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Assessment of the Levels of Some Heavy Metals in Soils Around the Nekede Dumpsite in Owerri, Nigeria.

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Abstract

The assessment of levels of some heavy metals in different layers (0-15; 15-30 and 30 -45 cm) of soils around the Nekede dumpsite in Owerri, Nigeria was conducted in order to verify any possible metals input from the waste dumpsite to the surrounding soils. Soil samples were collected from three points within the dumpsite and a control. The samples were analyzed using standard methods. Descriptive statistics was used to analyze data. Mean concentrations of the parameters were within maximum permissible limits except for cadmium (156.50 mg/kg), zinc (867.50 mg/kg) and total chloride (218.65 mg/kg) which were above the regulatory standard at sample location (A), closest to the dump site. It is recommended that the dumping activities in the site should be discontinued and remediation measures such as excavation and phytoremediation should be urgently carried out in the site.

Keywords: soil contamination, soil profile, waste-dumpsite, solid waste.

1.0 Introduction

Owerri, the capital city of Imo State, Nigeria is made up of three Local Government Areas; Owerri Municipal, Owerri North and Owerri West and is located between 5.485^{0}N and 7.035^{0}E. The town is approximately 100 square kilometers in area and has an estimated population of about 401,873 (FRNOG, 2007). Owerri is bordered by the Otamiri River to the east and Nworie River to the south.

Open dumps are the oldest and most common method of disposing solid wastes all over the world, especially in the developing cities such as Owerri. As observed by Amadi, Ameh and Jisa (2010) in their work, the practice has become a threat to the environment. In developing cities of the world, population explosion and urbanization have made waste management problems more complex by increasing the quantities and types of solid wastes produced (Ogbonna, Amangabara & Ekere, 2007). Most states in Nigeria including Imo state are characterized by heaps of garbage and rubbish on street corners and junctions, open places and in drainages, resulting from open dumping of wastes. Both the quantity and quality of solid waste generated in our cities including Owerri, vary widely from day to day and according to the season of the year and still increasing mainly due to improper waste management (Ademola, 1993; Osibanjo, 1995; Adeniji & Ogu, 1998; Ideriah, Omuaru & Adiukwu, 2005).

Soils may become contaminated by the accumulation of heavy metals and metalloids through emissions from the rapidly expanding industrial areas, mine tailings, disposal of high metal wastes, leaded gasoline and paints, land application of fertilizers, animal manures, sewage sludge, pesticides, wastewater irrigation, coal combustion residues, spillage of petrochemicals, and atmospheric deposition (Zhang, Loydahl, Grip, Jansson & Tong, 2007). Heavy metals constitute an ill-defined group of inorganic chemical hazards, and those most commonly found at contaminated sites are lead (Pb), chromium (Cr), arsenic (As), zinc (Zn), cadmium (Cd), copper (Cu), mercury (Hg), and nickel (Ni). Soils are the major sink for heavy metals released into the environment by aforementioned anthropogenic activities and unlike organic contaminants which are oxidized to carbon (IV) oxide by microbial action, most metals do not undergo microbial or chemical degradation (Kirpichtchikova *et al.,* 2006), and their total concentration in soils persists for a long time after their introduction. Changes in their chemical forms (speciation) and bioavailability are, however, possible. In soil, the chemistry of cadmium for example, is largely controlled by pH. Cadmium may be adsorbed on clay minerals, carbonates or hydrous oxides of iron and manganese or may be precipitated as cadmium carbonate, hydroxide, and phosphate. Under acidic conditions, cadmium solubility increases, and very little adsorption of cadmium by soil colloids, hydrous oxides, and organic matter takes place.

A study conducted by Kimani (2010) in Kenya on the Dandora waste dump site in Nairobi showed high levels of heavy metals, in particular, Pb, Hg, Cd, Cu and Cr in the soil samples obtained on the site. A medical examination of the children and adolescents living and schooling near the dump site indicated a high incidence of diseases that are associated with high exposure levels to these metal pollutants. For example, about 50 % of children examined who lived and schooled near the dump site had respiratory ailments and blood lead levels equal to or exceeding internationally accepted toxic levels (10 ug/dl of blood), while 30 % had size and staining abnormalities of their red blood cells, confirming high exposure to heavy metal poisoning. These findings demonstrate the severe risks associated with municipal waste dumps.

In his assessment of heavy metals pollution in dumpsites in Ilorin Metropolis, Abdul-Salam (2009) observed that about 70 % of Mn, Fe, Zn, Cd and Pb were found in the exchangeable bound to carbonate and bound to iron/manganese oxide fractions. These fractions represent the mobile and lethal portion of the total metals to the ecosystem. The metal enrichment factor revealed that Zn, Cd and Pb were of anthropogenic source while Fe is of natural and anthropogenic sources. The author concluded that the dumpsites pose negative consequences on the soil and groundwater environment.

A similar study was conducted by Temilola, Oluwatoyin and Emmanuel (2014) on the impact assessment of dumpsites on quality of near-by soil and underground water in Lagos, Nigeria. The study estimated the levels of some physicochemical, microbial and heavy metals of two soil samples obtained from the dumpsites and nine hand-dug wells at different proximities to the dumpsites. Mean concentration of the physicochemical parameters except sulphate and phosphate were found to be greater at wells near the functional dumpsite at Olusosun. However, all the parameters determined were within the World Health Organization (WHO) and Nigerian Standard for Drinking Water Quality (NSDWQ) permissible limits. Metals in the water samples were within WHO and NSDWQ permissible limit except for Lead in both dumpsites with mean concentration of 0.069 ± 0.075 mg/l for wells near Oke-Afa dumpsite and 0.17 ± 0.086 mg/l for wells near Olusosun dumpsite. The soil samples in both dumpsites show a considerable level of pollution as all the metal determined exceeded the specified WHO limit. The comparative analysis of the abandoned dumpsite with the active dumpsite reveals no significant difference in the concentration of soil and water parameters measured.

Anjanapriya and Lalitha (2015) studied the impacts of heavy metals in soil profile of surrounding municipal solid waste dump site. Results from the study indicated that the levels of heavy metals were almost same in top soil, middle soil and bottom soil. High concentration of cadmium, copper, nickel, chromium and zinc were obtained near the dumpsite, but the lowest level of heavy metals was measured on the sixth site when compared to near the dumpsite. The levels of heavy metals decreased with increasing distance from the municipal solid waste dumpsite. The results indicated that the heavy metal contamination on soil was attributable to the presence of the waste dumpsite.

2.0 Materials and Method

2.1 Sampling Site

The Nekede dumpsite is located between latitude 7^{o}02.044'E and longitude 5^{o}24.072'N with an elevation of 194.4ft. along Owerri-Aba road, close to the Nekede Mechanic village. It is about two hectares in area and is surrounded by a stretch of residential buildings and farmlands.

2.2 Sample Collection

A total of four soil samples were collected with a stainless soil auger for this study. Three samples (A, B, C) were randomly collected from soils near the dumpsite in the direction of run-off and the fourth sample (D), serving as the control was collected from a site, 1km from the study area and free from the impact of the waste dump. The samples were transferred into plastic containers and transported to the laboratory for further treatment and analysis. In the laboratory the samples were exposed and allowed to dry at room temperature for a period of 4-7 days and large objects (sticks, stones, broken bottles) were removed. The air dried samples were then crushed and sieved through a 2 mm sieve before further analysis. All soil samples were taken within 0-15, 15-30 and 30-45 cm depths. For the metals,10ml concentrated HNO_3 was added to 1 g of soil sample in a digesting tube. The samples were placed in the digester for 8 hrs at 96ºC with intermittent stirring. Upon complete digestion, samples were filtered into 100ml volumetric flask using Whatman No. 42 filter paper, made up to 100 ml mark in the volumetric flask using distilled deionized water, and the concentrations of Cd, Zn, Pb, Ni, Cu, Fe, and Co in the supernant solution determined using Varian Spectra AA 600 atomic absorption spectrophotometer, with air acetylene flame connected to it.

Table 1: Sampling Design

Depth (cm)	Sample 1	Sample 2	Sample 3	Sample 4
0-15	A0	B0	C0	D0
15-30	A15	B15	C15	D15
30-45	A30	B30	C30	D30

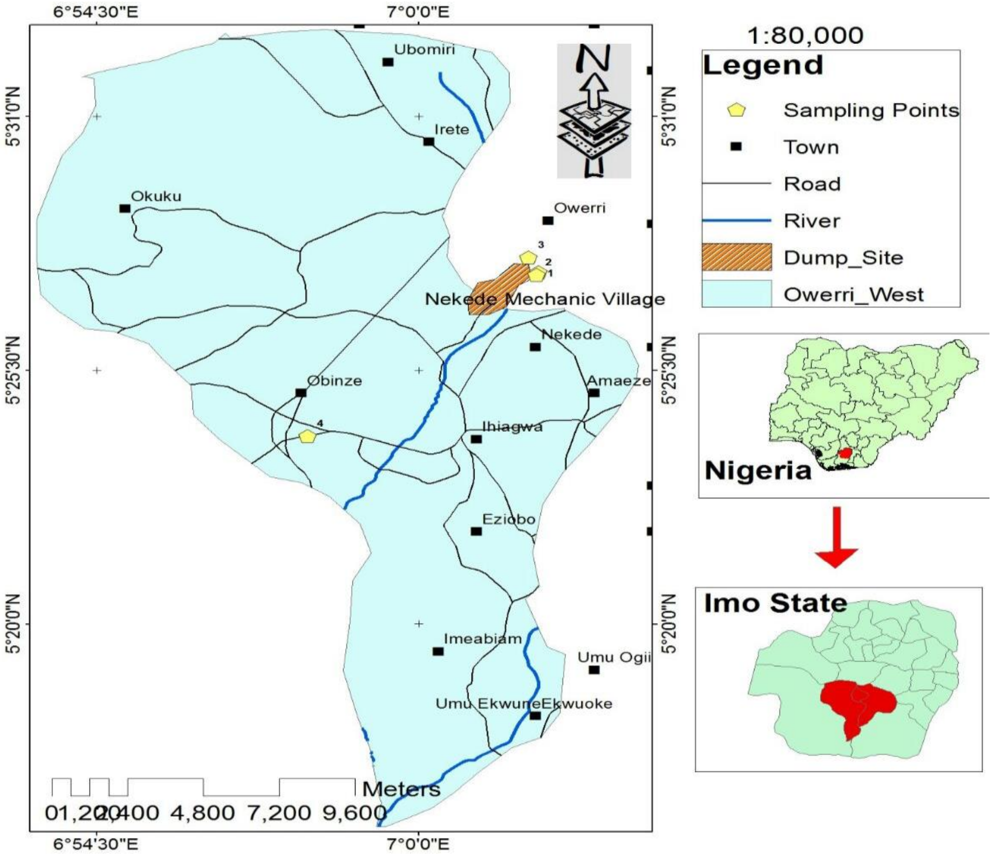

Fig. 1: Map of Owerri-West showing Nekede waste dumpsite and the sampling stations.

The data in Table 2 shows that the pH values in the entire study area ranged in a narrow interval. Top soils (0 - 15 cm) across the area ranged between 6.00 - 6.90, the mid soil (15 - 30 cm) ranged between 6.20 - 6.45, while the bottom soil(30 - 45 cm) ranged between 5.85 - 6.15. This revealed a slightly acidic soil (mean pH=6.27) across the entire soil profiles. pH is vital in determining solute concentration and contaminants sorption and desorption in soil. Low pH encourages the mobility and bioavailability of heavy metals. However, it is observed that the variations in pH across the entire soil profiles were narrow and slightly acidic and therefore, may not significantly affect the bioavailability of metals in the soils. The total organic matter (TOM) content across the entire samples ranged from 1.36 - 4.25 %.The high organic carbon content of the samples indicates that the wastes disposed at the dumpsite contain more organic compounds than inorganic metals. TOM in soils A and C increased from top soil to bottom soil whereas for soil B, it decreased from top soil to bottom soil. Higher TOM (>3.0 %) levels are associated with fine soils whereas lower levels are associated with coarse soils. The PSD analysis of the soil samples showed a variable admixture of gravel, sand and silt. Sand (>63 µm) was the main component of all soil samples with a range of 97.04 - 96.68 %. Gravel contents were in the range of 0.12 - 2.64 % and silt in the range 0.35 - 3.03 %. The total chloride was relatively high and this could further explain the observed elevated values in the electrical conductivity of the soil. Table 3 gives the descriptive statistics of the raw results for physicochemical properties and levels of heavy metals in soil samples shown in Table 2.

3.0 Results and Discussion

Table 2: Physicochemical properties of soils in the studied locations.

Parameter	Soil Depth (cm)	Sample A	Sample B	Sample C	Sample D (control)
pH	0-15	6.00	6.90	6.60	6.55
	15-30	6.20	6.25	6.45	6.05
	30-45	6.05	5.85	6.15	3.60
TOM(%)	0-15	2.88	3.05	2.87	3.45
	15-30	3.280	2.32	3.92	3.68
	30-45	3.85	1.36	4.25	3.36
TCl (mg/kg)	0-15	182.1	200.35	163.85	182.15
	15-30	173.15	173.05	208.75	154.85
	30-45	200.35	218.65	173.05	127.55
EC µS/cm	0-15	20.00	10.07	35.00	10.03
	15-30	10.00	45.00	10.02	15.01
	30-45	95.00	30.00	10.01	15.00
PSD(µm)	0-15	2.64	1.99	1.75	0.12
	15-30	97.01	97.04	96.68	96.85
Heavy metals (mg/kg)					
	30-45	0.35	0.96	1.24	3.03
Cd	0-15	156.50	12.00	0.00	0.00
	15-30	29.00	0.01	0.00	0.00
	30-45	11.23	0.00	0.00	0.00
Zn	0-15	793.50	867.50	275.50	122.5
	15-30	410.00	267.00	662.05	135.50
	30-45	290.00	378.00	303.00	565.50
Pb	0-15	76.50	23.50	0.05	6.00
	15-30	30.50	8.50	14.00	50.50
	30-45	20.00	9.50	16.50	63.00
Ni	0-15	6.00	9.00	9.00	0.00
	15-30	10.50	0.00	11.50	0.00
	30-45	5.00	0.35	6.50	0.00
Cu	0-15	43.50	11.00	10.00	0.00
	15-30	19.50	0.00	3.00	0.00
	30-45	32.50	27.50	2.00	0.00
Fe	0-15	861.50	926.00	755.00	47.00
	15-30	881.00	836.50	935.50	17.00
	30-45	902.00	718.00	244.00	158.50
Co	0-15	0.00	0.00	0.00	0.00
	15-30	0.00	0.00	0.00	0.00
	30-45	0.00	0.00	0.00	0.00

Key: S.D = Standard Deviation; EC = Electrical Conductivity; PSD = Particle Size Distribution; TCl = Total Chloride, TOM = Total Organic Matter.

Table 3: Descriptive statistics of physicochemical properties of soil samples.

Parameter	Min	Max	Range	Mean	Standard error	Standard (ESDAT, 2009)
pH	5.85	6.90	1.05	6.27	0.109	6-8
%TOM	1.36	4.25	2.89	3.09	0.297	-
TCl(mg/kg)	163.85	218.65	54.80	188.14	6.412	-
EC(µS/cm)	10.00	95.00	85.00	29.46	9.26	-
PSD(µm)	0.35	97.04	96.69	33.30	15.91	-
Heavy metals (mg/kg)						
Cd	0.00	156.50	156.50	24.53	16.81	13
Zn	267.00	867.50	600.50	471.84	79.14	720
Pb	0.05	76.50	76.45	22.12	7.42	530
Ni	0.00	11.50	11.50	6.43	1.38	100
Cu	0.00	43.50	43.50	16.56	5.07	190
Fe	244.00	935.50	691.50	784.33	71.88	-

Results for cadmium show that soil samples A and B decreased from topsoil to sub-soils whereas soil samples C had no variations from topsoil to sub-soils. Cadmium was not detected at (C0, C15 and C30) and the highest value of 156.50 mg/kg was at A0, which were closest to the dumpsite. According to Jarup (2003) and Ebong, Akpan and Mkpene (2008), the presence of high cadmium could be due to the dumping of PVC plastics, nickel-cadmium batteries, motor oil and disposal of sludge from an auto mechanic workshop. The metal was not detected at the control. The results for Zn showed that its value in soil sample A decreases from topsoil to sub-soils, while in samples B and C, the levels varied from topsoil to sub-soils. The lowest Zn value of 267.00mg/kg was at B15 and the highest value of 867.50 mg/kg was at B0, a value greater than the ESDAT limit of 720.00 mg/kg. All the levels recorded at the control were below the standard. The high level of Zn could be attributed to leaching from electronic wastes. Although, Zn is an essential trace element, an excess of its intake by human can lead to copper deficiency, immune system disorders, mental apathy, reproductive and growth disorders. Observed levels of lead revealed that soil sample A and B decreased from topsoil to sub-soil. The lowest Pb value of 0.05 mg/kg was at C0 and the highest value of 76.50 mg/kg was at A0. These values were below the standard limit and compared favorably with the control. For Nickel, results revealed that the highest value of 11.50 mg/kg was at C15, and varied from topsoil to subsoil across the samples and profiles. The metal was not detected at the control. The results for copper showed that soil samples A, B and C varied from topsoil to subsoil. The highest value of 43.50 mg/kg was at A0. The metal was not detected at the control. Results for Iron showed that soil samples A and B decreased from topsoil to subsoil, while soil sample C varied from topsoil to subsoil. The lowest Fe value of 244.00 mg/kg was at C30 and the highest value of 935.50 mg/kg was at C15.

4.0 Conclusion

The results from this study showed that the Nekede dumpsite had low acidic to slightly alkaline pH. The high organic carbon content of the samples indicates that the wastes disposed at these dumpsites contain more organic compounds than inorganic metals. The total chloride was relatively high and this could further explain the observed elevated values in the electrical conductivity of the soil. Heavy metals contamination of the soil was not observed except for cadmium and zinc which were higher than the recommended limit only at the sample points closer to the dumpsite. It is recommended that the dumping activities in the site should be discontinued forthwith and remediation measures such as excavation and phytoremediation should be urgently carried out in the site.

References

Abdul-Salam, N. (2009). Assessment of heavy metals pollution in dumpsites in Ilorin Metropolis. Ethiopian Journal of Environmental Studies and Management, 2(2).

Ademola, T. S. (1993). Environmental crisis and development in Nigeria. University of Port Harcourt Inaugural Lectures Series No. 13, 9 -15

Adeniji, K. & Ogu, V. I. (1998). Sustainable physical development in Nigeria Institute of Social and Economic Research Publication, 1, 1-10.

Amadi, A. N., Ameh, M. I., & Jisa, J. (2010). The impact of dumpsites on ground water quality in Markurdi Metropolis, Benue State. *Natur. Appl. Sci. J.,* 11(1), 90-102.

Anjanapriya, S. & Lalitha, S. (2015). Impacts of heavy metals in soil profile of surrounding municipal solid waste dump site. *International Journal of Science and Research (IJSR)* 2319-7064.

Ebong, G.A., Akpan, M.M. & Mkpene, V.N., (2008). Heavy metal content of municipal and rural dumpsite soils and rate of accumulation by *Carica Papaya and Talinumtriangulare* in Uyo Nigeria. *E-journal of chemistry*, 5(2), 281-290.

Environmental Data Base Management Circular for Soil Remediation. (2009)

Ideriah, T. J. K, Omuaru, V. O. T & Adiukwu, P. A.(2005). Heavy metal contamination of soils around municipal solid wastes dump in Port Harcourt, Nigeria. *Global Journal of Environmental Sciences*, 4 (1), 1-4.

Jarup, L. (2003). Toxicity of heavy metals and sources in the environment. *British Medical Bulletin,* 68, 167-182.

Kimani, N. G. (2010). Environmental pollution and impacts on public health: Implications of the Dandora Municipal dumping site in Nairobi, Kenya. *Urban Environment.*

Kiripichtchikova, T.A., Manseau, A., Spadini, L., Panfill, F., Marcus, M. A. & Jacquet, T. (2006). Speciation and solubility of heavy metals in contaminated soil using X-ray microfluorescence, EXAFS Spectroscopy, chemical extraction and thermodynamic modeling, *Geochimica et cosmochimicaActa*, 70 (9), 2163-2190.

Ogbonna, D. N., Amangabara, G. T & Ekere, T. O.(2007). Urban solid waste generation in Port Harcourt metropolis and its implications for waste management. *Management of Environmental Quality,* 18 (1), 71-88.

Osibanjo, O. (1995). National waste management profile for Nigeria. Paper presented at the project steering committee meeting of the international maritime organization (IMO) FEPA Nig. Case study. Input into the Global Waste survey. Presidential Hotel Port Harcourt 31st Jan. 1-15.

Temilola, O., Oluwatoyin A. & Emmanuel A. (2014). Impact assessment of dumpsites on quality of near-by soil and underground water: A case study of an abandoned and a functional dumpsite in Lagos, Nigeria.

Zhang S., Lövdahl, L., Grip, H., Jansson, P. & Tong, Y. (2007). Modelling the effects of mulching and fallow cropping on water balance in the Chinese Loess Plateau, 210 (Article in Journal). *Soil and Tillage Research, Elsevier Science,* BV 2007-11-05. 000244850400006.