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SPATIAL ASSESSMENT OF SOME SELECTED HEAVY METALS AND SOIL PHYSICOCHEMICAL PROPERTIES IN OPEN DUMPSITES IN OWERRI NORTH NIGERIA

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ABSTRACT: *The rising demand for food and other essentials due to increase in urban population had perpetuate a rise in the amount of waste generated daily by each household. In this study, soil physicochemical parameters (pH, SOM, TN, Exchangeable bases of Ca, Mg, Na, K, CEC) and heavy metal (Cu, Pb, Cr, Cd) concentration in two dumpsites in Owerri North were assessed and compared with the control soils from the same terrain using standard analytical methods. The results show that the both the dumpsites and the control sites had high % sand (>80.0%) with lower clay and silt contents. Soil mean pH varied between 5.08±0.01 in the control of Nekede and 8.20±0.02 in the main dumpsite of Egbu. The SOM ranged from 0.619±0.57 to 2.410±0.85% with the Nekede dumpsite having clear variation of SOM with its control comparable to Egbu dumpsite SOM. Total nitrogen (N) content ranged from 0.112±0.08 to 0.196±0.08%. Available P ranged from 14.92±0.99 to 85.81±0.76 mg/kg. Cation exchange capacity (CEC) varied between 19.6±0.97 to 25.2±1.24 Cmol/kg. Exchangeable Ca, Mg, K and Na, were far above the critical levels set by FAO for agricultural soil. Cu concentration ranged from 0.92±0.20 to 1.67±0.25. Pb was found in trace amount (<0.0001±0.01 mg/kg) in both dumpsites and control sites. Mean concentration of Cr in the dumpsite soils varied between 1.89±0.58 and 3.77±2.26 mg/kg in the two dumpsites, while Cd was found to be higher than the soil permissible limit. It ranges from 2.08±0.80 to 4.51±1.86 mg/kg. Conclusively, the concentrations of heavy metals studied in the soil were found to be lower than the maximum permissible limit except Cd. However, the dumpsite though high in soil nutrients and low in evaluated heavy metals might be unsafe for human consumption due to but high concentration of Cd in the study area.*

KEYWORDS: Spatial assessment, Heavy metals, Soil physicochemical properties, Open dumpsites, Owerri North.

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INTRODUCTION

Increase in world population and high industrial activities has resulted in the generation of large quantities of domestic municipal and industrial wastes (Lagerkvist and Dahlen, 2019; Twumasi et al., 2016). The increased wastes production is however not commensurate with capacity in waste management especially in developing countries. This has led to wide instances of improper waste disposal and management, which pose serious threats to the environment and development of major cities nationwide especially Africa (Lebreton and Andrady, 2019). A major contemporary concern with indiscriminate disposal and burning of wastes is that they yield substances that contain toxic metals known as heavy metals (Sari et al, 2019). Heavy metals are described as those metals with specific gravity higher or more than 5 g/cm. Most common heavy metals are copper, nickel, chromium, lead, cadmium, mercury and iron. Some heavy metals, such as iron and nickel are essential to the survival of all forms of life if they are low in concentrations (Leah and Johnny, 2014).

However, heavy metals like lead, cadmium, chromium and mercury are toxic to living organisms even in low concentrations. These metals can cause anomalies in metabolic functions of the organism especially in greater quantities (Manahan, 2001). The disposal of domestic, commercial and industrial garbage in the world is a problem that continues to grow with human civilization (Abdus-Salam, 2009). More emphatic are the untreated dumplings that rapidly increase soil toxicity making such large area dumpsites potentially hazardous for agricultural purposes (Anikwe and Nwobodo, 2001; Adelekan and Alawode, 2011). Adelekan and Abegunde (2011) also indicate that municipal waste dumpsites bear soils that are sufficiently rich in organic matter that would be acceptable for surface feeder plants. Consequently, Brady (1996) and Helmore and Ratta (1995) reported that open dump fields perform a dual purpose of safe disposal of wastes and simultaneously create improved physical and chemical properties of soils that constitute productive agricultural fields.

However, the decay of these solid wastes releases substances that can affect the soil nutrients content, increase the concentration of heavy metals in the soil, altering the natural balance of nutrients available for plant growth and development thereby affecting species diversity and agricultural productions. Although, heavy metals have received the attention of researchers all over the world, mainly due to their harmful effects on plants and other living organisms (Tahar and Keltoum, 2011). Some of these heavy metals such as Cr, Cd and Pb have been known to have no known biological importance. Moreover, due to the complexity of soil as a natural resource, the damaging effects of the heavy metals that are continually been released to the soil by the solid wastes and its impact on the soil properties are not well understood. Based on these backdrops, the study aimed at assessing some selected heavy metals contents in soil and the soil physicochemical properties in two dumpsites in Owerri North, Imo State Nigeria.

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MATERIALS AND METHODS

Description of the study area

The study was conducted in two dumpsites located in Owerri North, Imo State. They include Nekede automobile mechanic village dumpsite in Nekede Community and Egbu Road dumpsite in Egbu community both in Owerri North Area of Imo State, Nigeria. The two study area lies within longitude 5.464014 and 5.482417 and latitude 7.039690 and 7.049657 in Nekede and Egbu respectively. The two study locations are of humid tropical rainforest ecosystem. The rainy season usually occurs from the month of March to mid or late of October and often interrupted by short spell in the month of August to early September. The dry spell may last 7-14 days. It is usually cold during rainy season, also the dry season, which often comes from early November month to February. The annual rainfall values ranges between 2000mm to 3000mm and the rainfall pattern is bimodal with heavy experience from July to September. The temperature of the study location ranges from 25^{o}C to 32^{o}C. The relative humidity of the study area ranges from 85 - 89%, which is highly controlled with the temperature and the type of vegetation of area.

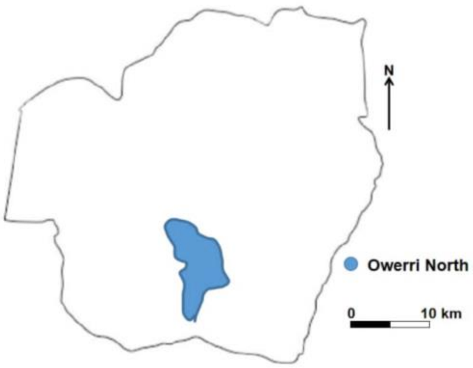

Figure 1: Map of Imo State showing the study location (Credit: This study)

Soil sample collection and preparation

Sampling of soil from the two selected dumpsites was done from the four cardinal points (North, South, East and West) in the dumpsite. The overlying wastes at the dumpsite were removed prior to surface soil sample collection and the sampling done at two depths; 0 - 15 cm and 15 – 30 cm using a soil auger and a spatula. Another set of soil samples was also collected also at the four cardinal points, 20 m away from the dumpsite (uncultivated land) at the same depth. A total of 32 samples were collected (16 samples from Nekede mechanic village dumpsite and 16 samples from Egbu road dumpsite). The soils were air dried, ground and sieved through a 2 mm sieve. The soil samples was stored in labelled polythene bags and subsequently subjected to the laboratory analysis. Below are the coordinates for the sampled point within the two dumpsites and the control sites.

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Table 1: Details of sampling points

Dumpsite/Control site	Description of sampling points	GPS coordinates of sampling points	Elevation (meters)
Nekede Mechanic Village Dumpsite	North	Lat 5.464014; Long 7.039690	78.8
	South	Lat 5.464016; Long 7.039790	81.8
	East	Lat 5.463942; Long 7.039753	75.4
	West	Lat 5.463903; Long 7.039833	78.2
Nekede Mechanic Village Control site (20m away from the dumpsite)	North	Lat 5.464067; Long 7.039624	75.6
	South	Lat 5.464143; Long 7.040073	70.9
	East	Lat 5.463831; Long 7.039790	73.2
	West	Lat 5.463893; Long 7.039956	71.4
Egbu Dumpsite	North	Lat 5.482417; Long 7.049657	72.4
	South	Lat 5.482242; Long 7.049869	72.6
	East	Lat 5.482303; Long 7.049635	70.0
	West	Lat 5.482194; Long 7.049645	71.2
Egbu Control site (20m away from the dumpsite)	North	Lat 5.482562; Long 7.049737	69.1
	South	Lat 5.482263; Long 7.050063	72.2
	East	Lat 5.482292; Long 7.049479	72.3
	West	Lat 5.481376; Long 7.049821	72.4

Laboratory analysis

Particle size distribution was determined by hydrometer method (Bouyoucos, 1962) using sodium hexametaphosphate as dispersant. The texture class was also determined using the 'textured triangular diagram' (Loganathan, 1984). Soil pH was measured in water suspension (1:2.5) using the glass electrode coupled pH meter. The cation exchange capacity (CEC) was determined by extracting the cations with 1 M ammonium acetate buffered at pH 7. Calcium (Ca) and magnesium (Mg) were determined by EDTA titration while potassium (K) and sodium (Na) were determined by flame photometry. Exchangeable acidity (EA) was determined by titration method (Juo, 1979). Available phosphorous (Av. P) was extracted with Bray solution 11 and the phosphorous determined by the molybdenum method as described by Udo and Ogunwale (1978). The percent organic matter (%OM) was calculated from the percent organic carbon (OC%) measured using Walker-Black wet oxidation method. Total nitrogen (TN) was determined using the modified Kjeldahl distillation methods (Juo, 1979). The concentrations of heavy metals, Cu, Pb, Cr and Cd were determined using atomic absorption spectrophotometer (AAS) following the standard procedures as given in APHA (1995). All analyses were done in duplicates.

Data analysis

The data generated from the laboratory analysis was subjected to descriptive statistical analysis to determine the mean and standard deviation using Microsoft Excel 2010. Tables were used to highlight the spatial variations.

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RESULTS AND DISCUSSION

The Physical properties of the soil

In this study, the sampled soil texture ranges from loamy sand to sandy (Table 2). The % sand in Egbu ranged from 86.0±0.02 to 88.0±0.03 while in Nekede it ranges from 88.0±0.02 to 90.0±0.02. The % silt content in Egbu sites were higher than that found in and around Nekede dumpsite. The ranges of % clay were approximately the same (7.0±0.01 to 9.0±0.03) in both sites evaluated. The two dumpsites sampled (Egbu and Nekede) together with their control sites had higher sand and lower clay and silt contents. This is because of the predominance of sand fraction in the study areas. This finding is similar to the findings of Onyekanne et al. (2012) that the soils of the coastal plain sand contains coarse grained and lack cementing agents such as organic and inorganic colloids.

Table 2: Textural properties of the soil

Location	Sample Code	Depth (cm)	Sand	Silt	Clay	Textural Class
			(%)			
Egbu	DS	0 – 15	88.0±0.03	5.0±0.01	7.0±0.04	Sandy
		15 – 30	86.0±0.02	5.0±0.03	9.0±0.02	Loamy Sand
	CS	0 – 15	88.0±0.01	5.0±0.02	7.0±0.03	Sandy
		15 – 30	88.0±0.02	5.0±0.01	7.0±0.01	Sandy
Nekede	DS	0 – 15	90.0±0.02	3.0±0.02	7.0±0.02	Sandy
		15 – 30	90.0±0.01	3.0±0.02	7.0±0.03	Sandy
	CS	0 – 15	90.0±0.02	1.0±0.01	9.0±0.03	Sandy
		15 – 30	88.0±0.02	3.0±0.03	9.0±0.01	Sandy

DS = Dump site; CS = control site. Data represent mean ± SD of four replicates.

The Soil Chemical properties of the soil

The soil pH (H_2O) in the two dumpsites ranges from 7.50±0.02 to 8.20±0.02 with highest from Egbu dumpsite and the lowest from Nekede dumpsite (Table 3). From the above pH ranges, it shows that all the soils from the two dumpsites are alkaline which is in agreement with research reported by Huang et al. 2015 on abandoned open dumpsite in eastern China. In general, the mean pH values of the studied dumpsite soils were greater than the value obtained on the control site which ranges from 7.90±0.01 to 5.80±0.01. This higher value of the pH found on the dumpsite relative to the control may be a result of mineral build-up by wastes on the dumpsite. The higher pH dumpsite against its control site is similar to the pH reported by Prechthai et al. 2008 on a dumpsite.

The presence of organic matter increases the cation exchange capacity of the soil which in turn helps in nutrient retention and subsequent assimilation by plants. Soil organic matter in the soils under investigation in this study according to Esu, 1991 was of low to moderate range (0.619±0.57 to 2.410±0.85 %) as indicated in Table 3. In Nekede dumpsite a clear variation in SOM was seen when compared with its control site than that found in Egbu dumpsite. The moderately high amount of organic matter of the dumpsite soils relative to control soils is suggestive of degradation or presence of degradable and compostable wastes

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(Munoz et al., 1994). This observation was supported by Oyedele et al. (2008) who reported that dumpsites had significantly higher pH regime and soil organic matter as compared to the control soil.

The total nitrogen (TN) in the dumpsite soils (0.196±0.06 and 0.168±0.07 %) was higher compared to the control (0.183±0.10 and 0.112±0.08 %) locations in Egbu and Nekede respectively (Table 3). This might be due to the composition of the wastes which might include agricultural and farmyard waste sources. Also, the activities of soil organisms in the decomposition of these wastes may have accounted for the rich nutrient contents of the soil (Obute et al., 2010; Amos-Tautua et al., 2014). The levels of Av. P in the sampled soils ranged from 14.92±0.99 to 85.81±0.76 mg/kg with the dumpsite having higher Av. P than the control. This could be attributed to the presence of high amount of organic matter and plants decomposition (Ideriah et al., 2006). All the sampled soils had available P values more than 10 mg/kg, hence considered suitable for crop production (FAO, 1976).

Table 3: Soil Chemical Properties (pH, SOM, Total N and Available P)

Location	Sample Code	Depth (cm)	pH (H_2O)	OM (%)	TN (%)	Avail. P (mg/kg)
Egbu	DS	0 – 15	8.20±0.02	1.032±0.75	0.196±0.06	39.17±1.01
		15 – 30	8.00±0.02	1.582±0.64	0.126±0.05	38.24±0.98
	CS	0 – 15	7.90±0.01	1.720±0.54	0.183±0.10	31.71±1.23
		15 – 30	7.90±0.03	1.169±0.45	0.154±0.04	35.44±1.11
Nekede	DS	0 – 15	7.50±0.02	2.410±0.85	0.168±0.07	50.70±0.86
		15 – 30	7.60±0.03	1.789±0.66	0.140±0.09	85.81±0.76
	CS	0 – 15	6.30±0.02	1.032±0.55	0.126±0.20	45.36±1.05
		15 – 30	5.80±0.01	0.619±0.57	0.112±0.08	14.92±0.99

DS = Dump site; CS = control site. Data represent mean ± SD of four replicates.

Table 4 showed that almost all the analyzed soil samples from the study sites had high Ca values above 4.0 Cmol/kg except that found in Nekede control site at the depth of 15 – 30 cm (3.478±0.09), which is regarded as lower limit for fertile soils (FAO 1976). Exchangeable K ranges from 0.010±0.00 to 0.156±0.02 Cmol/kg; indicating low to medium concentration according to Esu, 1991. Magnesium concentrations are of high range (1.391±0.02 to 5.565±1.21Cmol/kg) in all the sampled soil of both dumpsites and the controls. Exchangeable Na is of medium range according to the rating of Esu, 1991. The implication of these is that the soils are quite rich in Ca and Mg nutrients and therefore an indication of good yield potential without any input of fertilizers if used as feeder.

The CEC is the amount of exchangeable cations per unit weight of dry soil that plays a very important role in soil nutrient retention and fertility. It depends especially on the pH, clay and on the soil organic matter content. The CEC ranges from 19.6±0.97 to 25.2±1.24 in all the sampled soils from the study sites. According to the soil rating chart by Esu (1991), the CEC concentrations observed in the sampled soils are high. High CEC found around the dumpsite might be due to the decomposition of the wastes which might include agricultural and farmyard waste sources leading to an increase in organic matter content. However, high CEC also found in the control sites near the dumpsite might be due to the movement of decomposed waste, a factor strongly controlled by soil type. This is in agreement with the

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work of Nyles and Ray, 1999, who stated that soils with its separates high in sand and low in clay content have high pollutant leaching potentials.

Table 4: Soil Chemical properties (Exchangeable bases and CEC)

Location	Sample Code	Depth (cm)	Exchangeable Bases				CEC
			Na	K	Ca	Mg	
			Cmol/kg				
Egbu	DS	0 – 15	0.201±0.09	0.117±0.04	13.564±2.30	4.869±0.11	20.4±0.34
		15 – 30	0.164±0.07	0.136±0.08	13.216±1.24	3.130±0.19	22.8±1.11
	CS	0 – 15	0.142±0.02	0.068±0.01	10.782±0.10	4.521±0.21	25.2±1.24
		15 – 30	0.135±0.06	0.141±0.06	9.391±0.56	3.478±0.35	20.4±0.96
Nekede	DS	0 – 15	0.114±0.09	0.156±0.02	12.869±3.2	5.565±1.21	22.8±1.41
		15 – 30	0.136±0.04	0.039±0.01	10.086±1.01	3.826±0.89	21.6±1.09
	CS	0 – 15	0.162±0.05	0.078±0.01	4.174±0.08	2.087±0.07	19.6±0.97
		15 – 30	0.120±0.06	0.010±0.00	3.478±0.09	1.391±0.02	25.2±1.22

DS = Dump site; CS = control site. Data represent mean ± SD of four replicates.

Heavy metal concentrations in the soil

The distribution of mean concentration of the heavy metals present in the soils is shown in Table 5. The result shows that the metal loads from the refuse dump soils were found to be slightly higher than the control area (20 m from the dumpsite) with the exception of Pb which was found in traces in all the soils. Our results are collaborated by Al-Turki and Helal (2004) and Ren et al. (2005) who reported that lead (Pb) and cadmium (Cd) are anthropogenic metals, and without external interference, are normally not abundant in upper layer soils.

Cu concentration in this study ranges from 0.92±0.20 to 1.67±0.25 mg/kg (Table 5). Cu concentration from sampled soils are within the critical level (1-2 mg/kg) reported by Sims and Johnson, 1991 and (1.0 – 3.0 mg/kg) (Deb and Sakal, 2002) except that from Nekede at the depth of 15 – 30cm which is below the critical level. This result reflects low concentrations of Cu in the study sites which are common in sandy soils. This is in conformity with the findings of Enwezor et al. 1990 on tropical soils. However, parent material, soil texture, and organic matter are factors that defer the availability of copper (Brady and Weil, 2013).

The results from table 5 showed Cr range of 3.77±2.26 to 2.02±0.25 mg/kg and 3.64±0.67 to 1.89±0.58 mg/kg in Egbu and Nekede respectively. Cr concentration from the dumpsite showed a slight higher concentration than that found on the control sites, but all the concentrations are still lower than the critical permissible level which is 50 mg/kg for soil recommended for agriculture by MAFF (1992). The sources of Cr in the soils could be due to waste consisting of lead-chromium batteries, coloured polythene bags, discarded plastic materials and empty paint containers (Jung et al., 2006).

Lead levels in all the soil samples were found in trace amounts (<0.0001 ± 0.01 mg/kg) and these values are far lower than the natural limits of 30 - 50 mg/kg in soil as given by WHO/FAO (2001) and de Varies et al. (2003). The values of the metal concentrations obtained for both dumpsites together with their controls are all far below the maximum

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tolerable levels proposed for agricultural soil. This is in agreement with the findings of Asawalam and Eke (2006) and Njoku and Ayoka (2007) who investigated the trace metal concentrations and heavy metal pollutants from dumpsite soils in Owerri, Nigeria.

Table 5 showed the concentration of Cd which followed a different trend compared to the other heavy metals in the two studied locations. Cd concentration ranges from 2.08±0.80 to 4.51±1.86 mg/kg. The values of cadmium at the dumpsite and the control side (20 m away from the dumpsite) were higher than the limit prescribed by United State Environmental Protection Agency USEPA standard (1.4mg/kg). The finding was supported by other studies conducted in Adama and Maradi in Niger solid waste dump sites that revealed a higher average content of cadmium nearest to the dump site (Kebede et al. 2016; Abdourahamane et al. 2015). In this study, though high but the trend in Cd differs from that found in other analyzed heavy metals with higher concentration on the lower depth and on the control comparable. This might be a function of pH and soil grain size. According to Oviasogie and Ndiokwere (2008), lower pH favours availability, mobility and redistribution of the metals like Cd in the various fractions due to increased solubility of the ions in acidic environment. In the present study, soil pH (H_2O) from the control in Nekede ranges from 5.80 to 6.30 indicating a moderate acidic reaction. The moderately acidic pH from the control site may tend to have an increased solubility and mobility as well as increased heavy metal concentration in the studied soil (Odu et al., 1985).

Table 5: Heavy metal concentrations in the soil

Location	Sample code	Depth (cm)	Cu (mg/kg)	Cr (mg/kg)	Cd (mg/kg)	Pb (mg/kg)
Egbu	DS	0 – 15	1.30±0.40	3.77±2.26	3.49±1.23	<0.0001±0.01
		15 – 30	1.24±0.33	2.08±0.85	3.01±1.28	<0.0001±0.01
	CS	0 – 15	1.29±1.14	2.73±0.45	2.08±0.80	<0.0001±0.01
		15 – 30	1.03±0.17	2.02±0.25	3.06±1.94	<0.0001±0.01
Nekede	DS	0 – 15	1.67±0.25	3.64±0.67	3.01±0.73	<0.0001±0.01
		15 – 30	1.56±0.19	2.34±0.85	4.17±0.92	<0.0001±0.01
	CS	0 - 15	1.24±0.36	2.40±0.65	4.51±1.86	<0.0001±0.01
		15 – 30	0.92±0.20	1.89±0.58	4.46±2.00	<0.0001±0.01

DS = Dump site; CS = control site. Data represent mean ± SD of four replicates.

CONCLUSION

This research has shown that there is heavy metal concentration on open dumpsites soil which is the resulting effect of heavy metal-containing wastes that are improperly disposed in them. Buildups of heavy metal on these dumpsites have leached to the nearest place a function strongly controlled by the soil texture. Finally, in this study all the heavy metal evaluated had their values to be far below the maximum tolerable levels set by FAO and WHO for agricultural soil with the expectation of Cd. Soils of the dumpsites and those around the dumpsites (control) though high in soil nutrients possess high risk. Hence, cultivation of consumable crops in or around dumpsites is highly risky to humans. This is because of the presence of Cd at high rate; and also it is necessary to take measures both to

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stop cultivating crops and to conduct a public talk on the risks associated with dumpsite. It is highly recommended that the municipality in Owerri North should invest in waste management and environmental protection activities. Indiscriminate waste discharge should be prohibited. Waste reduction, recycling, and reuse must be promoted, while at the same time, encouraging the construction of a sanitary landfill or at least a controlled tipping site to manage the generated waste.

REFERENCES

Abdourahamane, S. I. Manzo, L. O. and Djimaetal. T. I., (2015). Impact of solid waste disposal system on soil in Maradi City (Niger Republic): a preliminary study of heavy metal contamination," International Journal of Current Microbiology and Applied Sciences, 4(5), 650–659.

Abdus-Salam N. (2009). Assessment of Heavy Metals Pollution in Dumpsites in Ilorin Metropolis. Ethiopian Journal of Environmental Studies and Management 2, 2.

Adelekan, B. A. and Abegunde, K. D. (2011). Heavy metals contamination of soil and groundwater at automobile mechanic villages in Ibadan, Nigeria, International Journal of Physical Sciences, 6, 1045 – 1058.

Adelekan, B. A. and Alawode, A. O. (2011). Contributions of refuse dumps to heavy metal concentrations in soil profile and groundwater in Ibadan, Nigeria. J. Appl. Biosci. 40, 7227-2737.

Al-Turki, A. I. and Helal, M. I. D. (2004). Mobilization of Pb, Zn, Cu and Cd, in Polluted Soil. Pak. J. Biol. Sci. A. 7:1972-1980.

Amos-Tautua, B. M. W., Onigbinde, A. O. and Ere, D. (2014). Assessment of some heavy metals and physicochemical properties in surface soils of municipal open waste dumpsite in Yenagoa, Nigeria, African J Environ Sci Technol., 8:41 – 47.

Anikwe, M.A.N, Nwobodo K.C.A (2002). Long term effect of municipal waste disposal on soil properties and productively of sites used for urban Agriculture in Abakaliki, Nigeria, Bio-resources Technol. 83, 241-250.

APHA (1995). American Public Health Association. Standard Methods for the Examination of Water and Waste Water, 19th edn. APHAAWWA-WPCF, Washington, DC. p. 525-987.

Asawalam, D. O. and Eke, C. I. (2006). Trace metal concentration in soils used for Waste disposal around Owerri, Nigeria. In: Proceedings of the 40th Conference of the Agriculture Society of Nigeria, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. p. 427-430.

Bouyoucos GJ (1962). Hydrometer method improved for making particle size analyses of soils. Agro. J. 54:464.

Brady NC (1996). The Nature and Properties of Soils, 11th ed.; McMillan: New York. p. 621.

Brady, N. C. and Weil, R. (2013). Nature and properties of soils, the: Pearson new international edition. Pearson Higher Ed.

De Vries W, Schütze G, Lots S, Meili M, Römkens P, de Temmerman L, et al. Critical limits for cadmium, lead and mercury related to ecotoxicological effects on soil organisms, aquatic organisms, plants, animals and humans. In: Schütze G, Lorent U, Spranger T, editors. Proceedings of the expert meeting on critical limits for heavy metals and methods for their application, Berlin, 2–4 December 2002 Held under the UN/ECE

Article DOI: 10.52589/AJENSR-DOV7M2LL
DOI URL: https://doi.org/10.52589/AJENSR-DOV7M2LL

Convention on Long- Range Transboundary Air Pollution UBA-Texte 47/03. Berlin: Umweltbundesamt; 2003. p. 29–78.

Deb, D. L. and Sakal, R., 2002, Micronutrients. In: Indian Society of Soil Science. Indian Research Institute, New Delhi. Pp. 391-403.

Enwezor, W. O., Ohiri, A. C., Opuwahribo, E. E. and Udo, E. J., 1990, Literature review on soil fertility investigations in Nigeria. Niger Agric. J. 30:59 – 75.

Esu, I. E. (1991). Detailed soil survey of NIHORT farm at Bunkure, Kano State, Nigeria. Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, 32.

FAO (1976). A Framwork for Land Evaluation. FAO Bulletin 32, FAO/UNESCO, France.

Helmore K, Ratta A (1995). The Surprising yields of Urban Agriculture. Choices. The Human Dev. Magazines of UNDP. 4(1).

Ideriah, T. J. K., Omuaru, V. O. T. and Adiukwu, P. U. (2006). Soil quality around a solid waste dumpsite in Port Harcourt. Afric J Ecol., 44(3):388-394.

Jung, C. H., Matsuto, T. and Tanaka, N. (2006). Flow analysis of metals in a municipal solid waste management system. Waste Management 26, 1337 – 1348.

Juo, A. S. R. (1979). Selected Methods for Soil and Plant Analysis. IITA Manual No.1.

Kebede, A. A., Olani, D. D. and Edesa, T. G. (2016). Heavy metal content and physic chemical properties of soil around solid waste disposal sites. American Journal of Scientific and Industrial Research, 7(5): 129–139.

Lagerkvist, A. and Dahlen, L., 2019. Solid waste generation and characterization. Recovery of materials and Energy from Urban Wastes: A volume in the encyclopedia of sustainability science and Technology 2:7-20.

Leah A. S. C. and Johnny A. C. (2014). Heavy Metal Concentration of Dumpsite Soil and Accumulation in Zea Mays (Corn) Growing In A Closed Dumpsite in Manila, Philippines. International Journal of Environmental Science and Development (5) 1.

Lebreton, L. and Andrady, A. (2019). Future Scenarios of global plastic waste generation and disposal Palgrave communication 5(1): 1-11.

Loganathan P (1984). Laboratory Manual of Soil and Plant Analysis. Rivers State University of Science and Technology, Port- Harcourt, Nigeria.

MAFF (Ministry of Agriculture, Fisheries and Food) and Welch Office Agriculture Department (1992). Code of Good Agriculture Practice for the Protection of Soil. Draft Consultation Document, MAFF, London Munoz M, Pena L, Halloroms JO (1994). Use of an Industrial by- product as a liming source. J. Agric. Univ. Puerto Rilo 78 (3-4) 73-86.

Manahan S. E. (2001). Fundamentals of Environmental Chemistry, 2nd ed. CRC Press, LLC Boca Ralton, Florida, pp. 853-861.

Njoku, P. C. and Ayoka, A. O. (2007). Evaluation of heavy metal pollutants from soils at municipal solid waste deposit in Owerri, Imo State, Nigeria. J. Chem. Soc. Nig. 32(1):57-60. Nyles CB, Ray RN (1999). The Nature and Properties of Soils. 12th Ed. United States of America. p. 743 – 785.

Obute, C. C., Ndukwu, B. C. and Eze, E. (2010). Changes in species diversity and physico-chemical properties of plants in abandoned dumpsites in parts of Port Harcourt, Nigeria. Scientia Africana, 9(1): 181-193.

Odu, C. T. I., Esurosu, OF, Nwaboshi I. C. and Ogunwale, J. A. (1985). Environmental study (Soil and Vegetation) of Nigeria Agip Oil Company Operation Area. A report submitted to Nigeria Agip Oil Company Limited, Lagos, Nigeria. p. 102-107.

Article DOI: 10.52589/AJENSR-DOV7M2LL
DOI URL: https://doi.org/10.52589/AJENSR-DOV7M2LL

Onyekanne, C. F.; Akamigbo, F. O. R. and Nnaji, G. U. (2012). Characterization and classification of soils of Ideato North Local Government Area. Nigerian Journal of Soil Science, 22 (1), 11-17.

Oviasogie, P. O and Ndiokwere, C. L. (2008). Fractionation of lead and cadmium in refuse dump soil treated with cassava milling effluent. J. Agric. Environ. 9:10.

Oyedele, D. J., Gasu, M. B. and Awotoye, O. O. (2008). Changes in soil properties and plant uptake of heavy metals on selected municipal solid waste dump sites in Ile-Ife, Nigeria. Afr. J. Environ. Sci. Technol. 3(5):107115.

Prechthai, T., Parkpian, P., and Visvanathan, C. (2008). Assessment of heavy metal contamination and its mobilization from municipal solid waste open dumping site. Journal of Hazardous Materials, 156(1-3), 86-94.

Ren, H. M., Wang, J. D. and Zhang, X. L. (2005). Assessment of Soil Lead Exposure in Children in Shenyang, China. Environ. Pollut. 144:327335.

Sari, Harryes R. K., Anggraini F. A., Alansyah, M. A. and Ahadi. A. (2019). The effectiveness of heavy metals Pb, Cd and Zn reduction in NPK fertilize waste combined with biofilters of seaweed (Gracillaria Sp), blood clam (Anadara sp.) and Zeolite IOP conference series: Earth and Environmental Science. 236.

Sims, J. T. and Johnson, G. V., 1991, Micronutrient soil tests. In: J.J. Mortvedi. F.R. Cox, R.M. Welch. (Editors). Soil Sci. Soc. Am. Inc. Madison, Wisconsin, USA.

Tahar, K. and B. Keltoum, (2011). Effects of heavy metals pollution in soil and plant in the industrial area, West Algeria. J. Korean Chem. Soc., 55: 1018-1023.

Twumasi, P., Tandoh, M. A., Borbi, M. A., Ajoke, A. R., Owisu-Temkorang, E., Okoro, R., and Dumeri, R. M. (2016). Assessment of the levels of Cadmium and lead in soil and vegetable sample from selected dumpsite in the Kumasi metropolis of Ghana. African Journal of Agricultural Resources 11:1608-1616.

Udo, E. J. and Ogunwale, J. A. (1978). Laboratory Manual for the Analysis of Soils, Plants and water Samples. Dept. of Agronomy University of Ibadan. p. 45.

WHO/FAO. Codex alimentarius commission. Food additives and contaminants. Food Standards Programme, ALINORM 10/12A. Joint FAO/WHO; 2001.

Article DOI: 10.52589/AJENSR-DOV7M2LL
DOI URL: https://doi.org/10.52589/AJENSR-DOV7M2LL