Syllabus Review **2 (3),** 2011: 106 - 113

SYLLABUS REVIEW
Science Series

RESEARCH ARTICLE – ENVIRONMENT

Physico-chemical properties of soils under municipal solid waste dump sites in Ife East Local Government Area, Osun State, Nigeria.

Gasu, M.B[1] and Ntemuse, U.E[2]
[1]Department of Urban and Regional Planning, Osun State University, Osogbo. [2]Department of Botany, Obafemi Awolowo University, Ile-Ife
Corresponding author: Gasu, M. B. +2348033816133, gasumart@yahoo.com

Received: 17 December 2010 / Revised: 9 September 2011 / Accepted: 24 October 2011

Summary
The study was carried out to examine the effect of municipal solid waste (MSW) dump sites on physico-chemical properties of soils in Ife East Local Government Area of Osun State, Nigeria. A total of 90 soil samples were collected from four dump sites and a control across two seasons. Each sample site was divided into four quadrats each 3m² and a total of 9-15 cores soil per quadrat were collected from three of the four quadrats randomly at depths (0-15 cm), (15-30 cm) and (30-50 cm) using a stainless steel Dutch auger in composite replicate mixed thoroughly and sub samples collected and analysed for soil properties. Statistical analysis made use of SAS software using analysis of variance (ANOVA) and Duncan Multiple range test (DMRT) to separate means of soil properties. The study revealed that municipal solid waste dump sites vary significantly in their physico-chemical properties along the profile from one depth to the other. The study revealed that there were variations in factors explaining changes in soil physico-chemical properties at depth 0-15 cm, 15-30 cm and 30-50 cm. Also more of physical parameters were responsible for variation in soil properties at top soil (0-15 cm) while at the sub soil (15-30 cm and 30-50 cm) more of chemical parameters were responsible for variations in soil properties on the dump sites in both seasons. It was further observed that % sand, % OM and % silt in both seasons decreased with increasing depth with the exception of % clay which increased with increasing depth. The study showed that changes in soil physico-chemical characteristics at dump sites could be attributed to combination of interactions from different soil properties rather than a single soil factor which could be harnessed for planning and decision making for a better managed environment.

Key words: Municipal solid wastes, dump sites, soil properties, depth, wet, dry season and planning implications.

Introduction

There has been a dramatic increase in the level of awareness and concern about the state of the global and local environment in recent decades prompted by the growing body of evidence on the extent to which pollution has caused severe environmental changes (Hagerty *et al.*, 1973; Alloway and Ayres, 1997; White *et al.*, 1997; Oyedele *et al.*, 2008). A common feature amongst the developed and underdeveloped human society is "waste generation". Waste is a by-product of development but of concern is the way it is managed. Developed countries have put in place structures and institutions to deal with their waste problems but the developing countries have not and that is why it is a cause of great concern (Okpala, 1994). This problem of waste management is pronounced in the third world due to acute shortage of manpower, lack of equipment and their maintenance (Feachem *et al.*, 1983; NEST, 1991). Solid waste has therefore accumulated in most Nigerian cities forming mountains of heaps that disfigured the city's image creating an eyesore; blocking streets; damming rivers and causing floods; producing a stench and tremendous health hazards. The problem with MSW is that it contains heavy metals such as Cd, Zn,Cu and Pb which end up in the soil as the sink as they are leached out from the dump sites and difficult to clean (Alloway and Ayres, 1997; Pivetz, 2001; Oyedele, *et al.,* 2008). The situation of MSW disposal is really pathetic in Ife East Local Government Area, as there is acute shortage of manpower and lack of basic equipment for collection, transportation and disposal in an environmentally sound manner hence, it is just dumped. Effective and efficient waste management requires sustainable management of waste (Oyediran, 1994). Sustainable development calls for efficient management of resources, which requires effective waste generation, and management (incineration, recycling, sanitary land filling and composting (Akingbade, 1991).

Municipal solid waste comprises waste from diverse sources dumped together such as residential, offices, agricultural, institutional, industrial and commercial activities, mining and mineral and miscellaneous waste. Municipal solid waste management is inadequate and ineffective in most parts of Nigeria as confirmed by the Federal Environmental Protection Agency (FEPA, 1992). The ugly sights and the foul smell from the mounts of rubbish on the streets, drains and undeveloped plots welcome most visitors to most of our towns and cities which may end up in the soil. As a result of the adsorptive and buffering properties of soils, some pollutants have long half-lives in the soil. Therefore, food crops grown on these polluted soils may be affected by some of the pollutants for centuries even millennia because soil is difficult and expensive to clean up (Alloway and Ayres, 1997). The objectives of the study are to examine the effects of municipal solid waste open dump on soil physico-chemical properties.

Statement of the problem

The Nigerian Environmental Study Action Team (NEST, 1991) observed that there has been a phenomenal increase in the volume of solid waste generated daily in Nigeria within the past few years due largely to increasing rate of population growth, urbanization, industrialization and general economic growth. NEST (1991) estimated that 2.2 million tones of garbage per year was produced by 110 million Nigerians and when projected using the 1991 census figures of 88.5 million, then 19 million tones were generated in 1994. Nwankwo (1991) estimated that solid waste accumulation in Nigerian cities stood at 200 metric tones per year and 6 million metric tones in the next 20 years. Available data on the estimated and projected volume of solid waste generation shows that it could almost double the current rate by the end of the present century (Federal Ministry of Housing and Environment 1982) and that household waste constitute up to 70% of solid waste generation in Nigeria.

Oyediran (1994) also observed emerging environmentally disastrous trends with an army of scavengers made up of youths and adults who struggled to make up for life amongst goats, dogs and pigs on refuse dumps. These set of persons are exposed to toxic and dangerous chemicals and could suffer from skin diseases and reproductive abnormalities (like abortion and deformed babies). He noted further that these refuse mountains block motorable raods, build up on rivers banks and swamps, emit foul odours and serve as breeding ground for pathogenic agents. Solid waste helps in transmission of bacteria, viral and parasitic causing agents like *Trichiuris trichiuria* and *Ascaris*, with parasitic *lumbricoides* being the commonest (Ologhobo, 1994; Oyediran, 1994).

Integrated solid waste management

One of the most environmental sound management methods that could attempt to solve the solid waste problems in Nigeria proposed by UNEP 2004 is the "Integrated Municipal Solid Waste Management System". Chapter 21 of Agenda 21(a blueprint for global actions to support the transition to sustainable development) of the United Nations Conference on Environment of Rio de Janeiro 1992 addresses specifically environmental sound management of solid waste and related sewage issues. It identifies the basis for action and means of implementation to support the Rio declaration. It looks forward to maintaining the quality of the Earth's environment by attempting to change unsustainable patterns of production and consumption (Westlake, 1995; White *et al.*, 1997). Integrated municipal solid waste management has identified four major waste-related programs areas; minimizing waste, maximizing environmentally sound waste re-use and recycling; adoption of cleaner production technology to promoting environmentally sound waste disposal and treatment and extending waste coverage services. It seeks further, to stabilize or reduce the production of waste destined for final disposal over an agreed time frame, by formulating goals based on waste weight volume and composition and to introduce separation to facilitate waste recycling and re-use. To strengthen and increase national waste re-use and recycling systems, it further employed National government to "according to their capabilities and available resources sought technical assistance from United Nations and other relevant organizations. All the components of the integrated approach are aimed at improving landfill operations, which is regarded as the most sound waste management practice if well operated.

Soil and Heavy Metals

The word soil is derived through "old French" from Latin "Solum" which means floor or ground. Generally soil refers to the loose surface of the earth as distinguished from solid rock (Thien and Graveel, 1997). Many people, when they think of the word soil have in mind that material which nourishes and supports plants growth. This means that soil will include rocks, water, snow and even air-all of which are capable of supporting plant life (Foth and Turk, 1972). A farmer has a more practical concept of soil and looks at soil as the medium in which crops grow. To the Civil Engineer and planner, soil is the material, which supports foundations, roads or airport runway and other physical developmental structures.

According to Wild (1995) soil is seen as life sustaining pedosphere and that it has exceptional high content of solid components in relation to liquid and gaseous components and it has strong influence on evolutionary and ecological processes. He stated further that apart from being the medium for plant growth, it acts as filter for drinking water and sink for pollutants. Comprehensively, soil can be looked upon as a vital resource for sustaining two basic human needs, a quality food supply and a livable environment (Thien and Graveel, 1997). From an environmentalist eyes, soil is the interface between the atmosphere and lithosphere. It is where we live as a home and in addition to being a resource for food production, the soil collects and purifies water and disposes of wastes. Soil can be a pollutant as dust in the air and as sediment in water. The environmentalist in utilizing the soil should take into consideration all the aspects which affect man's life, including the quality of the environment especially the threats posed by heavy metals.

Heavy metals generally is a collective term used for a group of metals and metalloids with an atomic density greater than 6 g/cm^3, is gradually emerging as a source of silent environmental metal poisoning in sub humid tropical soils (Nriagu, 1988; Shuman,1999; Ademoroti, 1996; Alloway and Ayres, 1997). It is mostly applied to elements such as Cadmium (Cd), Chromium (Cr) Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb), Zinc (Zn), which are associated with pollution and toxicity problems which are very difficult to clean (Pivetz, 2001; Wilkin, 2007). Generally heavy metals pollution can affect all environments but its effects are most long lasting in soils because of the relatively strong adsorption of many metals onto the humic and clay colloids. The duration of contamination may be for hundreds or thousands of years, for instance; half-lives; Cd 15-1100 years, Cu 310-1500 years and Pb 740-500 years depending on the soil type and their physico-chemical parameters. Unlike organic pollutants which will ultimately decompose, metals will remain as metal atoms although their speciation may change with time as the organic molecules binding them decompose or soil conditions change (Alloway and Ayres, 1997). It should be noted further that Pb and Cu tend to be adsorbed most strongly while Zn and Cd are usually held more weakly, which implies that these later metals are likely to be more liable and bioavailable (Alloway and Ayres 1997; Huang Li-hua and Sun Wei-min, 2004; Gasu, 2006). Generally, it has been observed that all metals are most soluble and bioavailable at low pH and therefore toxicity problems are likely to be more severe in acidic environments (Alloway and Ayres, 1997).

Methodology

Study Area

The study was conducted in Ife East Local government area latitudes $7^0\ 27^1$ and $7^0\ 32^1$N and longitudes $4^0\ 22^1$ and $4^0\ 29^1$ E, Osun State, Southwestern Nigeria (Fig. 1). The climate of this area could be identified to be humid tropical environment characterized by marked wet and dry season, typical of South West Nigeria. The rainy season covers a period of seven to nine months with double rainfall maxima. The mean annual rainfall recorded from the meteorological station in Teaching and Research farm of Obafemi Awolowo University (OAU) Ile-Ife and corroborated by the meteorological station Osogbo for this area is 1196 mm and may be higher due to orographic effect (Smyth and Montgomery, 1962). The soil found in this area is classified as the Iwo association. The soils of the Iwo association are developed from coarse-grained rock materials, derived from coarse-grained granitic rocks and gneisses. The normal soils of this series are sedentary characterized by dark brownish gray clayey sand to very clayey fine sand (loamy sand to sand loamy) top soils (Smyth and Montgomery, 1962).

Sample Collection

A total of 90 soil samples were purposively collected from 4 dump sites and a control across two seasons (wet and dry) using the Dutch Stainless steel Auger in composite replicate at different depths of (0-15 cm), (15-30 cm) and (30-50 cm) after scrapping and removing debris. Four of the five sites were municipal solid waste dump sites purposely selected from the densely populated areas of the local government where refuse generation was high. Each sample site was divided into four quadrats each 3 m^2 and a total 9-15 cores soil per quadrat were collected from three of the four quadrats randomly, homogenized in three clean plastic buckets before three sub samples were collected and taken to the laboratory for analysis.

Sample Preparation/Analytical procedure

In the laboratory the subsamples were air dried, crushed and passed through a 2 mm sieve and the less than 2 mm particles retained for laboratory analysis for organic matter, pH, exchangeable cations, particle size analysis and heavy metals. The particle size analysis was determined by the hydrometer method (Bouyoucos, 1962) with sodium hexametaphosphate (calgon) as the dispersing agent, organic matter was determined by chromic acid oxidation method (Walkley and Black, 1934), exchangeable bases were extracted with ammonium acetate at pH 7 and the Ca, Na and K contents of the extracts were determined with a Jenway flame photometer while Magnesium was determined using Perkin Elmer Atomic Adsorption Spectrophotometer (AAS). The soil pH was measured as described by Hendershot *et al.* (1993). Heavy metals were extracted using a mixture of 1 ml HNO_3 and 3 ml of HCl (*aqua regia*) and the content heated on a hot plate in a fume cupboard to dryness at 1000°C, allowed to cool and leached with 0.5 M HCl before analysis using a Perkin Elmer AAS. Statistical analysis made use of Analysis of Variance (ANOVA) at 5% level of significance ($P<0.05$), was carried out on the physico-chemical properties of soils. Means were separated using Duncan New Multiple Range Test (DNMRT) with the aid of SAS software package.

Results and Discussion

The concentration of heavy metals in the soils showed wide variations between samples. This was indicative of the heterogeneous distribution of heavy metals in the sampled soils conforming to the views of kim *et al.* (2002); Alloway and Ayres, (1997); Oyedele *et al.* (1995); Oyedele *et al.* (2008).

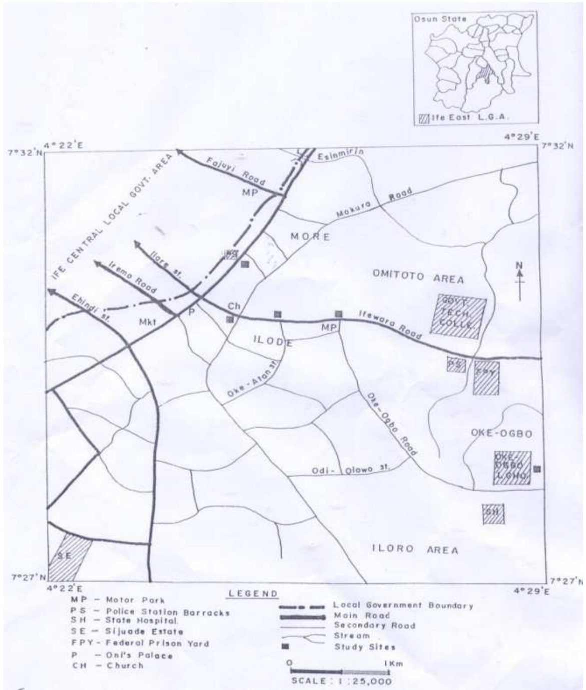

Fig:1. Map of Ife East Local Government showing the study sites. Source: Reproduced by Author from map of Ife East Local Government.

Variation of soil textural properties, exchangeable bases, and heavy metals with depth in both wet and dry seasons.

Table 1 shows the variation in the exchangeable bases, textural properties, and heavy metals with depth in the dry season. There were no significant changes in the parameters measured between the depth 0-15cm, 15-30cm and 30-50cm in the dry season except for % Organic Matter (OM) 3.5 and 4.8, Na with values of 0.79 Cmol Kg^{-1} and 0.102 Cmol Kg^{-1}, Ca with mean values of 11.6 Cmol Kg^{-1} and 13.8 Cmol Kg^{-1} and Pb with mean values of 17.7 $\mu gg^{-1}$and 29.8 $\mu gg^{-1}$where significant differences existed in the dry season. The natural occurring concentrations of heavy metals in the soil ranged from, Cd 0.03 to 0.3μgg^{-1}, Pb 2 to 20 μgg^{-1}, Cu 0.1to 3 μgg^{-1} and Zn 1 to 40 μgg^{-1} (Stewart *et al.*, 1974). These values were significant though lower than those found occurring naturally in the soil except for Pb, which was significantly higher, but lower than the tolerable/ critical levels of 100 μgg^{-1} Pb, which can be considered as phytotoxically excessive (Pendias and Pendias, 1984). The threshold values are 300 μgg^{-1} Zn, 100 μgg^{-1} Pb, 100μgg^{-1} Cu, and 3 μgg^{-1} Cd (Pendias and Pendias, 1984).

Table: 1 Variation of soil textural properties, exchangeable bases, and heavy metals along the soil profile during the dry season.

Depth	pH	%Sand	%Silt	%Clay	%OM	{K	Na	Ca	Mg}	{Zn	Pb	Cu	Cd}
							Cmol Kg^{-1}				$\mu g g^{-1}$		
0-15	7.2^a	65.6^a	12.2^a	20.5^b	$4.8a^b$	2.2^b	0.79^b	14.8^b	7.9^a	2.0^a	23.8^a	0.49^a	0.08^a
15-30	7.1^a	65.5^a	11.3^a	21.8^b	4.0^a	2.1^b	0.94^{ab}	13.3^{ab}	7.2^a	2.6^a	38.3^{ab}	0.23^b	0.08^b
30-50	7.1^a	59.9^b	11.5^a	28.3^a	3.5^b	3.1^a	0.102^a	11.6^a	7.6^a	2.1^a	51.2^b	0.37^{ab}	0.06^a

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.

Table: 2 Variation in textural properties, exchangeable bases, and heavy metals along the soil profile during the wet season.

Depth	pH	%Sand	%Silt	%Clay	%OM	{K	Na	Ca	Mg}	{Zn	Pb	Cu	Cd}
			%				Cmol Kg^{-1}				$\mu g g^{-1}$		
0-15	6.9^a	67.9^a	14.0^b	19.9^b	3.0^a	2.2^a	0.50^a	13.2^b	6.2^a	2.2^a	17.7^b	0.45^a	0.04^a
15-30	7.0^a	66.5^a	12.7^a	22.1^b	3.1^{ab}	1.9^a	0.63^{ab}	14.0^a	6.1^a	1.4^{ab}	28.1^a	0.42^a	0.05^a
30-50	6.9^a	60.9^b	12.5^a	27.7^a	2.7^b	2.0^a	0.75^b	14.8^a	6.4^a	2.1^a	29.8^a	0.29^b	0.04^a

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.

Similarly, in the wet season no significant variations in the mean values of the parameters at different depths were observed except for the following % silt, Na and Cu (Table 2). Furthermore, it was observed that % silt, K, % OM, and Mg content all reduced with depth which is in line with studies by Alloway, *et al.* (1997) while clay, Ca and Pb increased with depth. This shows that Pb and Ca are very mobile down the profile in the wet season than dry season which may be due to precipitation and other soil characteristics such as pH, complexing ligands, redox potential and other soil chemistry (Puls *et al.,* 1991; Mclean and Bledsoe, 1992; Wilkin, 2007; Oyedele, *et al.*, 2008).

Significant differences existed in the distribution of Cu and Zn in the wet season (Table 2), which can be attributed to leaching conforming to observations of earlier studies by Hodgson, (1963), Alloway and Ayres, (1997); Loneragan *et al.* (1981) and Gasu, 2006. Results further illustrate that the concentrations of Cu and Zn decreases with increasing soil depth which means that it is adsorbed most strongly on soil colloids which is in line with Hodgson, (1963); Alloway and Ayres, (1997) who observed that Cu and Zn are among the least mobile of the trace elements. Furthermore, Cavallaro and McBride (1978) suggested that Cu might be retained in the soil through exchange and specific adsorption mechanism. Hickey and Kittrick (1984); Kuo *et al.* (1983); Tessier *et al.* (1980) found out that the greatest percent of the total Zn in polluted soils is readily adsorbed by clay minerals. It has been observed by most of the above-mentioned scholars that the behaviour of these metals in the soil depend on soil pH, properties of the metals, redox conditions, soil chemistry, organic matter content, clay content, cation exchange capacity, and soluble ligands in the surrounding fluid.

The soil pH did not show significant differences along the profile from one depth to the other which ranged from pH of 7.1 to 7.2 in the dry season, 6.9 to 7.0 in the wet season which were similar to earlier values of 4.0-8.5 by Alloway and Ayres (1997). The results therefore showed that the soils were generally acidic a typical characteristic of tropical soils, which can increase the concentration of metals in the soil solution and probably leached down the profile or be taken up by plants roots. The pH of the soil is a very important parameter, directly influencing sorption/desorption, precipitation/dissolution, complex formation, and oxidation-reduction reactions and maximum retention of cationic metals which occurs at pH > 7 while anionic occurs at pH < 7 (Mclean and Bledsoe, 1992; Pivetz, 2001; Wilkin, 2007) which is within the range of this study. The soil can be classified as sandy clay loam with high % OM which plays a very important role in adsorption reactions in the soil thereby buffering pollutants from contaminating ground water sources (Puls *et al.,* 1991; Mclean and

Bledsoe, 1992; Oyedele *et al.*, 2008). Sandy soils with low organic matter content may allow pollutants to leach through them, which may pollute ground water sources.

Significant differences existed in the mean values of the parameters across the two seasons with the exception of % sand and % clay where no significant differences were observed (Table: 3).

Table: 3 Mean seasonal variability of soil texture, exchangeable cations and heavy metals

Seasons	pH	%Sand	%Silt	%Clay	%OM	{K	Na	Ca	Mg}	{Zn	Pb	Cu	Cd}
							Cmol Kg^{-1}					μgg^{-1}	
Wet	7.1^{a}	63.7^{a}	13.1^{a}	23.5^{a}	2.9^{b}	2.1^{b}	0.88^{a}	12.9^{b}	6.2^{b}	2.3^{a}	37.7^{a}	036^{b}	0.08^{a}
Dry	7.0^{b}	65.1^{a}	11.6^{b}	23.2^{a}	4.1^{a}	2.5^{a}	0.63^{b}	13.9^{a}	7.5^{a}	1.9^{b}	25.2^{b}	0.39^{a}	0.04^{b}

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.

Summary and Conclusion

The study revealed that municipal solid waste dump sites vary in their physico-chemical properties from one dump site to the other. It was observed further that percentage sand, percentage organic matter and percentage silt (physical properties) in both seasons decreased with increasing depth with the exception of percentage clay which increased with increase in depth in both seasons due to eluviation resulting from the high precipitation in the region. Soils of the dump sites were found to be enriched with heavy metals (Zn, Cu and Cd) more than the adjacent soils (control) but were still within the tolerable/ critical level, with the exception of Pb which had a higher value but not above the critical value of $100\mu gg^{1}$ (Pendias and Pendias, 1984). It was also revealed by the study that no single soil variable was responsible for the variation of soil properties directly but rather a combination of the variables, which is in line with earlier studies by Oyedele *et al.* (1995).

Recommendations/Planning Implications

The planning implications show that a successful Municipal Solid Waste Management System (MSWMS) depends on adequate financing, qualified manpower, enabling legislation and a supporting institutional and environmental policy. Adequate regulations regarding domestic solid waste management already exists in Nigeria in the National Policy on Environment (FEPA, 1989) and S .51-National Environmental protection (FEPA, 1991), management of solid and Hazardous waste Regulations (Akinbami *et al.*, 1996), now National Environmental Standard and Regulation Agency (NESREA, 2007). What is left to be done now is their strict implementation. The planning implications show further that a successful MSWMS would require change in the mentality and attitude of the citizenry (where they must take responsibility to pay for the waste they generate), the way government institutions are currently operated and the recognition of the role of an effective MSWMS in a region, city or country's sustainable development. Phytoremediation, which is the use of plants or plant products to restore or stabilize contaminated sites, should be further investigated to establish those plants that extract more heavy metals (hyper accumulators) so that they can be used as a cost-effective and environmental friendly means of restoring contaminated soils before use.

References

Ademoroti C. M. A. 1996. Environmental Chemistry and Toxicology, Foludex press Ltd Ibadan, 17-24.

Akinbami J. F., Akinwumi I. O., Salami A. T. 1996. A paper on Implications of Environmental Degradation in Nigeria, Natural Research Journal, United Nations 20 : 349-431.

Akingbade T. 1991. Nigeria on Trail of the Environment. Desktop publishing Triple 'E' System Associate Ltd Lagos.

Alloway B. J., Ayres D.C. 1997. Chemical Principles of Environmental pollution, Blackie Academic and Professional, 53-359.

Bouyoucous G. J. 1962. Hydrometer Method Improved for Making Particle Size Analyses of Soils. Agro. 54, 464 pp.

Cavallaro N., McBride M.B. 1978. Copper and cadmium adsorption characteristics of selected acid calcareous soils. Soil Sci. So. Am. J. 42: 550-556.

Feachem R., McGarry. M., Mara D. W. 1983. Waste and Health in Hot Climates. John Wiley and sons Ltd, 320-364.

Fedearal Ministry of Housing and Environment 1982. The State of the Environment in Nigeria, monograph No 2, FMHE.

FEPA 1991. Federal Environmental Protection Agency Decree 1992, FEPA Abuja, 1-238.

FEPA 1992. The Federal Environmental Protection Agency1988.

Foth H. D., Turk. L. M. 1972. Fundamentals of Soil Science, John Willey and sons Inc, London, 1-12, 27-45, 127-189.

Gasu M.B. 2006. Physico-chemical Properties of Soils Under Municipal Solid Waste Open Dump Sites in Ife East Local

Government Area of Osun State, Nigeria. M.Sc. Thesis Institute of Ecology and Environmental studies, OAU, Ile-Ife, 4-169.

Hagerty D. J., Pavoni J. L., Heer J. E. 1973. Solid Waste Management Van Nostrand Reinhold Co, New York.

Hendershot W.H., Lalande H., Duquette M. 1993. Soil reaction and exchangeable acidity. In: M.R.Carter (ed.) Soil sampling and methods of analysis Canadian Society of Soil Science. Lewis Publishers, Boca Raton, FL, 141–145.

Hickey M.G., Kittrick J.A. 1984. Chemical Partitioning of Cadmium, Copper, Nickel, and Zinc in the Soils and Sediments Containing High Levels of Heavy Metals. J. Environ. Qua. 13 : 372-376.

Hodgson J. F. 1963. Chemistry of the Micronutrient Elements in Soil. Advances in Agron. 15: 119-159.

Huang Li-hua, Sun Wei-min 2004. Adsorption of Pb II on Sediment of the Dianshan Lake: Adsorption Models and Kinetics. Journal of Shanghai University (English Edition), 8(3) : 364-368.

Ju-Yong kim., Kyoung-Woong kim., Jong-Un, L., Jin-Soo, L., Jenny C. 2002. Assessment of As and Heavy metal contamination in the vicinity of Dukum Au-Ag Mine Korea. Environmental Geochemistry and health 24 : 215-227.

Kabata Pendias A., Pendias H. 1984. Trace Elements in Soils and Plants. CRC press, Boca Raton FL, 315pp.

Kuo S., Heilman, P. E., Baker, A.S. 1983. Distribution and Forms of Copper, Zinc, Cadmium, Iron, and Manganese in Soils Near a Copper Smelter. Soil Sci. 153 : 101-109.

Loneragan J.F., Robson, A.D., Graham R.D. (ed). 1981. Copper in Soils and Plants. Sidney, Academic Press, 1981, 265-85.

McBride M.B. 1981. Forms and Distribution of Copper in Solid and Solution Phases of Soil, Copper in Soils and Plants, Loneragan. J. F, Robson. A. D and Graham (ed), Academic press publishers, 24- 42.

McLean J.E., Bledsoe B.E. 1992. Behaviour of Metals in Soils in Ground Water Issue: EPA/540/S-92/018. U. S. EPA Robert S. Kerr Environ. Res. Laboratory, Ada, 1-20.

NESREA 2007. National Environmental Standards Regulation Enforcement Agency (Establishment) Act, 2007.

NEST 1991. Nigeria's Threatened Environment, National Profile of Nigerian Environmental Study / Action TEAM (NEST), Ibadan, 58- 69.

Nriagu J.O. 1988. A silent Epidemic of Environmental Metal Poisoning. Environ. Pollution 50 : 139-161.

Nwankwo C. I. C. 1991. Solid Waste Management. General Views at a Glance at the Nigerian Mining and Geology. Proceedings of the 3rd Annual Celebration and 27th Annual Conference. The Nigerian Mining and Geo-science Society, Nigeria. Vol. 22 No. 2, 219-222.

Okpala D. C. I. 1994. Institutional Problems in Management of Nigerian Urban Environment, NISER Monograph series, No.15, NISER Publication Ibadan, Nigeria, 68-77.

Ologhobo A. 1994. Strategies for Efficient Waste Disposal in Nigeria Proceeding of NEST Annual workshop in 1994, NEST Ibadan, 119 –124.

Oyedele D.J., Obioh I.B., Adejumo J.A., Oluwole A.F., Aina P.O., Asubiojo O.I. 1995. Lead Contamination of Soils and Vegetation in the Vicinity of a Lead Smelter in Nigeria. Sci. Total Environ. 1732 : 189-195.

Oyedele D. J., Gasu M. B., 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. Environmental Sci. Technology 3: 107-115.

Oyediran A.B.O. 1994. Waste Generation and Disposal in Nigeria a keynote Address Presented at a Workshop on Waste Generation and Disposal in Nigeria NEST Annual conference, NEST Ibadan, 95-100.

Pivetz B. E. 2001. Phytoremediation of Contaminated Soil and Ground Water at Hazardous Waste Sites. EPA/540/S-01/500 U.S.EPA Robert S. Kerr Environ. Res. Center Ada, OK 74820, 1-36.

Puls R. W., Powell R. M., Clark D., Paul C, J. 1991. Facilitated Transport of Inorganic Contaminants in Ground Water: Part II Colloidal transport. EPA/600/M-91/040. U. S. EPA Robert S. Kerr Environmental Resource Laboratory, Ada.

Smyth A. J., Montgomery R. F. 1962. Soil and Land Use in Central Western Nigeria, Government printers, Ibadan, Nigeria, 10-84.

Shuman L.M. 1999. Organic Waste Amendments Effect on Zinc Fractions of Two Soils. J. Environ. Qua. 28 : 1442-1447.

Stewart E. A., Grimshaw, H. M., Parkinson, J. A., Quarmby C. 1974. Chemical Analysis of Ecological Materials Blackwell Scientific publications, 13-54, 93-116, 119-234.

Tessier A., Campbell P.G.C., Bisson M. 1980. Trace Metal Speciation in the Yamaoka and St. Francois Rivers (Quebec). Ca. J. Earth Sci. 17 : 90-105.

Thien S.J., Graveel J.G. 1997. Laboratory Manual for Soil Science, Agricultural and Environmental Principles. McGraw-Hill Companies, Inc. USA, 1-24.

UNEP 2004. United Nations Environment Programme, "International Source Book on Environmentally Sound Technologies (ESTs) for Municipal Solid Waste Management (MSWM)" Technical Publication UNEP.

Walkley A., Black, I.A. 1934. An Examination of the Degfjaref method for Determining Soil Organic Matter and a Proposed Modification of the Chromic Acid Titration Method, Soil Sci. 37: 9-38.

Westlake K. 1995. Landfill waste Pollution and control, Albion publishing Great Britain, 1-17 and 26-41.

White P., Franke M., Hindle P. 1997. Integrated Waste Management: A life Inventory. Blackie Academic and Professionals, London, 1 – 15.

Wild A. 1995. Soil and the Environment: An Introduction. Cambridge University press, 109-165.

Wilkin R. T. 2007. Metal Attenuation Processes at Mining Sites. USEPA, Ground Water and Ecosystems Restoration Division of the National Risk Management Research Laboratory, Office of Research and Development, U.S. Environmental Protection Agency, 919 Kerr Research Drive, Ada, Oklahoma 74820, 1-13.

Appendix

Table 4: Variation in some physical properties and exchangeable cations at depth 0-15 cm on different dump sites during the wet season.

Site	pH	%Sand	%Silt	%Clay	%OM	{Ca	Mg	K	Na}
						Cmol Kg^{-1}			
A	7.7^{a}	64.7^{a}	16.0^{a}	19.3^{ab}	2.7^{b}	12.5^{ab}	7.3^{a}	1.5^{b}	0.98^{a}
B	7.1^{b}	63.3^{a}	14.7^{a}	22.0^{a}	3.1^{a}	13.8^{ab}	6.1^{ab}	1.7^{b}	0.75^{ab}
C	7.4^{ab}	61.7^{a}	15.3^{a}	23.0^{a}	3.5^{a}	14.2^{ab}	6.7^{ab}	1.5^{b}	0.75^{ab}
D	7.3^{ab}	69.3^{a}	14.7^{a}	16.0^{b}	3.6^{a}	9.7^{b}	5.5^{b}	2.3^{b}	0.99^{a}
E	5.5^{c}	69.0^{a}	9.3^{b}	22.0^{a}	2.3^{b}	18.8^{a}	5.3^{b}	4.0^{a}	0.49^{b}

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.

Table 5: Variation in some physical properties and exchangeable cations at depth 0-15 cm on different dump sites during the dry season.

Site	pH	%Sand	%Silt	%Clay	%OM	{Ca	Mg	K	Na}
						Cmol Kg^{-1}			
A	7.5^{a}	62.7^{a}	17.3^{a}	20.0^{ab}	6.2^{a}	14.9^{a}	10.4^{a}	3.1^{a}	0.59^{ab}
B	7.3^{a}	71.7^{a}	10.0^{bc}	18.3^{b}	4.5^{ab}	14.5^{a}	8.5^{ab}	1.7^{b}	0.57^{ab}
C	6.6^{ab}	68.7^{a}	11.7^{bc}	19.7^{ab}	5.0^{ab}	14.3^{a}	8.8^{ab}	1.8^{b}	0.65^{a}
D	7.3^{a}	70.7^{a}	14.0^{ab}	15.7^{b}	5.0^{ab}	10.3^{a}	7.3^{b}	2.7^{ab}	0.51^{b}
E	6.0^{a}	66.3^{a}	8.0^{c}	25.7^{a}	3.0^{c}	11.8^{a}	4.2^{c}	1.9^{b}	0.57^{ab}

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.

Table 6: Variation in some physical properties and exchangeable cations at depth 15- 30 cm on different dump sites during the wet season.

Site	pH	%Sand	%Silt	%Clay	%OM	{Ca	Mg	K	Na}
						Cmol Kg^{-1}			
A	7.7^{a}	62.0^{b}	18.0^{a}	20.0^{ab}	4.2^{a}	15.3^{a}	5.9^{bc}	1.4^{b}	0.91^{ab}
B	7.2^{a}	68.0^{ab}	12.3^{ab}	19.7^{ab}	2.9^{b}	11.7^{b}	5.9^{bc}	1.5^{b}	1.15^{a}
C	7.4^{a}	61.3^{b}	13.0^{ab}	25.3^{a}	3.9^{ab}	10.5^{b}	6.5^{b}	2.8^{a}	0.96^{ab}
D	7.4^{a}	71.3^{a}	12.7^{ab}	16.0^{b}	3.6^{ab}	13.5^{ab}	5.3^{c}	1.8^{b}	1.08^{a}
E	5.8^{b}	64.3^{ab}	16.0^{b}	7.7^{c}	1.1^{c}	15.3^{a}	7.0^{a}	2.2^{ab}	0.59^{b}

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.

Table 7: Variation in some physical properties and exchangeable cations at depth 30-50cm on different dump sites during the dry season.

Site	pH	%Sand	%Silt	%Clay	%OM	{Ca	Mg	K	Na}
						Cmol Kg^{-1}			
A	7.6^{a}	55.3^{b}	16.0^{a}	28.7^{b}	4.7^{a}	15.3^{ab}	10.4^{a}	3.7^{a}	0.90^{a}
B	7.3^{a}	61.7^{ab}	14.0^{ab}	24.3^{b}	3.6^{a}	12.2^{b}	9.5^{a}	3.3^{a}	0.52^{b}
C	7.2^{a}	64.0^{ab}	9.0^{b}	27.0^{b}	4.4^{a}	20.5^{a}	8.4^{ab}	2.3^{ab}	0.67^{ab}
D	7.3^{a}	70.3^{a}	14.7^{ab}	15.0^{c}	3.7^{a}	10.5^{b}	6.4^{b}	2.4^{ab}	0.59^{b}
E	5.3^{b}	53.0^{c}	3.7^{c}	43.3^{a}	1.3^{b}	17.2^{ab}	3.4^{c}	3.7^{a}	0.62^{ab}

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.

Table 8: Variation in some physical properties and exchangeable cations at depth 30-50 cm on different dump sites during the wet season.

Site	pH	%Sand	%Silt	%Clay	%OM	{Ca	Mg	K	Na}
						Cmol Kg^{-1}			
A	7.7^{a}	58.3^{ab}	16.3^{a}	25.3^{b}	3.9^{ab}	10.5^{ab}	5.9^{a}	1.5^{ab}	0.96^{ab}
B	7.1^{a}	55.7^{ab}	12.3^{ab}	32.0^{ab}	2.1^{b}	11.3^{ab}	6.4^{a}	1.8^{ab}	1.04^{a}
C	7.4^{a}	57.7^{ab}	12.0^{ab}	30.3^{ab}	4.2^{a}	8.7^{b}	6,7^{a}	1.9^{ab}	0.75^{b}
D	7.4^{a}	69.3^{a}	17.3^{a}	13.3^{c}	1.8^{c}	14.3^{a}	6.4^{a}	2.5^{a}	1.09^{a}
E	5.8^{b}	58.7^{ab}	4.7^{c}	40.3^{a}	1.3^{c}	13.3^{a}	6.8^{a}	2.2^{a}	0.67^{b}

Means with the same letters are not significantly different from each other at $p<0.05$ according to New Duncan Multiple Range Test.