ISSN: 3065-0380

Columbia Journal of Agricultural and Environmental Sciences

Research Article

SOIL POLLUTION ASSESSMENT LINKED TO WASTE DISPOSAL IN NSUKKA ENVIRONMENT

Ngozi Amaka Eze

Department of Soil Science and Land Resource Management, Faculty of Agricultural Science, University of Nigeria Nsukka, Enugu state, Nigeria.

DOI: 10.5281/zenodo.19626693

Abstract

Rapid urban growth and population increase in Nigeria have exacerbated the problem of solid waste management, resulting in widespread environmental challenges. Studies indicate that household waste generation in Nigeria ranges between 0.44 and 0.66 kg per person per day, with an estimated annual solid waste production of approximately 45 million tonnes. This high volume of waste is often improperly disposed of, accumulating along roadsides, commercial areas, and even within educational institutions. In Southeastern Nigeria, particularly Enugu State, improper disposal of industrial, domestic, and agricultural waste has become a significant environmental concern. Soil, as a vital component of the ecosystem, plays a crucial role in supporting food production, water filtration, carbon sequestration, and biodiversity. The interaction between waste disposal and soil quality is critical, as unregulated dumping can lead to soil contamination, reduced fertility, and long-term environmental degradation. This study evaluates the health of soils in relation to waste disposal sites at the University of Nigeria, Nsukka, with the aim of understanding the impact of solid waste on soil properties and ecosystem services. The findings provide insight into sustainable waste management practices and strategies for preserving soil functionality in urban and peri-urban environments.

Keywords: Soil Health, Waste Disposal, Solid Waste Management, Environmental Impact, Nigeria

1. INTRODUCTION

Solid waste problem in Nigeria began with a rapid increase in urban growth, partly due to a growing population and rising immigration status (Adisa and Mogaji, 2016). Waste management has been a major problem in Nigeria, especially since independence (Baynes, 2019). According to Ayuba *et al*., (2013), the density of household waste in Nigeria ranges from 280-370 kgm^{-3}per annum. According to a study conducted by Adekunle *et al*., (2017*)*, the average household waste generation rate in Nigeria is estimated to be between 0.44 and 0.66 kg person^{-1}day^{-1}. The daily waste generation rate in Nigeria is indeed estimated to be between 0.49-0.65 kg/capita/day, depending on the location and level of urbanization, *(*Akunnaya *et al*., and 2021). Additionally, an annual production volume of solid waste in Nigeria to be approximately 45 million tonnes, which is equivalent to 25 million pieces based on an assumed average weight of 1.8 kg per piece. This collaborates heaps of waste littered throughout the landscape, road sides and commercial areas, even in the realm of primary, secondary and higher educational institutions around the country.

In Southeastern Nigeria, especially in Enugu state, waste management is becoming an increasing daily problem and a complex task. Millions of tons of solid waste from various sources (industrial, domestic and agricultural) are disposed in the ground. Soil is a complex and dynamic natural system that provides essential services, such as food production, water filtration, carbon sequestration, and biodiversity conservation, to humans and the environment. However, soil can also become contaminated and degraded due to human activities, including the disposal of solid waste. Solid wastes come from various sources, including households, businesses, construction sites, and industrial operations. Food waste, for example, is a common source of solid waste found in landfills and other disposal sites. The decomposition of organic food waste releases methane potent greenhouse gas that contributes to climate change, and whose flammability could pose a danger to local residents, (Rong *et al.*, 2015). Construction waste, commercial waste, and sludge from water treatment plants and air pollution control equipment are also sources of solid waste that can end up in soil. These wastes can contain various contaminants, including heavy metals, organic chemicals, and pathogens, that can pose a significant threat to the environment and human health if not properly managed. Over time, the accumulation of contaminants can lead to soil degradation, groundwater pollution, and potential exposure of toxins to humans and wildlife. Hence, the disposal of solid waste in soil poses a significant environmental and health concern that requires proper management and disposal practices to minimize the negative impacts on soil quality and human health. Different categories of waste have its specific time to degenerate. For instance, organic waste such as vegetable and fruit peels, leftover food stuff, etc takes a week or two to degenerate, while paper takes ten to thirty days to degenerate.

Open or accidental dumping of waste is a common practice among low- and middle-income people in many developing countries (Salami *et al.,* 2014). Such indiscrimination of waste may degrade the environment; pollute soil and water resources, and pose a potential health to plant, animals and humans (Baderna *et al.*, 2011). Landfills can be a significant source of air pollution due to various factors such as unpleasant smells, methane eruptions and fires, dust and windblown waste, and pests like worms and flies. These factors can potentially impact the health of nearby residents and workers. Additionally, cultural activities that involve improper disposal of hazardous and industrial waste can lead to soil contamination, *(*EPA, 2018). Solid waste also causes nuisance and significant environmental pollution through the production of both biogas and leachate (Aronsson *et al.*, 2010). The leaching of heavy metals in disposal sites is increasing, posing a significant threat to the environment and human health by World Health Organization (WHO 2010). When solid waste is disposed in soil, it can contaminate the soil and groundwater through a process known as leaching. Leachate is typically produced in landfills from the decomposition of organic matter and other waste materials that are deposited in the landfill. As precipitation, such as rain or snow, infiltrates through the landfill, it comes into contact with the decomposing waste, generating leachate. The leachate can contain a range of pollutants and has the potential to contaminate surrounding soil and groundwater if it is not properly managed (EPA, 2018). Due to leaching, infiltration, and seepage, soil around dumpsites can be contaminated with heavy metals such as lead, copper, zinc, iron, manganese, chromium, and cadmium. These heavy metals in solid waste lead to serious problems because they are not biodegradable. Heavy metals in soil can alter the soil chemistry and have an impact on soil microorganisms and some plant species that depend on the soil for nutrition (Nganje *et al* 2007). Ideriah *et al.* (2005) noted that the concentration of heavy metal in soil around waste dumps are influence by types of wastes, topography, runoff and level of scavenging of heavy metals by plants and other organisms.

Studies have shown evidence of in-situ and spatial contamination of soil at dumpsites and allied locations of waste disposal (Adeyemi *et al., 2016).* Other studies have shown that soils from solid waste dump sites were rich in soil nutrients (nitrogen, phosphorus, potassium, calcium, magnesium and sulfur) which are released into the soil as organic matter decomposes, while soils from municipal waste dump site are higher in heavy metals-such as lead, cadmium, copper, chromium and zinc (International Journal of Environmental Research and Public Health 2020*).* Municipal waste dump sites are designed for the disposal of household and commercial waste generated within a specific jurisdiction, while solid waste dump sites can handle a wider range of waste materials, including hazardous and non-hazardous materials from various sources. Refuse dumps can also impact soil biodiversity, potentially reducing the abundance and diversity of soil organisms. A recent study recorded significantly lower diversity of soil mites and springtails in soils near a landfill site than in control soils, indicating a negative impact on soil biodiversity (Mwamuka *et al.*, 2020). It was also recorded that soils near a landfill site had significantly lower carbon sequestration potential than soils in non-dumpsite areas, indicating a negative impact on this important ecosystem service (Adekunle *et al.*, 2021).

The University of Nigeria, Nsukka Enugu State, Nigeria, was established in 1955 as the first indigenous university in Nigeria. In terms of waste management, the University of Nigeria Nsukka generates a significant amount of waste on a daily basis due to its large population of students, staff, and visitors. This waste includes both solid and liquid waste, such as food waste, plastic bags, paper, bottles, and other items. According to a study conducted by Okeke and Ezeudu (2019), the university generates approximately 3.6 metric tons of solid waste daily, with an average waste generation rate of 0.45 kg/capita/day. This waste is disposed through a combination of methods, including open dumping, burning, and burial in pits. The study also found that waste segregation and recycling practices at the university were limited, with most waste being disposed of in an unsustainable manner. Years ago, the university has taken steps to improve its waste management practices, such as the establishment of a waste management committee, and the construction of a waste transfer station for the sorting and collection of waste. Presently there is indiscriminate disposal of waste in an open field such Odim, Awolowo hostel, SUB (Student Union Building) etc. These wastes are carried away by wind littering the environment with dirt up to 20cm away from the site and the unpleasant odor affects the students and residence living around.

The major operational shortcomings observed at the Nsukka University landfill site were the lack of sanitary facilities, the lack of staff and supervision of day-to-day activities, and the lack of tools and equipment needed to perform regular cleaning operations (Nwachukwu *et al.*, 2017). Consequently, environmental pollution, health hazard, increased operating cost and negative impact of the university reputation. Hence, the significant of this study is to elucidate to the University of Nigeria Nsukka governing council, the environmentalist and other policy makers the impact of indiscriminate refuse disposal on possible soil degradation and environmental pollution.

This work aimed at assessing the impact of refuse dump on soil physicochemical characteristics and assesses the degradation status of the soils.

Materials and method

Study area

The study was conducted in the dumpsites within University of Nigeria, Nsukka, Enugu state, Southeastern Nigeria. Odim-gate dumpsite is located after Eni-Njoku hostel and the site has been used for refuse dump for over ten (10) years according to the residents or inhabitants living around there. It lies within geographical coordinates of latitude N6°52 and longitude E7°24 with an altitude of 400 m and the control site which is adjacent to the dumpsite is 50 m away and lies between latitude N6°52 and longitude E7°24 with an altitude of 400 m. Odim residence wastes, wastes from building sites around Odim, some condemned metallic and plastic materials, farm residues etc are usually dumped on the site and burnt during dry season.

Fig 1: Cross-section of Odim Dumpsite

Faculty of engineering dumpsite is located at the back UNN Chitis restaurant, besides Abuja building. The site has been used for refuse dump for over six (6) years and refuse from engineering canteens, chemistry and physics laboratory are been dumped there. It undergoes burning during dry season. The area lies within latitude N6°52 and longitude E7°24 with an altitude of 419 m and the control site which is adjacent to the dumpsite is 50 m away. The control site lies within latitude N6°51 and longitude E7°24 with an altitude of 421m.

ISSN: 3065-0380

Columbia Journal of Agricultural and Environmental Sciences

Research Article

Fig 2: Cross-section of Engineering Dumpsite

Collection of soil sample

At the location, both disturbed and undisturbed soil samples were collected from three points in the dumpsite at two depths; 0-20cm and 20-40cm. The disturbed and undisturbed soil samples were collected using soil auger and core samplers respectively. A total of 24 soil samples (disturbed and undisturbed) were collected and labeled appropriately. The soil samples were taken to the Department of Soil Science undergraduate laboratory for preparation and analysis.

The disturbed soil samples were air-dried. Thereafter, the soil samples were crushed and sieved through 2.00mm mesh and used for the determination of soil chemical properties, heavy metals concentration and particle size distribution. The undisturbed core samples were trimmed and saturated for 48 hours and used for saturated hydraulic conductivity, bulk density, and porosity determination

PHYSIOCHEMICAL ANALYSIS

Saturated Hydraulic conductivity

The undisturbed core samples were trimmed to the height of the cores and saturate for 24-48 hours in a bowl containing water, the saturation weight was taken and hydraulic conductivity was carried out for 5 minutes interval until three consecutive steady state flows was obtained. The core samples were also subjected to tension of 60cm and oven dry at temperature 105°C and weight was taken. The hydraulic conductivity was calculated using Darcy's equation.

$$\mathrm{Ksat}\ (\mathrm{cm\ h^{-1}}) = \frac{Q}{AT} * \frac{L}{\Delta H} \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

Where Q is steady-state volume of flow (cm),

Published by Keith Publication

A is cross sectional area (cm^3),
L is length of core sample (cm),
t is change in time interval (h), and
ΔH is hydraulic head change (cm).

Total porosity

The total soil porosity was calculated as the function of the total volume not occupied by soil solid assuming a particle density of $2.65 Mgm^{-3}$, using the formula below (Danielson and Sutherland, 1986).

$$\text{Porosity (\%)} = \left(1 - \frac{Db}{Dp}\right) 100; \;\ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where Dp= particle density, assumed to be $2.65 Mgm^{-3}$ and Db=bulk density.

Bulk density

The soil core samples that have been used for the determination of hydraulic Conductivity will be saturated, weighed, oven dry at temperature of 105°C for 24 hours and weigh again as described by Blake and Hartage (1986).

$$\text{Bulk density } = \frac{\text{oven−dried mass of soil in megagrams}}{\text{volume of cylinder in cubic meter}} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots \;(3)$$

Particle size distribution

Soil particle size distribution was determined by the Bouyoucos Hydrometer method using sodium hydroxide (NaOH) or Sodium Hexametaphosphate (Calgon) as dispersing agent

Soil pH

The pH of the soil was determined in duplicate of water and 0.1N KCL solution at the soil-liquid ratio of 1:2.5 (Cezary *et al.*, 2016.) The mixture will be stirred intermediately for 30 minutes; the pH values were taken using a glass electrode pH meter (Mclean, 1982).

Organic Carbon (OC)

Soil organic carbon (SOC) was determined by the modified Walkey and Black wet digestion and oxidation method (Nelson and Sommers, 1996).

$$\text{\% Organic Carbon} = \frac{(B-T)\times N \times 0.003 \times 1.33}{Weight\ of\ sample} \times \frac{100}{1} \;\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \;(4)$$

Where, B= Blank Titre Value, T =Sample Titre Value, 1.33 = Correction factor, and N is the concentration of ferrous sulphate. The percentage organic matter was calculated by multiplying the organic carbon value by the conventional "Van Bernmeler" factor of 1.724 (Adepetu *et al.*, 2000).

Total Nitrogen (TN)

Total nitrogen was determined using the Micro-Kjelhal of distillation method as described by (Bremner, 1996). The ammonia from the digestion was distilled with 45 % NaOH into 2.5 % boric acid and determined by titrating with 0.05N KCl.

Exchangeable bases (EB)

Exchangeable bases were determined by leaching the soil with 1N pH7, solution. Exchangeable calcium and magnesium was determined from the extract by EDTA titration. Exchangeable Sodium and Potassium was extracted using IN ammonium Acetate (NH4 OAC) solution and determined by the use of a flame photometer (Van Reeuwijk, 2002).

Effective Cation exchange capacity (ECEC)

Effective Cation exchange capacity (ECEC) was determine by the summation of exchangeable bases (EB) and exchangeable acids (EA).

Exchangeable Acidity (EA)

It was determined by the titration method using 1KCl. Extract of Mclean (1982) was used to determine exchangeable hydrogen and aluminum (H^+ and Al^{3+}).

Available phosphorus (Av.P)

Available phosphorus was extracted using Bray-2 following the procedure described by (Juo *et al;* 1996). Available phosphorus extract was determined by blue color method (Murphy and Riley, 1962).

Analysis of heavy metals in soils

Heavy metals content of Iron (Fe), Zinc (Zn), and lead (Pd) of all the dumpsite soil samples was be analyzed using Atomic Absorption Spectrophotometer (AAS)

Data analysis

A two-way analysis of variance (ANOVA) in RCBD with Genstat statistical package Ninth (9th) edition was used to analyze the physiochemical properties of the soils obtained from the dumpsite soils and its control site. Permissible limits of heavy metals in agricultural soil recommended by WHO was used to assess the degradation status of the soil studied.

RESULT AND DISCUSSION

Physical properties of the soil obtained from the soil under study

Generally, the textural class of the soil in Odim dumpsite showed dominance of sand fraction compare to clay and silt. The sandy nature of the area could be attributed to the parent material (Coastal plain sand) and climate which is in line with the findings of Akamigbo, (1999) and Wang, (2001). The texture of the soil samples were sandy, sandy loam and loamy sand. This is an indication of soil property derived from parent materials or the geologic processes that contributed to their formation. These soils are similar to those derived from unconsolidated coastal plain sand.

The soil bulk density was significantly higher in the control soils of the two location compared to the dumpsites (Odim control =ENG control >odim and ENG dumpsite). The low bulk density observed in the dumpsites could be as a result of higher pore spaces, which is consistent with the report by Igwe (2001). Across the locations, the saturated hydraulic conductivity was significantly higher in the Odim control soil > Odim dumpsite = ENG dumpsite =ENG control. Saturated hydraulic conductivity is a measure of how well the soil transmits water under saturated conditions (Marshall *et al.*, 1996) and the higher conductivity implies that the soil in Odim control site transmits water better under saturated condition. Also the saturated hydraulic conductivity was higher in the Sub soil (20-40) than the top soil (0-20). This could be due to the activities of soil organisms in the sub soil. Percentage total porosity (% TP) follow similar trend with bulk density this is in line with Naghdi *et al.*, (2016), who related that soil porosity is strongly influence by soil bulk density.

Table 3a: Particle size distribution of the soils under study

Location	Depth (cm)	% Clay	% Silt	% sand	Total	Textural class
Odim dumpsite	0-20	13.67	3.67	82.66		SL
	20-40	16.33	4.33	79.33		SL
Odim control	0-20	15.67	3.00	81.33		SL
	20-40	19.00	3.67	77.33		SL
CV (%)		11.10	12.81	2.52		
ENG dumpsite	0-20	15.00	7.67	77.33		SL
	20-40	13.00	3.67	83.00		LS
ENG control	0-20	16.33	5.67	78.00		SL
	20-40	21.67	6.33	72.00		SCL
CV (%)		19.4	24.67	5.03		
Grand CV (%)		30.5	37.48	7.55		

Note: SL= Sandy loam, LS= Loamy sand, SCL= Sandy clay loam, CV= Coefficient of variance, ENG = Engineering.

Table 3b: Main effect of location on soil physical properties

Location	Bulk density (g/cm^3)	Ksat (cm h^{-1})	%Total Porosity
Odim dumpsite	1.56	15.29	41.32
Odim control	1.67	19.70	36.54
ENG dumpsite	1.53	14.39	42.52
ENG control	1.63	14.17	38.37

P-value	0.00	0.01	0.01
LSD	0.06	3.17	3.60

Table 3c: Main effect of soil depth on soil physical properties

Location	**Bulk density (g/cm^3)**	**Ksat (cm h^{-1})**	**% total Porosity**
Top soil (0-20)	1.59	14.61	40.41
Sub soil (20-40)	1.61	17.16	38.61
P-value	NS	0.03	NS
LSD	NS	2.24	NS

Note: ENG= Engineering, Ksat= Saturated hydraulic conductivity, P-value=Probability value, LSD= Least significant different.

Table 3d: Interaction effect of location and soil depth on soil physical properties

Location	**Depth (cm)**	**Bulk density(g/cm^3)**	**Ksat (cmh^{-1})**	**%Total porosity**
Odim dumpsite	0-20	1.64	12.80	40.50
	20-40	1.48	17.78	42.14
Odim control	0-20	1.65	17.68	37.11
	20-40	1.70	21.72	35.97
ENG dumpsite	0-20	1.46	13.64	44.91
	20-40	1.60	15.15	40.13
ENG control	0-20	1.60	14.32	39.12
	20-40	1.65	14.01	37.61
P-value	L × soil depth	0.00	NS	NS
LSD	L × soil depth	0.09	NS	NS

Note: ENG=Engineering, Ksat =Saturated Hydraulic conductivity, P-value= Probability value, LSD = Least significant different.

Chemical properties of the soil obtained from the soil under study

Table 4 shows the chemical properties of the soils. The soil pH was significantly higher in the ENG dumpsite > Odim dumpsite = ENG control = Odim control. The pH for Odim dumpsite was observed to range from slightly alkaline to neutral while its control is from neutral to slightly acidic. The pH for ENG dumpsite ranges from moderately alkaline to slightly alkaline and its control ranges from slightly alkaline to neutral. The high pH can decrease the ability of the soil to retain essential cation (positively charged ions like calcium, magnesium, and potassium) on it exchange sites. Also certain minerals become less soluble in alkaline soils, potentially leading to the precipitation minerals calcium carbonate. High pH can also affect soil microorganism negatively. The higher pH of the dumpsites corroborates with earlier reports on dumpsites by Uba *et al.* (2008) and Obasi *et al*. (2012).

The percentage soil organic matter content of the soil was observed to be statistically similar across the locations. Top soil (0-20) was significantly higher than the sub soil (20-40), also similar observation was also obtained in organic matter content of the soil. Soil organic matter enhances the usefulness of soils for agricultural purposes. It supplies essential nutrients and has unexcelled capacity to hold water and absorb cations. It functions as a source of food for microbes and thereby helps to enhance and control their activities (Brady *et al.*, 1990). Ayolagha and Onwugbuta (2001) reported that high organic matter (> 2.0 %) in soils is conducive for heavy metal chelation formation. This could be due to the decomposition of organic wastes by soil microbial activities that has led to increase in the soil organic matter contents which serve as major source of nitrogen and phosphorus for plant growth (Obute *et al.*, 2010, Amos-Tautua *et al.*, 2014). Changes in the mean values of total nitrogen, magnesium and available phosphorus was not significantly ($P \leq 0.05$) influenced by the mean effect of the soil on the location, soil depth and the interaction of location and soil depth**.** Across the soil depth hydrogen was not significant in the soil while across the location hydrogen was significantly higher in the Odim control< ENG control = Odim dumpsite = ENG dumpsite. The higher hydrogen in the control sites could be due the higher pH on the two dumpsites.

Across the locations, the aluminum content in the soil was significantly higher in the Odim control > Odim dumpsite = ENG dumpsite = ENG control. The higher aluminum content in Odim control could be attributed to the higher pH value. Also the aluminum was higher in the sub soil (20-40) than the top soil. Across the location, the Calcium content in the soil was significantly higher in Odim dumpsite = ENG dumpsite > ENG control < Odim control. This higher calcium content in the dumpsite soil can also be attributed to the type of waste that is dumped on the site, waste from cements which is high in calcium compound was observed.

According to Landon (1991) Ca/Mg values less than 12.0 indicate low fertility. This low fertility probably due to intense land use practice and excessive loss of Ca through leaching by the high tropical rainfall (Landon, 1991, Onweremadu, 2007). Addition of lime and organic manure can be used to supply Ca and improve soil fertility on the control land site used for agriculture (Uzoho *et al.*, 2007). Also there was significantly different in soil depth of calcium content, it is higher in the top soil than the sub soil; this could due to the direct accumulation of the high calcium content material. The sodium content in the soil across the location was statistically similar, but across the soil depth it was statistically higher in top soil than the sub soil. According to USDA 2007, the desired value for Na ranges from 0.3-0.7mg/kg. This shows that both soils are not above the desired value for Na in agricultural soils. The potassium content in the soil depth was observed to be significantly different across the soil depth, Top soil is higher than the subsoil; this could be due organic matter decomposition, which releases potassium as it decomposes. Across the soil depth, the Effective cation exchange capacity was higher in the top soil than sub soil. The cations (Ca^{2+}, Mg^{2+}, Na^+ and K^+) was higher in the top soil than sub soil. However, ECEC is the summation of all the cations. Also top soil has more organic matter content which contains negatively charge sites that attract and hold cations thereby contributing to a higher ECEC.

Table 4a: Main effect of location on soil chemical properties

LOC	**pH (H_2O)**	**pH (KCl)**	**OC**	**OM**	**TN**	**AV.P**	**H^+**	**Al^{3+}**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**	**ECEC**
			→	**% ←**		**(ppm)**	→			**cmol kg^{-1}**	←		
OD DS	7.80	6.95	1.49	2.56	0.05	28.1	1.60	0.23	1.90	1.10	0.06	0.12	5.24
OD CT	6.62	5.30	1.00	1.72	0.04	27.7	2.17	0.33	0.73	0.87	0.02	0.05	4.17
ENG DS	8.12	7.32	0.87	1.50	0.05	33.3	1.40	0.20	1.77	0.77	0.03	0.07	4.24
ENG CT	7.48	6.63	1.10	1.90	0.05	30.5	1.70	0.20	1.40	1.07	0.04	0.10	4.51
P-value	0.00	0.00	NS	NS	NS	NS	0.02	0.00	0.03	NS	NS	NS	NS
LSD	0.45	0.46	NS	NS	NS	NS	0.47	0.07	0.79	NS	NS	NS	NS

Note: OD= Odim, DS = Dumpsite, CT= Control, ENG = Engineering, P-value= Probability value, LSD= Least Significant Different, LOC= Location, OC =Organic carbon, OM= Organic matter, TN =Total nitrogen, AV.P= Available phosphorus, H= Hydrogen, Al= Aluminum, Ca= Calcium, Mg= Magnesium, Na= Sodium, K= Potassium, ECEC= Effective cation exchange capacity.

Table 4b: Main effect of soil depth on soil chemical properties

Location	**pH (H_2O)**	**pH (KCl)**	**OC**	**OM %**	**TN**	**AV.P (ppm)**	**H^+**	**Al^{3+}**	**Ca^{2+}**	**Mg^{2+} cmol kg^1**	**Na^+**	**K^+**	**ECEC**
Top soil 0-20	7.55	6.63	1.47	2.47	0.05	29.6	1.83	0.20	1.80	1.00	0.05	0.11	4.99
Sub soil 20-40	7.56	6.48	0.80	1.37	0.05	30.2	1.60	0.28	1.10	0.90	0.02	0.06	4.08
P-value	NS	NS	0.01	0.01	NS	NS	NS	0.00	0.02	NS	0.01	0.01	0.05
LSD	NS	NS	0.48	0.83	NS	NS	NS	0.05	0.56	NS	0.02	0.02	0.91

Note: OC= Organic carbon, OM= Organic matter, TN= Total nitrogen, AV.P= Available phosphorus, H= Hydrogen, Al= Aluminium, Ca= Calcium, Mg= Magnesium, Na= Sodium, K=Potassium, ECEC= Effective cation exchange capacity, LSD= Least significant different, P-value= Probability value, KCL= Potassium chloride, NS = Not significant.

Table 4c: Interaction effect of location and soil depth on soil chemical properties

Location	**Soil depth (cm)**	**pH (H_2O)**	**pH (KCl)**	**OC %**	**OM %**	**TN %**	**AV. P (ppm)**	**H^+**	**Al^{3+}**	**Ca^{2+}**	**Mg^{2+}**	**Na^+**	**K^+**	**ECEC**
								cmol/kg						
Odim Dumpsite	0-20	7.77	6.97	1.88	3.25	0.05	27.67	1.60	0.20	2.27	1.07	0.07	0.13	5.34
	20-40	7.83	6.93	1.09	1.88	0.05	28.60	1.60	0.27	1.53	1.13	0.04	0.10	5.14
Odim Control	0-20	6.73	5.53	0.98	1.69	0.04	28.60	2.27	0.20	0.80	0.73	0.03	0.07	4.10
	20-40	6.50	5.07	1.02	1.75	0.04	26.74	2.07	0.47	0.67	1.00	0.01	0.03	4.24
ENG Dumpsite	0-20	8.23	7.43	1.51	2.60	0.04	33.27	1.47	0.20	2.53	0.87	0.05	0.10	5.22

	20-40	8.00	7.20	0.23	0.40	0.07	33.26	1.33	0.20	1.00	0.67	0.01	0.04	3.25
ENG Control	0-20	7.47	6.57	1.36	2. 34	0.06	28.91	2.00	0.20	1.60	1.33	0.06	0.12	5.31
	20-40	7.50	6.70	0.84	1.46	0.05	32.02	1.40	0.20	1.20	0.80	0.03	0.07	3.70
P- value	L*S.D	NS	NS	NS	NS	NS	NS	NS	0.00	NS	NS	NS	NS	NS
LSD	L*S.D	NS	NS	NS	NS	NS	NS	NS	0.09	NS	NS	NS	NS	NS

Note: ENG = Engineering, OC= Organic carbon, OM= Organic matter, TN= Total nitrogen, AV.P= Available phosphorus, H= Hydrogen, Al= Aluminium, Ca= Calcium, Mg= Magnesium, Na= Sodium, K=Potassium, ECEC= Effective cation exchange capacity, LSD= Least significant different, P-value= Probability value, KCL= Potassium chloride, NS = Not significant.

Concentration of heavy metals in the soil under the study location

Across location, the Iron (Fe) concentration in the soil from the studied area was significantly higher in the Odim control > Odim dumpsite > ENG control = ENG dumpsite. The Odim dumpsite higher than the ENG dumpsite, this could be due to the type of waste (condemn metals) being disposed in odim dumpsite. Concentration of Fe from the control soil was higher than the dumpsites, this is in line with (Ezeaku 2000) Nsukka soils are well-drained ferallitic sandy clay loam soil. Also across the depth there was no significant different observed.

The Zinc (Zn) concentration across location was significant higher in the Odim dumpsite > ENG control > ENG dumpsite = Odim control. Zinc concentration was higher in soil from Odim dumpsite than the ENG dumpsite. The high concentration of zinc at odim dumpsite soil suggests that the source is anthropogenic instead of natural. This is in line with similar study conducted by Aswathanarayana (1995). Also the zinc was higher in the top soil (0-20) than the sub soil (20-40).

The Lead (Pd) concentration in the soil from both locations was not detectable at some replications; this could be as a result of high rainfall intensity and leaching. This implies that there was no contamination of lead in the soil under the study location. Based on the results obtained, it was observed that there was significantly increase of heavy metal concentration in both dumpsites in Zn<Fe<Pb. Generally the concentration of Zinc, Iron and Lead in both dumpsites was lower than the permissible limit of heavy metal in soil recommended by WHO.

Table 5a: Main effect of location on heavy metals

Location	Iron (Fe)	Zinc (Zn)	Lead (Pd)
	→	mg/kg	←
Odim dumpsite	3.32	3.73	
Odim control	4.35	2.43	
ENG dumpsite	2.20	2.91	
ENG control	2.95	3.33	
P- value	0.01	0.05	
LSD	1.04	0.92	

Table 5b: Main effect of soil depth on heavy metals

Location	Iron (Fe)	Zinc (Zn)	Lead (Pd)
	→	mg/kg	←
Top soil 0-20	3.23	3.52	
Sub soil 20-40	3.18	2.69	
P-value	NS	0.02	
LSD	NS	0.65	

Note: ENG =Engineering, P-value =Probability value, LSD= Least significant different.

Table 5c: Interaction effect of location and soil depth on heavy metals

Location	Soil depth (cm)	Iron (Fe)	Zinc (Zn)	Lead (Pd)
		→	mg/kg	←
Odim dumpsite	0-20	2.85	4.00	ND
	20-40	3.79	3.47	0.04
Odim control	0-20	4.72	2.13	0.03
	20-40	3.79	2.73	0.04
ENG dumpsite	0-20	2.11	4.60	0.04
	20-40	2.29	1.22	ND
ENG control	0-20	3.23	3.33	0.05
	20-40	2.67	3.33	0.03
P-value	Location* soil depth	NS	0.00	

LSD	Location* soil depth	NS	1.29

Note: ND= Not detected, ENG = Engineering, LSD = Least significant

Conclusion

This study has tried to investigate the physiochemical characteristics of soils at Odim and Engineering waste dump site in University of Nigeria Nsukka Enugu state of Nigeria. The results presented the physiochemical properties and heavy metal concentration in the soil of the study area. It was observed that Odim textural class was predominantly sandy compare to clay and silt, this type of soil should not be used for dumpsite as it has high infiltration rate. Odim dumpsite soil was higher in bulk density, saturated hydraulic conductivity, total porosity, hydrogen, aluminum and calcium. This shows that soil from Odim dumpsite will be more fertile than the ENG. The heavy metals are found in the decreasing order of Pd<Fe<Zn in the two dumpsites. The results showed low levels of these heavy metals from the dumpsites when compared with the permissible limit of heavy metal in soil recommended by WHO. The concentration of heavy metal on Odim dumpsite was higher than on Engineering dumpsite. Lead (Pd) could not be detected the implying that the concentration of this metal was below detection limit or not present at all. The concentration of heavy metal in the dumpsite appears not to pose serious environmental problems at the moment; however accumulation of these metals may later pose a threat to human health and the environment.

REFERENCE

Adekunle, I.M., Ihuoma, J.U. and Akinbile, C.O. (2021). Evaluation of carbon sequestration potential of soils in proximity to landfill site in Ibadan, Nigeria. *Journal of environmental management,* 293, 112909.

Adekunle, M.F., Adetoro, O.O. and Gently, A. (2017). Municipal solid waste management in Nigeria: practices and 10.

Adepetu, J.A., Nabhan, H. and Osinubi, A. (2000). Simple soil, water and plant testing techniques for soil resource management: Proceedings of a training course held in Ibadan, Nigeria. 16-27 September 1996. IITA, Ibadan.

Adeyemi, O. Adeyemo, A. and Awomeso, S. (2016). Assessment of soil quality parameters in and around a municipal landfill site in Lagos, Nigeria. *Environmental Monitoring and Assessment,* 188(7), 404.

Adisa, O.M. and Mogaji, P.B, (2016). *Journal of Environmental Science and Technology,* 9(2), 74-85.

Akamigbo, F.O.R. (1999). *Influence of land use on the soil properties of the humid agro ecology of southeastern Nigeria. Nig. Agric. J.,* 30:59-76.

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.

Aronsson, P., Dahlin, T. and Dimitriou, I. (2010). Treatment of landfill leachate by irrigation of willow coppice plant response and treatment efficiency.'' *Environmental Pollution*, vol. 158, no.3, pp. 795-804.

Aswathanarayana ,U. (1995) Geoenvironment: An introduction. Balkena Publishers, Kumamoto

Ayolagha, G.A. and 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.

Ayuba, K.A., Abd-Manaf, L., Sabrina, A.H. and Azmin, S.W. (2013). Current status of municipal solid waste management practice in FCT Abuja. *Research Journal of Environmental and Earth Scikences,* 5[6]; 295 – 304.

Baderna, D., Maggioni, S., Boriani, E., Gemma, S., Molteni, M., Lombardo, A., Colombo, A., Bordonali, S., Rotella, G., Lodi, M. and Benfenati, E. (2011). A combined approach to investigate the toxicity of an industrial landfills leachate; *Chemical analyses, risk assessment and in vitro assays, Environ. Res*. 111, 503 -511.

Blake, G.R., and Hartge, K.H, (1986). Bulk density. In A. Klute (Ed.), Methods of Soil Analysis, Part 1 (Agronomy No. 9, pp. 330-373). Madison, WI, USA: American Society of Agronomy.

Bremmer, J. M. and Mulvaney C.S, (1982). Total nitrogen In A. L. Page et al. (Eds.), Methods of soil analysis. Part 2. Chemical and microbial properties (2nd ed., Agron. Monog. 9, pp. 595-624). ASA and SSSA Madison, WI.

Cezary, K., Elzbieta, M., Bernard, G., Dorota, L. and Paulina, M. (2016). Conversion of Soil pH 1:2.5 KCI and 1:2.5 H20 to 1:5 H20: Conclusions for Soil Management, Environmental Monitoring, and International Soil Databases. *Pol. J. Environ. Stud*., 25(2), 647-653.

Danielson, R.E. and Sutherland, P.L. (1986). Porosity in A. Klute (Ed.), Methods of soil analysis. Part 1. *Physical and mineralogical methods (2nd ed., Agron. Monog*. 9, pp. 443-461). ASA and SSSA Madison, WI.