406 (± 0.352) $mgKg^{-1}$, Fe 425.52 ± 44.38$mgKg^{-1}$, Pb 22.93 ± 0.86$mgKg^{-1}$, Cr 31.69 ± 3.42$mgkg^{-1}$ and Cd 11.89 ± 0.86$mgKg^{-1}$. Concentrations of heavy metals at waste dumpsites were all higher than the control location.

Keywords: Heavy metal, concentration, Dumpsite

I. INRODUCTION

Municipal wastes constitute a serious problem in urban areas. One recalcitrant problem associated with waste dumpsites is heavy metals contamination. Heavy metal contamination poses serious health and environmental issues. When they find their way into water bodies like stream, lakes, rivers and groundwater, at certain concentrations they cause pollution. Heavy metals such as Lead, Zinc, Copper, Cadmium, Arsenic, Mercury and nickel play disruptive role when they enter the body system in higher concentration than required amount (Alloway, 1996). This often leads to Anemia, brain damage, anorexia, convulsion, vomiting and death (Bullut and Baysal, 2006). The Objective of this work was to investigate the concentration of heavy metals (Lead, nickel, Manganese, Zinc, Iron, Chromium and Cadmium) in waste dumpsites in three major cities namely Owerri, Aba and Onitsha in South eastern part of Nigeria.

II. MATERIALS AND METHODS

Study Area: The study was conducted at the major cities namely Owerri, Aba and Onitsha. These cities lie between Latitude 5°29′E and Longitude 7°02′N, Latitude 6°47′E and Longitude 6°10′N, Latitude 7°22′E and Longitude 5°7′N respectively. Soils of these places were derived from coastal plain sand and lies within the humid tropics characterized with total annual rainfall of 2500mm (Onweremadu, 2012). The annual temperature ranges from 26 to 29℃. Rain forest vegetation predominate the study area. The three study sites are commercial hubs in Southeast Nigeria. Onitsha and Aba are mega cities that attract trade and industry within

and outside the nation. The high rate of urbanization and industrialization has resulted to the increase in generation of waste in these cities. The wastes are heterogeneous in nature comprising of municipal and suburban wastes.

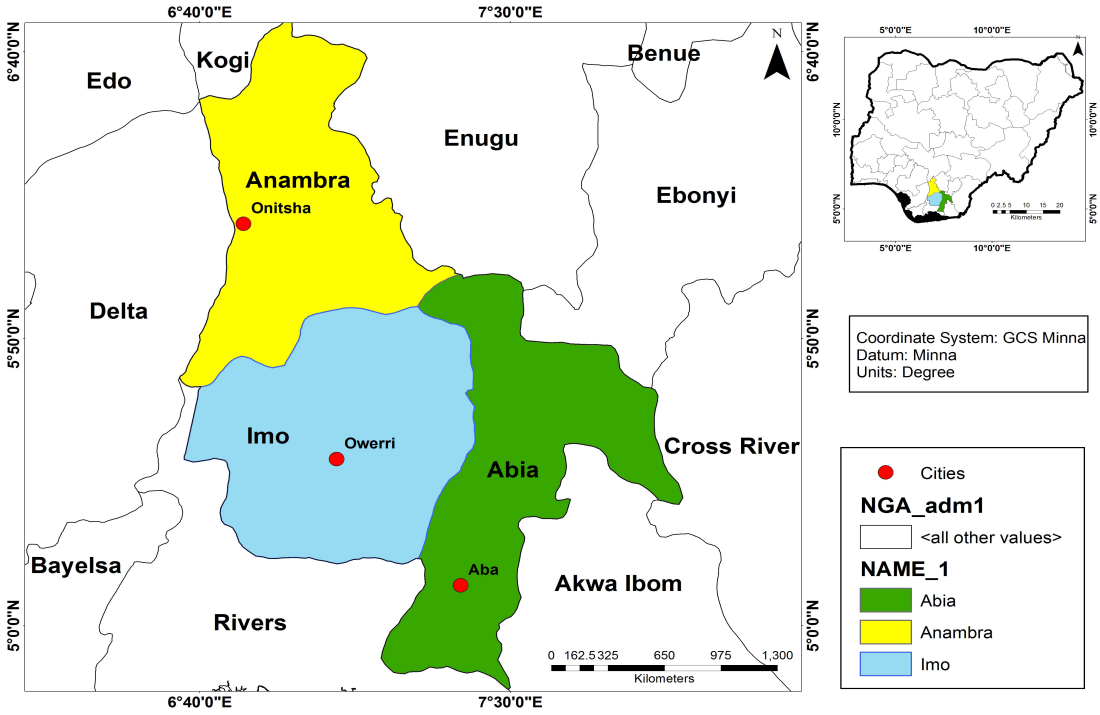

Figure1: The Study Area Map

11.1 Field Sampling**:**

Soil samples were collected at depths 0-15, 15-30 and 30-45cm with stainless soil anger and transferred into a well labeled polythene bags. Soil samples were air-drained and sieved using 2mm sieve in readiness for laboratory determinations.

11.11 B. Laboratory Analysis:

Bulk density was determined by core procedure and particle size distribution (Sand, silt and clay fractions) was measured using hydrometer technique. Soil moisture was estimated gravimetrically. Soil pH was determined electronically using pH meter in a soil solution ratio of 1:2.5. NI, Fe, Pb, Cr and Cd were determined using Atomic Absorption Spectrophotometer (Perkin Elmer 2280/2280 model) after pre-extraction of cations with dithionite-citrate carbonate. Soil data were subjected to analysis of variance and means were subjected with least significant difference (LSD at 5%) probability. The heavy metals studied correlated with some of the physical properties in all location.

III. RESULTS AND DISCUSSION

Location	Depth	Sand	Silt	Clay	Bulk Density	Moisture Content
	Cm	%	%	%	g/cm^3	%
Owerri	0 -15	72	11	17	2.103	6.06
Owerri	15 – 30	70	12.7	17.33	2.2	5.03
Owerri	30 – 45	69	13.3	17.67	2.103	5.2
*LSD(0.05)		NS	1.309	NS	0.008	0.093
Onitsha	0 -15	70.33	10	19.67	2.933	4.23
Onitsha	15 – 30	70	10.7	19.33	2.763	4.03
Onitsha	30 – 45	69	12.7	18.33	3.113	3.77
*LSD(0.05)		NS	0.756	1.511	0.535	0.142
Aba	0 -15	61	14.3	24.67	2.42	4.26
Aba	15 – 30	59.33	16.3	24.33	2.597	4.2
Aba	30 – 45	59.33	18.7	22	2.16	4.06
*LSD(0.05)		1.999	1.511	1.309	0.03	0.076
Control	0 -15	52	26.7	21.33	1.437	2.13
Control	15 – 30	46.67	28	25.33	1.883	2.23
Control	30 – 45	42.67	28	29.33	1.5	3.03
*LSD(0.05)		2.389	3.544	2.069	0NS	0.635
**LSD(0.05)		2.281	1.447	1.957	0.212	0.36

Table 1 showed the physical properties of the dumpsites.

**= LSD for the four locations, NS = Not significant, *= LSD for each location. Note: Values are means of the three replications in each location

Sand particle dominated the particle size of the soil irrespective of the location. It ranged from 426.7 to 720gKg^{-1}. The reason for this trend could be due to the parent material that is coastal plain sand from which the soils are derived from; the result agrees with other research findings in these locations. Onweremadu and Okereke (2012), Igwe *et al.* (1993) and Akamigbo (1999) have earlier reported similar trend of sand dominance of soils from South-Eastern Nigeria. The high sand composition (>700gKg^{-1}) especially in top and mid soil profiles in all the dumpsites could allow large quantities of leachates from decomposed wastes to permeate groundwater table with time. In Owerri and Onitsha locations there was no significance level recorded ($P \leq 0.05$) in sand particle but the reverse was the case in Aba and Control.

The high bulk density (>1.5g/cm^3) recorded especially at Aba could indicate that rate of filtration of water and plant root penetration will be reduced and this could lead to flooding and thus increase surface water pollution (Chen, 1991). This high value of bulk density could be attributed to low moisture content value and soil compaction. Brady and Weil (2002) revealed that moisture content and bulk density correlate negatively.

The pH value of the dumpsites studied was presented in Table 2. It showed that the pH values across all location were significant ($P \leq 0.05$). The soils were acidic and the values ranged from strongly acid to moderately acidic. The soil pH values were less than 6 in most of the locations due to high rainfall, which leads to soil erosion, and subsequent leaching of the basic cations in the soil such as Na^+, K^+, Ca^{2+} and Mg^{2+}. The pH values in Owerri, Onitsha and Aba varied significantly ($P \leq 0.05$). Generally South-Eastern soils are acidic in nature (Ahukaemere, 2012). Landon 1991 stated that acidic nature of soils favor the presence of most of the heavy metals especially Zn, Ni and Mn.

Table 2: Heavy metal Concentration in the study locations

Location	Depth	pH	Ni	Fe	Pb	Mn	Zn	Cr	Cd
	Cm		mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg	mg/kg
Owerri	0 -15	6.2	5.27	601.97	27.33	150.7	268.67	43.43	12.7
Owerri	15 - 30	5.5	4.38	682.17	32.37	180.8	302.27	50.5	15.8
Owerri	30 - 45	5.7	4.42	604.33	17.03	130.7	130.73	60.87	12.07
LSD(0.05)		**0.498**	**0.565**	**NS**	**3.923**	**2.937**	**23.27**	**4.638**	**0.409**
Onitsha	0 -15	5.433	6.07	514.27	34.23	159.7	150.5	37.27	13.97
Onitsha	15 - 30	5.567	2.19	600.7	41.7	163.23	190.97	41.53	16.93
Onitsha	30 - 45	5.967	3.39	604.67	20.2	167.23	174.9	10.67	15.13
LSD(0.05)		**0.119**	**0.623**	**NS**	**1.594**	**NS**	**2.093**	**2.01**	**1.75**
Aba	0 -15	6.867	4.17	627.77	37.3	191.7	208.67	51.43	16.47
Aba	15 - 30	6.767	5.12	622.53	40.5	184.9	145.77	44.03	13.5
Aba	30 - 45	7.1	5.28	635.07	24	192.6	162.37	30.9	24.97
LSD(0.05)		**0.151**	**0.189**	**11.12**	**1.404**	**NS**	**10.64**	**2.22**	**NS**
Control	0 -15	4.333	0.11	0.5	0.203	1.6367	3.45	1	4.463
Control	15 - 30	4.533	0.31	1.3333	0.153	20.693	12.21	3.17	1.923
Control	30 - 45	4.433	0.17	1.4	0.227	25.987	14.613	5.467	4.8
LSD(0.05)		**NS**	**NS**	**0.615**	**NS**	**7.4**	**3.816**	**2.076**	**3.578**
***LSD(0.05)**		**0.232**	**0.935**	**43.5**	**6.95**	**12.73**	**42.83**	**9.4**	**5.178**

**= LSD for the four locations, NS = Not significant, *= LSD for each location

Note: Values are means of the three replications in each location

In addition, Table 2 revealed that the Zn and Cr concentrations significantly varied ($P \leq 0.05$) in all the dumpsites, the concentration of Cd, Mg, Pb, Fe and Ni did not significantly ($P \leq 0.05$) vary in Aba dumpsite but all excluding Zn showed significant variation in concentration in other locations. Presented in Tables 3-6 are the correlation between soil physical properties and heavy metals studied. These heavy metals correlated with some of the physical properties at different levels either $P \leq 0.05$ or $P \leq 0.01$.

Table 3: Correlation showing the relationship between soil Physical Properties and Heavy metals in Owerri location

Heavy Metal	Bulk D	Clay	Sand	Silt	MC
Cd	0.958238**	-0.02347ns	-0.03017ns	0.04619ns	-0.48010ns
Cr	-0.116013ns	0.57079ns	-0.93608**	0.85232**	-0.69888*
Fe	0.490367ns	-0.21636ns	-0.108687ns	0.225361ns	-0.353554ns
Mn	0.914701**	-0.23205ns	0.215596ns	-0.15132ns	-0.263267ns
Ni	-0.507561ns	-0.44420ns	0.841443**	-0.796953**	0.88508**
Pb	0.735111*	-0.38608ns	0.496326ns	-0.414601ns	0.038277ns
Ph	-0.640576*	-0.28571ns	0.728931*	-0.734708*	0.896223**
Zn	0.639615*	-0.42784ns	0.618508*	-0.54049ns	0.181544ns

Table 4: Correlation showing the relationship between soil Physical Properties and Heavy metals in Onitsha location1

Heavy Metal	Bulk D	Clay	Sand	Silt	MC
Cd	-0.34498ns	0.15149ns	-0.27446ns	0.08689ns	-0.063895ns
Cr	-0.55908ns	0.73976*	0.654363*	-0.88521**	0.785249*
Fe	0.032588ns	-0.47232ns	-0.56367ns	0.660971*	-0.728997*
Mn	0.103801ns	-0.38466ns	-0.43413ns	0.521926ns	-0.578075ns
Ni	0.172515ns	0.389168ns	0.270061ns	-0.416986ns	0.586911ns
Pb	-0.592636ns	0.655374*	0.57576ns	-0.781642*	0.654436*
Ph	0.517754ns	-0.81772**	-0.66526*	0.940391**	-0.930332**
Zn	-0.251472ns	-0.25981ns	-0.27201ns	0.338605ns	-0.473693ns

*and** = significant at 0.05 and 0.01 probability levels respectively, ns = not significant

Table 5: Correlation showing the relationship between soil Physical Properties and Heavy metals in Aba location

Heavy Metal	Bulk D	Clay	Sand	Silt	MC
Cd	-0.51167ns	-0.46088ns	-0.22766ns	0.437154ns	-0.231674ns
Cr	0.709544*	0.905118**	0.611769ns	-0.947815**	0.922907**
Fe	-0.799303**	-0.775951*	-0.065560ns	0.563678ns	-0.397827ns
Mn	-0.661892*	-0.52850ns	0.332478ns	0.179396ns	-0.138208ns
Ni	-0.240897ns	-0.638982*	-0.834551**	0.887499**	-0.75253*
Pb	0.947829**	0.892443**	0.274709ns	-0.756391*	0.765632*
Ph	-0.89519**	-0.740697*	-0.13862ns	0.579306ns	-0.698705*
Zn	-0.14077ns	0.322783ns	0.772192*	-0.63847*	0.549602ns

*and** = significant at 0.05 and 0.01 probability levels respectively, ns = not significant

Table 6: Correlation showing the relationship between soil Physical Properties and Heavy metals in Control location

Heavy Metal	Bulk D	Clay	Sand	Silt	MC
Cd	-0.49885ns	0.220062ns	-0.108402ns	-0.23547ns	0.11406ns
Cr	0.208995ns	0.886763**	-0.933681**	0.525765ns	0.693403*
Fe	0.455386ns	0.806844**	-0.87117**	0.542594ns	0.494071ns
Mn	0.261106ns	0.886484**	-0.915041**	0.47115ns	0.588725ns
Ni	0.613117ns	0.319007ns	-0.366235ns	0.279213ns	0.131869ns
Pb	-0.481588ns	0.319226ns	-0.174395ns	-0.290696ns	0.197871ns
Ph	0.569435ns	0.346688ns	-0.364784ns	0.204822ns	0.100504ns
Zn	0.364391ns	0.881067**	-0.927042**	0.520484ns	0.558916ns

*and** = significant at 0.05 and 0.01 probability levels respectively, ns = not significant

Variability of the parameters studied (Table 7) and ranked according to Wieldin et al 1996 revealed that pH, sand, silt, clay, bulk density and moisture content recorded low variation (<15) across all the dumpsites and control. All the heavy metals studied except Cd have low variation (<15) in all dumpsites but not the same case in control site. Irregular pattern of variation was recorded.
The low variability among most of the heavy metals studied indicates that the concentrations of these elements are statistically the same thus poses the same effect irrespective of the location

.Table 7: Variability among the physical properties and heavy metal concentrations in the studied locations

	pH	Ni	Fe	Pb	Mn	Zn	Cr	Cd	Sand	Silt	Clay	Bulk D	Moisture Content
				Owerri									
CV(%)	3.1	5	12.3	5.7	0.9	4.1	3.5	3.4	0	3.6	2.7	0.2	0.9
Rank	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
				Onitsha									
CV(%)	1	7.1	1.5	2.6	2.5	0.7	3.9	6.2	1	4.2	3	8.1	2.5
Rank	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low	Low
				Aba									
CV(%)	1.1	2.6	0.7	3.7	1.8	2.7	2.1	55.5	1.2	3.5	2	0.9	1.1
Rank	Low	Low	Low	Low	Low	Low	Low	High	Low	Low	Low	Low	Low
				Control									
CV(%)	1.3	69.8	33.6	26.4	24.3	29.4	46	67.1	2.9	5.3	4.6	13.5	4.9
Rank	Low	High	High	High	Medium	High	High	High	Low	Low	Low	Low	Low

Rank : 0 – 15 = low, 15 – 25 = medium, 25 and above = High (Wielding,1996)

Note: The software used for the analysis is GENSTAT DISCOVERY 3RD Edition

Figure 2 below showed that Iron concentration was highest when compared with other heavy metals studied, unlike other sites Manganese was observed to have the highest concentration level. Akimigbo, (1999) has already indicated that most south eastern soils are dominated with Iron and Aluminium oxides this could be the reason why Iron concentration was highest

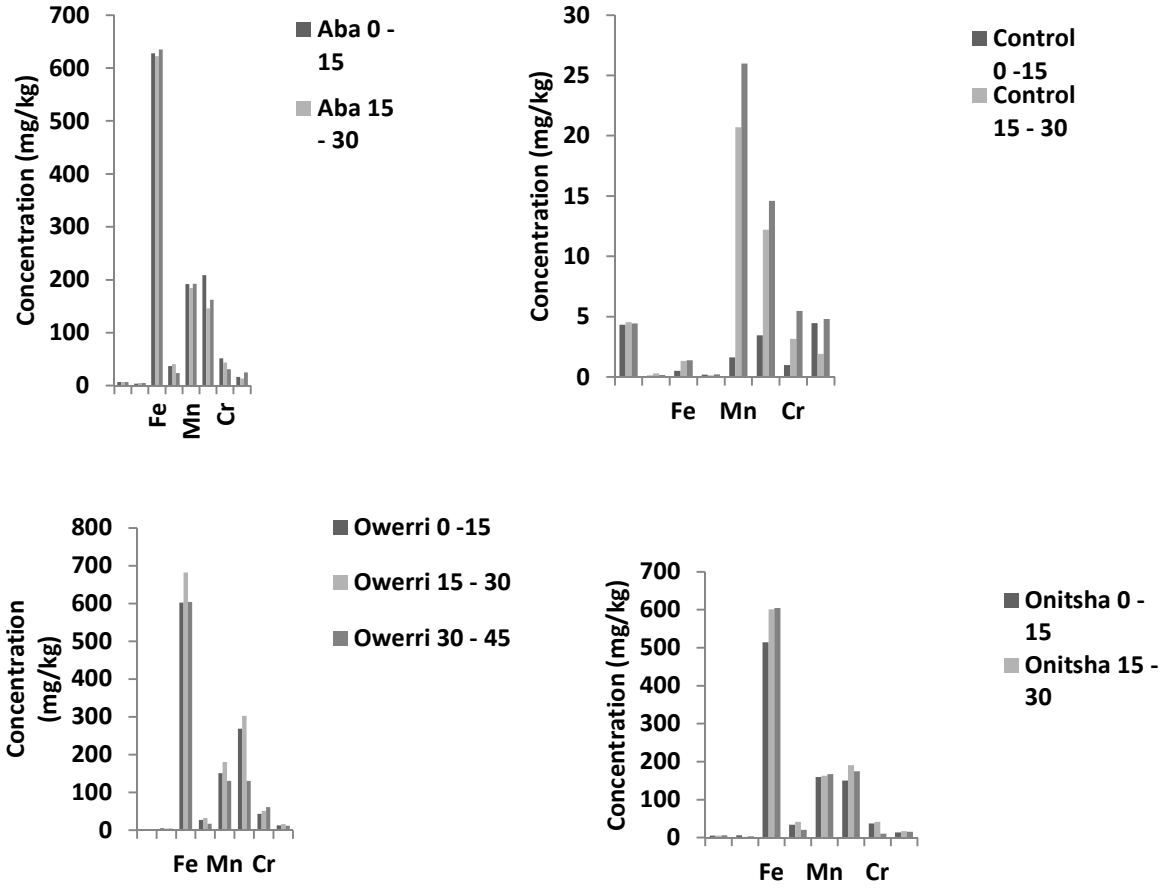

Figure 2: Distribution of Heavy metals in the studied locations

1V CONCLUSION

The study revealed that most of the heavy metals concentrations at the waste dumpsites were significantly higher than the control site. Nevertheless, the control site showed high values above the critical levels of some heavy metals namely copper(73.3mgKg^{-1}),Zinc(99.3mgKg-^{1}),Cadmium(0.2mgKg^{-1}) and lead(2.12mgKg^{-1}) according to WHO/FAO report 1989 which indicates potential problem in future if proper waste management is not carried out.

REFERENCES

Ahukaemere, C.M. (2012).” Vertical distribution of organic matter in relation to Land use types in soils of similar geological history of central southern Nigeria’ Nigeria journal of soil and environmental research 10:71-75.

Akamigbo F.O.R. (1999). “Influence of land use on soil properties of the Humid Tropical Agro-ecology of Southern Nigeria” Niger Agricultural Journal, 3:59-76.

Alloway B.J. (1990). Heavy metals in soils. Blackie and sons Ltd. Glasgow and London G.

Brady, N.C and Weil, R.R. (2002). The Nature and properties of soils. 15th Edition Prentice-Hall, Inc. New Jersey

Bullut, Y. and Z. Baysal (2006). Removal of lead (ii) from waste using wheat branch. . Journal of Environmental. Management 4:78-89

Chen, Z.S. (1999). Cadmium and lead contamination of soils near plastic stabilizing Materials producing plants in Northern Taiwan. Water , air and soil Pollution 57-58: 747-764

Igwe C.A., Akamigbo F.O., Mbagwu J.S.C (1993). Physical properties of soils of south Eastern Nigeria and the Role of some Aggregating Agents in their Stability. Soil Sci 160: 431-441

Landon, J.R. (1999). Bookker tropical soil manual. A handbook of soil survey and agricultural land evaluation in the tropics and subtropics. Longman Scientific and Technical. Hong Kong. pp 474

Onweremadu E.U and Okereke-Ejiogu E.N. (2012). Greener Journal of Agricultural Sciences; Soil Fertility Indicators low-input Agriculture in Communities of South Eastern Nigeria 2(7), pp 311-315

WHO/FAO., 1989. Report of 33rd meeting of Joint WHO/FAO Expect Committee on foods additives. Toxicological evaluation of certain foods additives and contaminants. No. 24, International Program on Chemical Safety, WHO, Geneva.

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