Micronutrients And Physicochemical Properties Of Soils Affected By Municipal Solid Wastes In Ekwulobia Southeastern Nigeria

Ndukwu B.N[1], Osujieke, D. N.[2] ,Ahukaemere C.M.[1], Umeh M.O[3]
[1]Department of Soil Science and Technology, Federal University of Technology, Owerri, Nigeria
[2]Department of Soil Science and Land Resources Management, Federal University, Wukari, Nigeria
3 Department of Natural Sciences, Federal Polytechnic Oko, Nigeria
E-mail address: bernang2001@yahoo.com

***Abstract*—The study investigated micronutrients and physicochemical properties of soils affected by municipal solid wastes in Ekwulobia, Southeastern Nigeria. A transect was used to align three profile pits used for the study. Collected soil samples were subjected to routine and special analysis. Soil data were subjected to simple mean, coefficient of variation and correlation analysis. Results indicated that soils are acidic. Organic C, TN and Av.P were higher in soils polluted by Municipal Solid wastes (OC=3.52, 3.06; TN=0.52, 0.42; Av.P=11.36, 10.41) than the unpolluted site (OC=2.41, TN=0.34, Av.P=9.06).Effective cation exchange capacity (ECEC) was high at the polluted sites (ECEC= 1.39, 1.44) than unpolluted site (ECEC=1.02). The micronutrients (Fe and Zn) were found to be higher in the polluted sites (Fe=2.17 mgkg^{-1}, 1.45 mgkg^{-1}; Zn=9.90 mgkg^{-1}, 4.80 mgkg^{-1}) than the unpolluted site (Fe=0.78 mgkg^{-1}; Zn= 0.06 mgkg^{-1}). Available Fe was within the natural limit for mineral soil environment while available Zn was higher than the critical limit of 0.8mgkg^{-1} and 0.5 mgkg^{-1}. Total exchangeable bases had moderate significant relationship Fe (r =0.60, $p<0.05$). The study revealed increase in plant nutrients and toxicity of micronutrients in soils by influence of municipal solid wastes disposal. It may be necessary to conduct further research on these soils in future studies such as waste processing/ solid waste management for the purpose good soil quality and environment sustainability.**

Keywords—Municipal solid wastes, Micronutrients, Soil properties and Pollution

I. INTRODUCTION

Municipal Solid Waste (MSW) is complex refuse consisting of various materials with different properties. It can be classified into domestic wastes, commercial wastes, Institutional and municipal wastes depending on their sources [1], some of the components are stable while others degrade as a result of biological and chemical processes. The increasing level of solid wastes has caused serious problem especially in the urban areas of the world where high rate of population growth and increasing per-capita income has resulted in the generation of enormous solid waste posing serious threats to soil quality. Soil known as a non- renewable natural resource, has several functions in the biosphere and humans in that it has high rate of degradation and extremely slow rate of regeneration processes [2]. It represents biomass production, storage of water, nutrients and heat, natural filter, intoxication [3] and buffering system. In Africa, especially in Nigeria, hunger and unhealthy people have been linked to unhealthy soils [4]. Now, the theory of soil quality has been gradually moving from a notion focused on yield potential and nutrient levels to one of environmental quality, food safety and human health [5]. Thus, the process of valuation of waste underwent a big evolution in time and one attends various processes created such as composting, recycling, the incineration and the setting in municipal solid waste. The use of compost manufactured coming from municipal solid waste contains high organic matter which can be absorbed by plants [6] and improves soil quality [7]. [8] suggested that continuous disposal of municipal waste on soils may lead to increase in micronutrient in the soil and surface water that would be detrimental to human health and inimical to deep feeding plants. In general, municipal solid waste (MSW) has a positive effect on soil microbial populations including rhizosphere organisms but suppress the population of certain nematodes that attack plants [9][10]. Municipal solid waste exerts a positive influence on physical and chemical soil properties such as porosity, aggregate stability, water holding capacity, pH-buffering capacity, cation exchange capacity, and releases nutrient generally [11][12]. However, there are concerns about potential public health hazards from the presence of pathogens and pollutants such as trace metals and organic contaminants [13][10]. The high rate of these wastes (MSW) applied to acid soil or added repeatedly may induce soil, air and water pollution. These phytotoxicity problems caused by an increase in the amount of certain essential micronutrients to toxic levels, especially Zn toxicity, or an increase in the bioavailability of non-essential heavy metals have resulted to health and environmental problems to the inhabitant of people leaving around the area [14]. Furthermore, research has shown that water that infiltrate through the solid wastes leach the constituents from the decomposed mass and while percolating cause the subsurface to be contaminated by organic and inorganic solutes [15]. Although municipal solid waste is an asset when properly managed, its volume has continued to increase tremendously in recent times especially in Ekwulobia in Anambara Southeast Nigeria as a result of increase in population and socio-economic development including wage increase and industrial establishment. Most of the untreated industrial effluents are discharged directly into neighboring water bodies or onto agricultural lands thus increasing heavy metal and micronutrient concentration [16]. As a result, the quality of some local streams and rivers has been degraded to the point where water is not safe for human consumption, for livestock use and irrigation [17]. Although, agricultural land in Ekwulobia is increasingly polluted by municipal solid wastes, most of these wastes are chemically unstable and are phytotoxic due to the production of ammonia, ethylene oxide and organic acids [18]. Assessing of soil quality involves measuring soil physical and chemical properties and using them to detect changes in soil as a result of municipal solid wastes and micronutrient effect. The objective of this study therefore was to investigate micronutrients and physicochemical properties of soils affected by municipal solid wastes in Ekwulobia Southeastern Nigeria.

II. MATERIALS AND METHODS

A. STUDY AREA

The study was conducted on a municipal solid waste dump site in Ekwulobia, Anambra state, lying between latitude 6° 1' N and longitude 7° 5' E. The soils of the study area are derived from Coastal Plain Sand (Benin formation). The soils are deep, porous and reddish in colour. The climate is humid tropical with minimum and maximum temperature of 25 °C to 30 °C. Bimodal rainfall peak characterized the area ranging from 1700-2500 mm annually. The area is dominated by rainforest vegetation whose density has been altered by anthropogenic activities. Farming and mining are the socio-economic activities of the area.

B FIELD SAMPLING

Three profile pits were used for the study and were located on three land unit namely highly polluted site, moderately polluted and unpolluted sites. The profile pits were aligned in space using transects at 100 m intervals. Soil profile pits were dug and described according to the procedure of [19].Soil samples were collected on the degree of horizon differentiation. The collected samples were air-dried, sieved using a 2-mm sieve in preparation for laboratory analysis.

C. LABORATORY ANALYSES

Particle size distribution was determined by hydrometer method [20]. Soil pH was determined using 1:2.5 soil – liquid ratio using a pH meter [21]. Organic carbon was determined by wet digestion method [22]. Total nitrogen was determined by micro-Kjeldah digestion technique [23]. Available phosphorous was determined using Bray II method [24]. Exchangeable acidity was determined by the method described by [25]. Exchangeable bases were determined by neutral ammonium acetate procedure buffered at pH 7.0 [26]. Na and K in the extract were determined by flame photometer while the Ca and Mg were determined by atomic absorption spectrophotometer. For the determination of micronutrients (Fe and Zn),it was determined according to the procedure of [27], by using dithionite citrate bicarbonate. The micronutrients (Fe and Zn) in the supernatant were read using atomic absorption spectrophotometer (AAS).

D. DATA ANALYSIS

The data generated were analyzed statistically using coefficient of variation as described by [28]. Where high variation= CV> 35 %, moderate variation= CV >15 < 3 5%, low variation= CV < 15 %. Correlation was used to determine the relationship between selected soil properties and studied micronutrient.

III. RESULTS AND DISCUSSION

A. PHYSICAL AND CHEMICAL PROPERTIES OF THE STUDIED SOILS

The results of the physical properties of soils as indicated in Table 1 shows that the soils of the study area were dominated with sand. The dominance of sand content over other particles was due to the influence of parent material and climatic effects on particle size movement [29]. The textural classes were similar irrespective of locations, distances and soil depths. This is expected since soil texture is inherited from the soil forming parent. Soils are acidic (Table2). The acidic nature of the soil was basically due to the leaching action of wastes management practices and parent materials [30] [31]. [32] reported similar results and stated that most of the wastes deposited were biodegradable which could cause exothermic reaction. [33] had earlier reported that strongly acidic and strongly alkaline soils are unsuitable for waste disposal. At strong and extreme soil acidity, most of the micronutrients and heavy metals become soluble and mobile. However, [34] reported low availability of micronutrients at pH between 6.5 and 7.0. The strong acid condition indicates that certain elements such as zinc, iron, manganese and aluminum are available in soils of the area. Organic C was high in the polluted sites compared to unpolluted sites. It was highest in highly polluted site (OC=3.52 %), followed by moderately polluted sites (OC=3.06 %) and lowest in the unpolluted site (OC=2.41 %)(Table 2). The sequential increase in Organic C in highly polluted site could be attributable to municipal solid wastes [6] [35]. The nature and composition of the solid wastes in different areas in Ekwulobia could have led to differences in soil organic C. [36] also demonstrated that high organic matter (OC) (>2.0%) in soils is conducive for micronutrient formation. Also, TN followed the same sequence as organic C with polluted sites having the highest TN compared to the unpolluted sites. The highest was in highly polluted (TN=0.52%), followed by moderately polluted (TN=0.42%) and lowest in un polluted (TN=0.34%)(Table2). The high amount of TN in the highly polluted site is dependent on the soil organic carbon resulting from municipal solid waste [37].Nitrogen released from the municipal solid waste (MSW) is relatively slow thus reducing potential N losses via leaching and decreases the possibility of ground water contamination [10]. The low TN at the unpolluted site could be related to high mineralization of N. Consequently, it has been documented that temperature and moisture content have profound effects on nitrogen availability through their effect on nitrogen mineralization, transformation and movement [38].

Furthermore, Av.P recorded the highest value at the polluted sites compared to the unpolluted site. The result was in this format: Highly polluted > Moderately polluted > Unpolluted. Available P was below the critical limit of15 mgkg^{-1} [39] [40]. The high Av.P may be attributed to the presence of organic matter (OC). [41] and [42] reported increase in soil organic matter and nutrients due to municipal solid wastes. Total exchange acidity (TEA) were higher in moderately polluted site (1.32 cmolkg^{-1}) compared to the unpolluted site (0.91 cmolkg^{-1}). These values were generally low to medium when compared with a medium range of 2.1 to 4.1 cmolkg^{-1}) as reported by [43]. Also, ECEC was higher in moderately polluted site (1.44 cmo lkg^{-1}) possibly due to the high rate of municipal solid wastes (MSW) and increased organic matter (OC) in the sites. [44] reported increase in CEC (ECEC) due to high loading rate of municipal solid waste (MSW). In addition, [45] reported that MSW can result in increased soil fertility and water retention in soil and decrease soil erosion and fertilizer requirements. However, the low ECEC at the unpolluted site (1.02 cmolkg^{-1}) could be attributed to low organic C (organic matter) coupled with the sandy nature of the area which would encourage rapid leaching of cations into the subsurface from the surface soils [46].

Table 1: Physical Properties of the Studied Site

Horizon	Depth (cm)	Sand	Silt	Clay	TC
		→	g/kg	←	
			HIGHLY POLLUTED SITE		
O	0- 15	786.6	101.4	111.0	SL
A	15- 26	767.6	91.4	141.0	SL
AB	26- 38	857.6	96.4	46.0	LS
Bt1	38- 78	867.6	85.0	47.4	LS
Bt2	78- 120	842.6	96.4	61.0	LS
Mean		**824.4**	**94.1**	**81.2**	
CV		**5.4**	**6.6**	**52.4**	
			MODERATELY POLLUTED SITE		
O	0- 10	862.6	101.4	36	LS
A	10- 30	847.8	94.8	57.4	LS
AB	30- 45	787.6	90.0	122.4	SL
Bt1	45- 90	807.6	111.4	81.0	LS
Bt2	90- 130	827.6	85.0	87.4	LS
Mean		**826.6**	**96.5**	**76.8**	
CV		**3.6**	**10.7**	**42.4**	
			UNPOLLUTED SITE		
A	0- 10	832.6	100.0	67.4	LS
AB	10- 20	807.6	110.0	82.4	LS
Bt1	20- 36	727.6	95.0	177.4	SL
Bt2	36- 78	812.6	105.0	82.4	LS
Bt3	78- 100	822.6	90.0	87.4	LS
Mean		**800.6**	**100.0**	**99.4**	
CV		**5.2**	**7.9**	**44.5**	

TC= textural class, SL= sandy loam, LS= loamy sand, CV= coefficient of variation, high variation= CV> 35 %, moderate variation= CV >15 < 3 5%, low variation= CV < 15 %

Table 2 Chemical properties of the studied site

HORIZON	DEPTH (cm)	pH (H_2O)	Ca	Mg	K	Na	TEB	H	Al	TEA	ECEC	BS	OC	TN	Av.P
			→				$cmolkg^{-1}$	←				→	%	←	$mgkg^{-1}$
							HIGHLY POLLUTED SITE								
O	0- 15	5.38	0.100	0.020	0.040	0.027	0.187	1.00	1.50	2.50	2.69	6.96	4.60	0.70	14.37
A	15- 26	5.88	0.030	0.028	0.036	0.034	0.128	0.20	1.30	1.50	1.63	7.86	3.80	0.50	10.21
AB	26- 38	4.83	0.026	0.014	0.030	0.029	0.099	0.20	0.50	0.70	0.79	12.39	3.40	0.60	11.11
Bt1	38-78	5.22	0.002	0.030	0.042	0.028	0.102	0.20	1.40	1.60	1.70	5.99	3.10	0.40	12.09
Bt2	78-120	5.00	0.002	0.002	0.029	0.030	0.063	0.00	0.10	0.10	0.16	38.65	2.70	0.40	9.04
Mean		**5.26**	**0.032**	**0.019**	**0.035**	**0.029**	**0.116**	**0.28**	**0.96**	**1.28**	**1.39**	**14.37**	**3.52**	**0.52**	**11.36**
CV		**7.7**	**125.6**	**60.5**	**16.4**	**9.1**	**39.8**	**144.9**	**64.9**	**71.7**	**69.1**	**96.0**	**20.6**	**25.1**	**17.8**
							MODERATELY POLLUTED SITE								
O	0- 10	5.39	0.040	0.030	0.027	0.033	0.130	0.20	0.95	1.15	1.28	10.16	3.70	0.50	12.08
A	10-30	5.61	0.004	0.010	0.036	0.042	0.092	0.05	0.50	0.55	0.64	14.33	3.50	0.40	11.46
AB	30-45	5.88	0.016	0.012	0.029	0.040	0.097	0.95	1.00	1.95	2.05	4.74	3.30	0.50	12.33
Bt1	45-90	6.20	0.024	0.110	0.034	0.026	0.194	1.00	0.50	1.50	1.69	11.45	2.60	0.50	8.05
Bt2	90-130	6.11	0.004	0.048	0.030	0.024	0.106	0.01	1.45	1.46	1.56	6.79	2.20	0.30	9.01
Mean		**5.84**	**0.018**	**0.042**	**0.031**	**0.033**	**0.124**	**0.44**	**0.88**	**1.32**	**1.44**	**9.50**	**3.06**	**0.42**	**10.41**
CV		**5.8**	**85.9**	**97.6**	**11.9**	**24.4**	**33.8**	**111.3**	**45.2**	**39.1**	**36.6**	**40.0**	**20.7**	**19.9**	**17.0**
							UNPOLLUTED SITE								
A	0- 10	6.53	0.060	0.004	0.042	0.038	0.144	0.20	1.50	1.70	1.84	7.81	3.05	0.40	9.25
AB	10-20	6.15	0.078	0.012	0.040	0.050	0.180	0.00	0.00	0.00	0.18	10.00	2.50	0.40	10.83
Bt1	20-36	6.12	0.004	0.024	0.037	0.034	0.099	0.10	2.00	2.10	2.19	4.50	2.20	0.30	10.01
Bt2	36-78	5.15	0.006	0.002	0.032	0.025	0.065	0.05	0.05	0.10	0.17	39.39	2.20	0.30	7.09
Bt3	78-100	5.37	0.002	0.004	0.029	0.027	0.062	0.20	0.45	0.65	0.71	8.71	2.10	0.30	8.13
Mean		**5.86**	**0.03**	**0.009**	**0.036**	**0.035**	**0.110**	**0.110**	**0.80**	**0.91**	**1.02**	**14.1**	**2.41**	**0.34**	**9.06**
CV		**9.9**	**120.6**	**99.1**	**15.1**	**28.7**	**46.6**	**81.3**	**112.8**	**104.1**	**92.7**	**101.5**	**16.1**	**16.1**	**16.4**

TEB= total exchangeable base, TEA= total exchangeable acid, ECEC= effective cation exchange capacity, BS= base saturation, OC= organic carbon, TN= total nitrogen, Av.P= available phosphorus, CV= coefficient of variation, high variation= CV> 35 %, moderate variation= CV >15 < 3 5%, low variation= CV < 15 %

B. CONCENTRATION AND DISTRIBUTION OF MICRONUTRIENTS (FE AND ZN) IN THE STUDIED SOIL

The results of the micronutrients presented in Table 3 indicated that available Fe and Zn were higher in polluted sites compared to the unpolluted site. It was highest in highly polluted site (Fe=2.17 $mgkg^{-1}$; Zn=9.90 $mgkg^{-1}$) and lowest in upolluted site (Fe=0.78 $mgkg^{-1}$; Zn=0.06 $mgkg^{-1}$). There distributions were irregular while there concentrations are in the following order: Zn>Fe. It was in the decreasing order from highly polluted site to the unpolluted site possibly due to mobility of these metals in soil solution and its uptake by plants. Most of these micronutrients (Fe and Zn) are leached with water present in the solid wastes [1]. The higher concentration of Fe and Zn in the polluted sites were related to the nature and composition of the municipal solid wastes, OM and soil pH. However, in the case of Av. Fe in the polluted sites, the differences in the formation of organo-metal complexes have subsequently altered Fe solubility. [47] also reported Fe availability due to decreased soil pH. Available Fe was below the critical limit of 0.1 N extractable (Fe) as 2.5-5.8 $mgkg^{-1}$[48] and was also within the natural limits for mineral soil environment [49]. Furthermore, the concentration of Zn in the polluted sites was above the critical level of 0.8 mgkg-1 [50] and 0.5 mgkg-1 [51]. The high proportion may be due to the municipal solid waste and presence of organic matter (Organic C) [52]. However, complexes are formed under acidic pH range [53].

Table 3 Concentration and distribution of (Micronutrients) Fe and Zn in the Studied Soil

Horizon	**Depth (cm)**	Available **Fe**	Available **Zn**
		→ mgkg^{-1} ←	
		HIGHLY POLLUTED	
O	0- 15	2.86	6.53
A	15- 26	3.52	17.37
AB	26- 38	3.06	25.20
Bt1	38- 78	0.32	0.00
Bt2	78- 120	1.09	0.19
Mean		**2.17**	**9.90**
CV		**63.9**	**112.7**
		MODERATELY POLLUTED	
O	0- 10	0.86	0.07
A	10- 30	1.97	16.87
AB	30- 45	0.67	0.00
Bt1	45- 90	3.12	7.17
Bt2	90- 130	0.63	0.00
Mean		**1.45**	**4.8**
CV		**74.7**	**153.7**
		UNPOLLUTED	
A	0- 10	1.14	0.04
AB	10- 20	1.86	0.09
Bt1	20- 36	0.49	0.05
Bt2	36- 78	0.18	0.00
Bt3	78- 100	0.21	0.10
Mean		**0.78**	**0.056**
CV		**92.6**	**72.1**

Av. Fe= Available Iron, Av. Zn= Available Zinc, CV= coefficient of variation, high variation= CV> 35 %, moderate variation= CV >15 < 3 5%, low variation= CV <15%

C. RELATIONSHIP BETWEEN AV. FE AND ZN WITH SELECTED SOIL PROPERTIES

Table 4 shows the result of the relationship between Av. Fe and Zn. From the result, total exchangeable base (TEB) had significant positive relationship with Av.Fe (0.60) indicating that municipal solid wastes increased TEB and available Fe. On the other hand available Zn had no relationship with selected soil properties.

Table 4 Relationship between Fe and Zn with Selected Soil Properties

SOIL PROPERTIES	Av.Fe	Av.Zn
Sand (gkg^{-1})	0.33^{ns}	0.06^{ns}
Silt (gkg^{-1})	0.36^{ns}	-0.01^{ns}
Clay (gkg^{-1})	0.05^{ns}	-0.01^{ns}
pH(H_2O)	0.20^{ns}	0.09^{ns}
TEB ($Cmolkg^{-1}$)	0.60*	0.07^{ns}
ECEC ($Cmolkg^{-1}$)	0.15^{ns}	-0.06^{ns}
OC (%)	0.31^{ns}	-0.03^{ns}

Av. Fe= Available Iron, Av. Zn= Available Zinc, TEB= total exchangeable base, ECEC= effective cation exchange capacity, OC= organic carbon, *= significant at 5 % probability level, ns= not significant

IV. CONCLUSION

This study revealed that dumping of municipal solid wastes (MSW) on soils had great influence on soil properties and micronutrients. In the study sites, MSW increased OC, TN, and Av.P. The concentration of available Fe was low and within the natural limits for mineral soil environment while available Zn was above the critical level of 0.8mgkg-1 and 0.5 mgkg-1. The excess of these micronutrients especially available Zn would enhance their toxicity in soils and deterioration of water table in the study area. Proper monitoring and remediation plan is needed to reduce the chances of ground water pollution by leaching of these contaminants. Further in-situ and in-vitro bioaccumulation studies can also be performed by using the information in this study for good soil quality and environment sustainability.

References

[1] Manohara, B and Belagali, S.L (2014). Characteristics of Essential Nutrients and Heavy metals during Municipal Solid Wastes Composting. International Journal of Innovative Research in Science Engineering and Technology 3(2): 9664-9672.

[2] Zovko, M. and Romic, M. (2011). "Soil Contamination by Trace Metals: Geochemical Behaviour as an Element of Risk Assessment, Earth and Environmental Sciences," InTech, http://www.intechopen.com/books/earth and environmental sciences soil contamination by trace metals geochemical behavior as an element of risk assessment.

[3] Hart, A. D., Oboh, C. A., Barimalaa, C. S and Sokari, T. G. (2005). "Concentration of Trace Metals (Lead, Iron, Copper and Zinc) in Crops Harvested in Some Oil Prospecting Locations in Rivers State, Nigeria," African Journal of Food and Nutritional Sciences,5(2) : 1-21.

[4] Ghanem, M., Samhan, S., Carlier, E and Ali, W (2011). "Groundwater Pollution Due to Pesticides and Heavy Metals in North West Bank," Journal of Environmental Protection, 2: 429-434.

[5] Muthusamy, M.,Panigrahy, B.K., Shetty, P.K., Subbiah, A and Ravi, R (2012) "Effect of Heavy Metal and Nutrient Uptake by Soils in Indian Cardamom Hills," Journal of Soil Science and Environmental Management, 3(8):196-206.

[6] Adelekan, B. A. and Alawode, A.O (2011).Contributions of municipal refuse dumps to heavy metals concentrations in soil profile and groundwater in Ibadan Nigeria. J. of Applied Biosci., 40: 2727-2737.

[7] Bolan, N. S. A.,Szogi, A. A.,Chuasavathi, T.,Seshadri, B., Rothrock Jr., J and Panneerselvam, P

(2010).“Uses and Management of Poultry Litter,” World’s Poultry Science Journal, 66 (4): 673-698.

[8] Anikwe, M. A. N and Nwobodo, K. C.A (2001). Long Term Effect of Municipal Waste Disposal on Soil Properties and Productivity of Sites use for Urban Agriculture in Abakaliki, Nigeria. Bioresources Technol. 83: 241- 251.

[9] Gallardo-Laro,F and Nogales, R (1987). Effect of the application of town refuse compost on the Soil-Plant system: A review. Biol. Waste 19:35-62.

[10] Shiralipour, A., McConnell, D.B and Smith, W.H (1992). Physical and Chemical Properties of Soils as affected by Municipal Solid Waste Compost Application. Bioenergy 3(3-4):261-266.

[11] Piccole, A. and Mbagwu, J. S. (1990). Effects of different organic waste amendments on soil micro aggregates stability and molecular sizes of humic substances. Plant soil 123: 27-37.

[12] Iglesias- Jimenez, E., Pere- Garcia, V., Espino, M and Hernandez-Moreno, J. M (1993).City refuse compost as a phosphorus source to overcome the p- fixation capacity of sesquioxide- rich soils. Plant soil 148: 115- 127.

[13] Chu, L.M and Wong, M.H (1987). Heavy metal Contents of vegetable crops treated with refuse compost on the Soil-Plant System. Plant Soil 103 (2): 91-197.

[14] Piccolo, A. and Mbagwu, J. S. (1990). Effects of different organic waste Amendments on soil micro aggregates stability and molecular sizes of humic substances. Plant soil 123: 27-37.

[15] Jeyapriya, S. P. andSeseetharam, M.K. (2010).Effect of municipal solid waste on the characteristic of soil. Pollution Research Paper, 29 (1):37-41.

[16] Hall, J.E (1991). Alternative uses for sewage sludge, proceedings of a conference organized by WRc, Medmenham, Pergamon Press, Oxford.

[17] Albaladejo, J., Stocking, M., Diaz, E and Castillo, V (1994). Land rehabilitation by urban refuse amendments in a Semi-arid environment: effect on Soil Chemical properties. Soil Technology 7: 249-260.

[19] Food and Agriculture Organisation(FAO), 2006. Guideline for soil profile descriptions. Rome. Pp 66.

[20] Gee, G.W., and Or, D. (2002). Particle size analysis in: Dane, J.H., Topp. G.C., (eds). Methods of soil analysis (part 4, physical methods.Am book series. No 5 ASA and SSSA Madison 1 : 255-295.

[21] Thomas, G. W., (1996). Soil pH, soil acidity. In: Methods of soil analysis part 3. Chemical methods L. D. sparks (eds) SSSA book series 159 – 165.

[22] Nelson, D. W, and Sommers, L. E., (1982). Total carbon, organic carbon and organic matter in: Paye, A. L., Miller, R. H., and Keeney, D. R. (eds). Methods of soil analysis, part 2. American Soc. of Agronomy Madison, Wisconsin Pp 539 – 579. Nigeria. Global J. of Pure and Applied Sciences 16(1) 23-29.

[23] Bremner, J.M. (1996). Nitrogen total. Sparks, D.L. (ed) methods of soils analysis, parts, chemical method. 2nd ed, SSSA Book Series No. 5, SSSA, Madison, W1

[24] Olsen, S.R. and Sommers,L.E. (1982). Determination of Available Phosphorus. In: Methods of Soil Analysis, Page, A.L., R.H. Miller and D.R. Keeney, (Eds.). American Society of Agronomy, Madison, USA.,pp: 403-407.

[25] Mclean, E. V., (1982). Aluminium. In page, A. L., Miller, R. H., Keeney, D. R., (eds). Methods of soil analysis, part 2, Am. Soc. Agron Madison WL. 978 – 998.

[26] Thomas, G. W., (1982). Exchangeable Bases. In: Methods of analysis part 2. Page, A. L., Miller, R. H., and Keeney, D. R (eds). pp 159 – 165. American Society of Agronomy Madison Wisconsin.

[28] Wilding, L.P.; Bouma, J. and Boss, D.W. 1994.Impact of spatial variability on interpretative modeling. In: Quantitative modeling of soil forming processes. Bryant, R.B. and Amold, R.W. SSSA Special publication. No.39: 6175.

[29] Igwe, C.A., Akamigbo, F.O.R and Mbagwu, J.S.C (1999). Chemical and Minerological properties of soils in Southern Nigeria in relation to aggregate stability. Geoderma 92 :111-123.

[30] Paudel, S. and Sah, J. P (2003).Physico-chemical characteristics of soil in tropical Sal (Shorea Robusta Gaertn) Forest in Eastern Nepal. Himalayan J. Sci., 1(2): 107-110. Research Institute, New Delhi. Pp. 391-403.

[31] Foth, H.D(2006). Fundamentals of soil science.8th Edition. New York: John Wiley & Sons.

[32] Ololade, I.A., Ashoghon, A.O.and Adeyemi, O(2007). Plant level of chromium and nicket at a refuse site, Any positive impact? J. Applied Sci., 7: 1768-1773.

[33] Bonarius, H.M (1975). Suitability guide for rating soils for waste disposal German Agency for Technical Cooperation, West Germany, pp: 68

[34] Bhattacharya, P. A.B., Mukherejee, P. A. B., Jack, J and Nordquist, S. (2002). Metal contamination experimental studies on remediation. Sci. Total Environ. 290: 165-180.

[35] Adelekan, B. A andAbegunde, K. D (2011).Heavy Metals Contamination of Soil and Groundwater at Automobile Mechanic Villages in Ibadan Nigeria. Int. J. Phys. Sci. 6(5):1045-1058.

[36] Ayolagha GA, Onwugbata G C (2001). Suitability comparison of waste disposal site.27th Proceedings of the Annual Conference of the Soil Science of Nigeria. November 5-9, 2001, University of Calabar, Nigeria.

[37] Brady, N.C. and Weil, R.R. (1999). The nature and properties of soils.12th edition. Prentice-Hall Inc. New Jersey, USA. 960p

[38] Adepetu, J.A and Corey, R.B (1985). Changes in N and P availability fraction in IWO soils from Nigeria under intensive cultivation. Plant and soil 46: 309-316

[39] Fertilizer Procurement and Distribution Division (FPDD) 1990. Literature review on soil fertility investigations in Nigeria (in Five volumes). Produced by the Federal Ministry of Agriculture and Natural Resources, Lagos

[40] Chude, V. O., Malgwi, W. B., Amapu, I. Y. and Ano, A. O. (2011).Manual on Soil Fertility Assessment. Federal Fertilizer Department. FAO and National programmeon Food security, Abuja, Nigeria. 62 pp.CRC Press, Boca Raton, FL.

[41] Erickson, F. (1999).Chemical analysis of solid waste material. First edition, Blackwell scientific publication.

[42] Aggclides C. and Londa, U (2002).Physical analysis of solid waste material. Blackwell scientific publication, pp 105-106.

[43] Holland, M. D., Allen, R. K., Barten, G. D and Murphy, S. T(1989). Land evaluation and agricultural recommendations for Cross River National Park, Oban Division. Report Prepared by the Overseas Development Resources Institute in Collaboration with WWF for the Federal Republic of Nigeria and the Cross River State Government.

[44] Mays, D.A and Giordano, P.M (1989). Landscaping municipal waste compost. Biocycle 30 (3) : 37-39.

[45] Glaub, J.C and Golueke, C.G (1989). Municipal organic wastes and composts for arid areas. Arid Soil Research and Rehabilitation 3 : 171-184.

[46] Amhakhian, S.O and Osemwota, I.O (2012). Physical and chemical properties of soils in Kogi State, Guinea Savanna zone of Nigeria. Nigerian journal of Soil Science 22 (1) : 44-52.

[47] Sculte, E.E. (2003) Soil and applied magnesium A3554, understanding plant nutrients, College of agricultural and life sciences university of Wisconsin-Madison.

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

[49] Brady, N.C. and Weil, R.R (1996).The nature and properties of soils. Eleventh edition. New York: Prentice Hall, Upper Saddle River.

[50] Lindsay, W.I and Norvell, W.A (1978). Development of DTPA soil test for Zinc, Iron, Manganese and Copper. Soil Sci. Soc. Am. J. 42 : 421- 428.

[51] Udo, B.T., Ibia, T.O., Udo, B.U and Edem, S.O (2008). Assessment of micronutrient status of inland depression and floodplain (Wetland) Soils in Akwa-Ibom State, Southeastern Nigeria. Journal of Tropical Agriculture, Food, Environment and Extension 7 (2) : 156-161.

[52] Goswami, U and Sarma, H.P (2008). Study of the impact of municipal solid waste dumping on soil quality in Guwahati city. Poll Res. 27(2) :327-330.

[53] Isirimah, N.O., Dickson, A.A and Igwe, C.A (2003). Introductory Soil Chemistry and Biology For Agriculture and Biotechnology OSIA Intl. Publishers ltd, PortHacourt, Nigeria.