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Soil quality dynamics and degradation potentials as influenced by land use systems in humid tropical soil of Southeastern, Nigeria

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ABSTRACT

An assessment of the effects of land use systems on soil quality dynamics and soil degradation potentials in Umuahia, Southeastern Nigeria was done in this study. Samples of soil were taken between 0 and 15 and between 15 and 30 cm. from coconut plantation (SSP_1), palm plantation (SSP_2), pineapple orchard (SSP_3) and waste dump site (SSP_4). The result revealed sand to be the dominant soil fraction in decreasing abundance: Waste dumpsite (WD)≥ Pineapple Orchard (PO) ≥ Coconut Plantation (CP)≥ Oil Palm Plantation (OPP), followed by silt :WD ≥ CP≥ PO ≥ OPP and clay: OPP≥CP≥PO≥WD. Land use systems recorded serious negative effects on soil physicochemical properties, with soil pH ranging between 3.43-7.20, waste dumpsite having neutral and others having less than 6.5-8.5 as the critical limit. The mean values of potentially toxic elements in soils as regard land use systems: Ni, Mn, Fe, Cr, Zn, Pb and Cu were all above the critical limits rendering the soil polluted. The effects of Land-use systems on biochemical indicators of soil degradation ranged from None to slightly (1) -Very highly degraded soils (4), with organic matter (OM) as biological indicator dominating the index. The effect of land use systems on soil degradation was in decreasing trend: WD > CP >OPP> PO constituting 32.5%, 26.7%, 20.8% and 20% respectively. Integrated waste management (IWM) and smart farming techniques should be encouraged for soil quality improvement.

Keywords: Soil quality dynamics; degradation potentials; land use systems

INTRODUCTION

In 2014, the world population grew to 7.2 billion people out of which 5.5 billion people, who were residing in developing nations of the world (Van Pham and Smith, 2014) depended hugely on agriculture for their livelihood (Lal, 2015). International Fund for Agricultural Development, IFAD (2010), claims that one billion out of the 5.5 billion people are small-scale farmers who manage less than two hectares of land and cultivating them for survival. These hectares of land are subjected to continuous use for agricultural produce year

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after year in order to meet up the world's food demand with geometric human population growth. Eventually, soil degradation becomes the resultant effect of the continuous usage of land.

Soil degradation implies the reduction of the physical and chemical fertility of the soil to such a point where it becomes almost impossible to maximize the agricultural productivity of the soil (Ezeaku and Davidson, 2008). The issue of soil degradation is global, and it is a shift in the health of the soil which often reduces the ecosystem's ability to service the goods and services needs of man *(Maximillian and Matthias,*2019). Onet *et al*. (2018), claim that soil degradation can result to the lowering and eventual loss of soil functioning capacity. These can be linked to both natural and anthropogenic factors which have become increasingly serious globally in present times and endangering terrestrial ecosystems and agricultural productivity.

Soil degradation is one issue facing the entire world and which is largely predominant and serious in the tropics and sub-tropics (Lal, 2015), leading to decreased soil ecosystem services estimated to have been reduced to about 60% between 1950 and 2010 (Leon and Osorio, 2014). According to Lamb *et al*. (2005), about five hundred million hectares of land have been impacted by accelerated soil degradation, and 33% of earth's land surface is affected by different types of soil degradation globally (UNEP,1999; Scherr,2001). Arable land loss is happening at a rate that is presently 30-35 times faster than it was in the past. (UNEP, 1999). It had been reported that, as at 50 years ago, over a quarter of the world's arable land has been irreversibly destroyed by human-induced land degradation (Senjobi *et al.,* 2010). Thus, if the process of destruction is not checked, agricultural lands will lose about 15-30% of its current output (FAO, 1984a) accounting loss to land degradation. This loss according to researchers could be due to improper land use systems which consequently lower the level of soil productivity (Senjobi *et al*., 2010; Ubuoh *et al*., 2018). A combination of physical, chemical and biological processes trigger soil degradation processes, or mechanisms. (Pimentel, 2006; Lal, 2009; Gorobtsova *et al*., 2016).

Although many researchers have made efforts in uncovering the processes and effects of soil degradation. Numerous investigations have been carried out regarding the consequences of soil degradation processes, including soil fertility erosion and cultivation. (Senjobi *et al*., 2013, Sotona, *et al.*, 2013), utilizing various soil characteristics as essential parameters in examining rate of soil degradation. However, it appears there are no suitable indices for examination of soil degradation in the tropical environment. It has been also reported that many studies have been on the effects of various land uses on the characteristics of soil and soil fertility, still, there remains inadequate information regarding land degradation and the direct method of assessing it (Graefard, 2000; Ubuoh *et al*., 2018; Ubuoh *et al*., 2021). This indicates that, the significance of an index for evaluating dynamics in the soil related to the use of land systems cannot be stressed enough, as regards agricultural practice. On soil degradation risk, the average degree of water erosion is utilized for assessment (Febles *et al*., 2009). Nitrogen and carbon contents have been evaluated for in physical and chemical assessment of soil parameters (Traoré *et al*., 2015). Again, certain soil quality parameters viz: bulk density, soil texture, pH and organic matter, have also been implicated as markers of deterioration (Tebebu *et al*., 2017). Nevertheless, there isn't clear agreement in scholarly works regarding the markers that should be used to gauge how much land degradation has occurred (Yameogo *et al*., 2019).

Despite the existing studies on soil degradation by authors like Romanov (2009), Kiryushin (2007), Lal (2009), Gorokhova and Kupriyanova (2012), Molchanov (2015), soil degradation causative agents (Zaidel’man, 2009, Babacv *et al.*, 2015), as well as their effect (Pimentel, 2006; Kuznetsova *et al.*, 2009), and the worldwide extent to which crop fields in the majority of the world's principal agricultural regions have lost their soil fertility (Mueller *et al.*, 2010), the global environmental phenomenon of soil degradation persists, with varying interpretations in diverse settings. (Yusuf *et al.*, 2019).

Thus, the task of feeding the world population currently pegged at 7.3 billion (in 2015) and estimated to reach 9.5 billion (by 2050) presents the need to improve agricultural productivity of ~70% between 2005 and 2050 (Lal, 2015). In addition, the increasing rate of land use changes to other uses as witnessed in Umuahia may lead to ecosystem disequilibrium if it is not checked (Nkemdirim *et al.*, 2017**)**, and, improper land use patterns may lead to mixing compatible land uses with incompatible land uses, hence environmental degradation, and drastic decrease in soil productivity that may lead to food insecurity and total hunger.

In line with the foregoing, there is then a need to increase agricultural production if the United Nations’ Sustainable Development Goals 2030 (SDGs) 2, 3, 6, 11, 13, 14, and 15 that specifies goals on explicit evaluation of soil resources (UN, 2015) must be achieved. Protecting soil quality, improving it if possible, and promoting desirable practices are especially crucial other than the use of synthetic fertilizers so as to steer clear of the environmental hazards linked to their usage. Hence, this study therefore focused on assessment of soil quality dynamics and soil degradation potentials by land use systems and practices in the study area. This will guarantee appropriate land use by farmers and land use planners on procedures that guarantee a reduction in soil deterioration for crop yield and environmental sustainability.

MATERIALS AND METHODS

Study Area

Umuahia is Abia state’s capital city situated in South eastern zone of Nigeria (Fig.1, Fig 2), and located on latitude and longitude 5° 52′ 0″ N, 7° 49′ 0″ E (Nkemdirim *et al.*, 2017). The area covers about 40 sq mi (100 km^2). The yearly average rainfall In Umuahia varies from 1568.4mm to 2601.3mm over a ten-year period, with average annual temperature of 26.7^{o}C (Agroclimatic data, 2007; Emeka-Chris, 2014). The yearly average evaporation over the ten- years period is 3.1mm, and the yearly average sun illumination in hours is 4.4 hours, whereas radiation measures 3.9 meters. Due to recurring yearly bush burning, the area's vegetation is primarily secondary forest with derived savannah tendencies. (Aregheore, 2005).

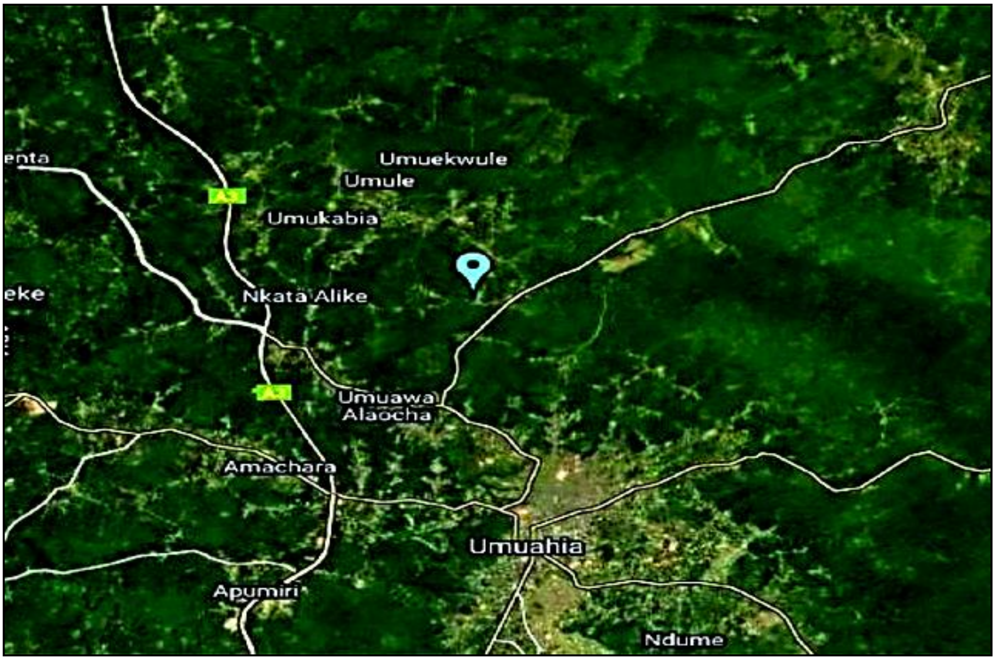

Figure 1: Satellite map of Umuahia in Nigeria showing the study Area (Google Maps, 2022)

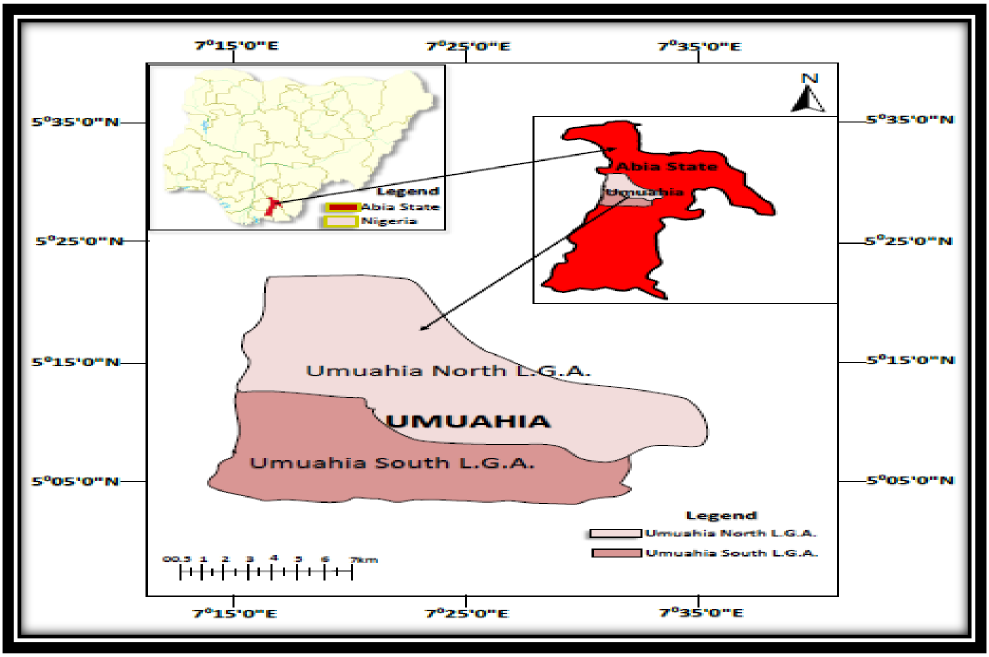

Figure 2: Digital Map of Abia Showing Umuahia as a Study Area

Experimental Design and Soil Sampling

Bearing in mind the purpose of the study, a reconnaissance survey of the area of study was conducted to identify peculiar land use practices in the study area (Table 1). The plantations found in the study area include Coconut plantation (CP), Pineapple Orchard (PO), and Oil Palm Plantation (OPP). The total experimental plot area measures about 450 fts by 270 fts in dimension. These plantations are about 50 to 100 fts apart from each other with each plantation plot section measuring between 80ft/100ft to 40/50ft. sampling was done randomly in triplicates after dividing each plantation plot into 9 blocks and taking 3 samples from each plantation to a total of 9 sample unit for the plantations plus extra 3 for waste dumpsite (which was situate away from the plantation site) resulting in a total of 12 samples for the study. Furthermore, soil bulk samples were collected using soil Auger at 0-15 cm as surface soil and 15-30cm depths as subsurface based on the randomly selected plot units with the help of Global Positioning Systems (GPS) (Table1). Each soil specimen was brought to the lab for examination after being kept in a clearly labeled polyethylene bag.

Table 1: Coordinates of the different types of land use in the research area

Land use Practice	Latitudes	Longitudes
Coconut plantation	5^0 29^1 03. 9^{11} N	7^0 32^1 35. 8^{11} E
Waste dump site	5^0 28^1 40. 4^{11} N	7^0 32^1 42. 7^{11} E
Pineapple orchard	5^0 29^1 06. 2^{11} N	7^0 32^1 21. 5^{11} E
Oil Palm plantation	5^0 29^1 03. 8^{11} N	7^0 32^1 09. 0^{11} E

Preparation of Soil Sample

In the laboratory, prior to analyses, the soil samples that were collected and bagged were put unto heat on drying trays in the drying room for 48 hours in order to split the lumps and guarantee adequate drying (Okeri *et al*., 2007**)**. Following drying, the soil was crushed and made to pass through a 2 mm nylon sieve (the mat left over materials that couldn't pass through the sieve were gotten rid of). The collected ground and fine particles were then put in containers and labeled prior to undergoing an analytical process.

Soil Analyses

The size of soil particles' distribution was ascertained by applying the conventional hydrometer and pipette method. (Allusion, 1973; Kettler *et al*., 2001; Gee and Or, 2002). The pH of the soil was ascertained by means of electrometric method with the aid of a pH meter in a glass electrode and with the use of a distilled H_2O and 0.1N of KCl solution in a liquid ratio of 1:3:5 (Thomas, 2006). Wackley (Blank method) was adopted in determining the content of soil organic matter whereby samples of the soil were collected at 0-15cm and at 15-30cm depths at each sampling point. Wackley method entails a volumetric titration of identified volume of both dichromate solution and soil solution. The Kjeldahl digestion method was used to estimate total nitrogen. (Bremmer 2006). The Bray II method, as outlined by Olson and Sommers, was utilized to determine the available phosphorus. (2002). The exchangeable bases viz Ca, K and Mg were gotten with normal neutral ammonium acetate (NH4 OAC) at a buffer pH value of 7.0 (Thomas, 1982). Exchangeable Calcium and Magnesium were determined in the extract by ETDA titration, while Potassium and Sodium was determined using Flame Photometer (Udo *et al.*, 2009). Exchangeable acidity (H^+) and exchangeable Aluminium (Al^{3+}) were ascertained by means of titrating procedure as outlined by Thomas (1996). Exchangeable acidity (H^+) was subtracted from exchangeable aluminium (Al3+) to obtain exchangeable hydrogen. By adding up each exchangeable base, the total exchangeable bases were determined (Ca, Mg, K, Na). Effective Cation Exchange Capacity (ECEC) was obtained by the summation of all the exchangeable cations and exchangeable acidity (Al^{3+}, H^+). Base Saturation (BS) was obtained by dividing the total exchangeable bases (TEB) by the corresponding effective cation exchange capacity (ECEC) value and multiplied by 100%, as expressed below:

$$\%\ \text{base saturation} = \frac{[(Ca + Mg + K + Na)]\ X\ 100}{ECEC} \qquad (1)$$

The low levels of exchangeable cations are not enough to lower the base saturation, because of the low denominator.

Soil Samples' Potentially Toxic Element Digestion

Toxic elements like Nickel (Ni), Manganese (Mn), Chromium (Cr), Lead (Pb), Iron (Fe), Copper (Cu) and Zinc (Zn), expressed in Mg/kg were determined using the Inductive Couple Plasma – Optical Emission Spectrometry (ICP-OES) with Ultra Sonic Nebulizer (USN)(model: Perkin Elmer optima 3000). The soil specimens were sieved by a membrane filter with pore sizes of 0.45 µm prior to Standard Methods analyses (APHA, 1995) . Microwave digestion techniques were employed to process the samples (Siaka *et al.*, 1998), which entails placing a 0.5 g of each specimen in Teflon vessel with addition of 5ml of Nitric Acid (HNO_3making up about 65%), 2ml of hydrogen peroxide (H_2O_2; making up about 30 %) 2ml of HF (making up about 40 %), with the use of a microwave digestion system (model: MILESTONE mls-1200 mega). After the samples were filtered, an aliquot was taken (about100ml). Using ICP-OES, the total amount of heavy metals in digestion solutions was determined (APHA, 1995). The extraction method was used to analyse the total metal levels by atomic absorption Spectrophotometer. Blanks with every component included in soil samples from different land use types. The chosen toxic elements were ascertained by flame-photometry and heavy metals were determined using an atomic absorption spectrophotometer.

Data Analysis

The data collected from the field were computed and analyzed using one-way analysis of variance (ANOVA) with statistical package for social science (SPSS) v. 21 and separation of means were carried out using Duncan's New Multiple Range Test (DNMRT) according to Steeland Torrie (1980). Also, the data obtained were subjected to Pearson product moment correlation to ascertain the association between the various soil properties.

Land Degradation Assessment

The degree of soil degradation was ascertained with the use of standard gauges and criteria for soil degradation assessment as spelt out by the Food and Agriculture Organization (FAO, 1979). In addition, the interpretation manual for assessing and evaluating analytical data (FAO, 2004) was also used. By comparing the properties of the soil with the indicators of soil degradation, analytical data from every soil sample was categorized into a degradation class. (Table 2, Table 3). The chemical and biological factors were used to estimate the level of degradation.

Table 2: Indicators and standards of soil chemical degradation

Indicator	*Degree of degradation (%)			
	1	2	3	4
Content/Amount of Nitrogen (Multiple decrease) N (%)	>0.13	0.10-0.13	>0.08-0.10	<0.08
Content/Amount of phosphorus Element (mgkg)	>8	7-8	6-7	<6
Content of Potassium Element (cmolkg)	>0.16	0.14-0.16	0.12-0.14	<0.12
Content/Amount of easily Soluble Salts (Increase by %)	<0.20	0.20-0.40	0.40-0.80	>0.8%
	<10	10-25	25-50	>50
Content/Amount of base saturation (decrease of saturation if more than 50%)	<2.5%	2.5-5%	5-10%	>10%
Excess Salts (Salinization) (Increase in conductivity Mmho/cm/yr	<10	2-3	2-5	>5

Ssource: FAO (1979),

Key:

1 = None to slightly degraded soils, 2 = soils that are moderately degraded, 3 = Soils that are highly degraded and 4 = Very highly degraded soils (Table 2)

Table 3: Indicators and standards of biological soil degradation

	*Degree of degradation (%)			
Indicator	1	2	3	4
Content of organic matter in soil (%)	> 2.5	2 - 2.5	1.0 - 2	< 1.0

Source**:** FAO (1979), Snakin *et al*.(1996).

Key:

1 = None to slightly degraded soils, 2 = soils that are moderately degraded, 3 = Soils that are highly degraded, 4 = Very highly degraded soils.

RESULTS AND DISCUSSION

Physical Properties of Soils from Various Land use Practices

The amount of sand content in the soil specimens ranged from 77.30% in the palm plantation to 85.30% in the dumpsite (Table 4) which agrees with 85.80% value of sand content found in solid waste dumpsite in Owerri (Ubuoh *et al.*, 2012) and with a mean value of 81.55 %, less than 778.40(g/kg) of sand observed in oil palm plantation in Owerri West (Ahukaemere *et al.*, 2012). The mean sand content of the dump site was significantly ($P \leq 0.05$) higher than sand content of other land use practices. Several researchers including Ukaegbu *et al*. (2015) and Nwite and Okolo (2017) had initially noted that soils for different land uses in south eastern Nigeria are predominantly laden with sand fraction. The surface sand content of the samples declined as soil depth increased, similar to Aweto and Enaruvbe

(2010) findings in Southeastern Nigeria. In line with the result of the soil fractions, Onwudike (2015) reported that regardless of the land use system in the study area (Southeastern Nigeria), the soils have a high percentage of sand (>70%) and were highly acidic, leading to poor physical conditions like low moisture retention and total porosity. The result of waste dump sites decreases soil quality due to high sandy content, suggesting the composition of high content of non-degradable wastes added to organic waste in the dumpsites. In dumpsites, lowering soil cover makes the soil vulnerable to water and wind erosion (Jiang *et al.*, 2017; Quijano *et al.*, 2017), and Clay and silt from the topsoil are lost when soil is incessantly turned up. (De Rouw and Rajot, 2004; Moussa *et al.*, 2015).

Sand in soil was in decreasing abundance of: Waste dumpsite (WD)≥ Pineapple Orchard (PO) ≥ Coconut Plantation (CP) ≥ Oil palm plantation (OPP). The mean silt content ranged from 5.00% in the palm plantation to 9.00% in the Coconut plantation. The Silt content of the soils was significantly ($P \leq 0.05$) different in the various land use practices (Table 4). The 8.00% silt content in waste dumpsite is greater than 5.10% in Aladinma waste dumpsite in Owerri (Ubuoh *et al.*, 2012). The silt contents in soil due to land use systems were in decreasing order: WD ≥ CP≥ PO ≥ OPP.

Mean Clay content ranged from 6.20% in the dumpsite to 17.20% in the oil palm plantation soil of the study (Table 4). The mean dumpsite value is less than 18.10% in Aladinma dumpsite, 14.10% in Egbeada dumpsite in Imo State (Ubuoh *et al.*, 2012). The clay content of the soils was significantly ($P \leq 0.05$) different in the various land use practices. Clay content in all the land use practices tends to increase with depth in all the soils indicating possible clay migration by eluviation – illuviation process within profiles in the study area (Malgwi, 2001). Clay content was in decreasing abundance of: OPP≥ CP≥PO≥WD.The texture of the soils studied were basically sandy loam and loamy sandy. The results of the particle size distributions (PSD) was in agreement with the findings of Cobo *et al.* (2010), Amuyou *et al.* (2013), Sotona *et al.* (2013), and Senjobi *et al.* (2013), who observed higher clay, silt, and sand composition in cropping lands, but there were insignificant differences in textural properties in relation to different land uses types (Ogidiolu, 2000; Adejuwon, 2008).

Table 4: Effects of various land use practices on soil physical properties

Land Use systems	Soil depth	Soil Fractions			Texture
		Sand %	Silt%	Clay%	
Coconut plantation	0-15 cm	85.80	6.50	10.20	SL
(CP) :SSP_1	15-30 cm	77.30	11.50	10.20	SL
Mean value		81.55 ± 1.47^{c}	9.00 ± 2.00^{a}	10.20 ± 25.00^{b}	
Oil palm plantation	0-15 cm	79.30	3.50	16.20	SL
(OPP): SSP_2	15-30 cm	75.30	6.50	18.2	SL
Mean value		77.30 ± 4.58^{d}	5.00 ± 4.00^{d}	17.20 ± 14.27^{a}	
Pineapple orchard	0-15 cm	83.30	7.50	8.20	SL
(PO): SSP_3	15-30 cm	83.30	6.50	10.20	SL
Mean value		83.30 ± 0.36^{bd}	7.00 ± 5.00^{c}	9.20 ± 0.65^{c}	
Waste dumpsite	0-15 cm	87.30	8.50	4.20	LS
(WD):SSP_4	15-30 cm	83.30	7.50	8.20	LS
Mean value		85.30 ± 0.21^{a}	8.00 ± 1.20^{b}	6.20 ± 0.59^{d}	

Different letters on the same column means there is a significant increase at $P \leq 0.05$ level, SL=Sandy loam, LS=Loamy sandy

Chemical Properties of Soils from Various Land Use Types

Soil pH: The land use systems were significantly different($P \leq 0.05$) with regards to soil pH (Table 5). The table demonstrated that the waste disposal site's neutral soil reaction had a mean value of pH 7.20 which falls within (6.6-7.5) FAO neutrality range (FAO,2004), whereas pineapple orchard with pH 5.43 falls within strong acidity mark by FAO (FAO, 2004) and Palm plantation with pH 3.43 falls within extreme acidity mark by FAO (<4.5 extremely acidic, FAO, 2004). However, coconut plantation with pH4.80 was strongly acidic in concentration (FAO, 2004). In line with the result of the soil fractions, Onwudike (2015) regardless of the land use system in Southeastern Nigeria, the soils were strongly acidic. The release of highly exchangeable bases from municipal waste may be the cause of the neutral to slightly acidic soils found beneath refuse disposal sites. (Ubuoh *et al.*, 2012; Alemayeha and Sheleme, 2013, Ubuoh *et al*., 2016). The moderate acidic nature of the soil for pineapple orchard could be due to the rise in clay amounts emmanating from the removal of topsoil and vegetation from the area. This made the clay contents more likely to release hydrogen ions from their colloidal surface into the solution, lowering the pH of the soil (Oguike and Onwuka, 2017). All the soil samples from land use practices, except waste dumpsite have pH (H_2O) less than the critical level (6.5-8.5) (FAO, 2004). They have acidic pH, less or equal to 5.5. A pH of above 5.5 makes most nutrients available for field crops, according to Landon (1991) and Tisdale *et al*. (1993). The low values of soil pH among land use practices in the study could be caused by leaching and other processes that remove basic cations from the soil even below the sampling depth as well as from runoff generated from accelerated erosion (Ubuoh *et al.*, 2018.). The loss of basic cations increases the activity of H+ and Al3+ in the soil solution, lowering the pH and making the soil more acidic (Akpan and Ofem, 2014).

Available Phosphorus (Available P): The mean soil phosphorus values obtained was highest (40.4mg/l) in oil palm plantation but lowest (25.95mg/l) in the dump site soils (Table 5). Accordingly, coconut plantation recorded 36.80 mg/l of the available phosphorus, with pineapple orchard and solid waste dumpsite having 36.70 mg/l and 25.95 mg/l respectively. The available P. varied significantly among the various land use practices at $P \geq 0.05$ level. Conversely, available phosphorus is above the critical threshold (10-15 mg/l) in soil (Landon (1991). The high amount of available Phosphorous in the study area may be primarily caused by the soil's high levels of background P availability or by the soils' limited ability to fix P (Fisseha and Gebrekidan, 2007; Siéwé *et al.,* 2008).

Nitrogen(N): Total soil nitrogen recorded highest in Palm Plantation and lowest in dumpsite with mean values of 0.18% and 0.11% respectively (Table 5). The total percentage mean soil nitrogen was significantly ($P \leq 0.05$) different among the land uses. The nitrogen content in all soils sampled are below the < 0.3% critical value in line with high organic matter contents (Désiré and Azinwi, 2016). Apart from being significant, the values of total nitrogen in all the land use types were low, this may be as a result of leaching (McCauley, *et al*., 2017). The significantly ($P \leq 0.05$) high nitrogen content of Palm Plantation can be attributed to high clay content in the land use which helps to hold nutrients. Also, the significantly ($P \leq 0.05$) lowest nitrogen content of the dumpsite soils can be attributed to high sand content which encourages leaching of nutrients.

Soil Organic Carbon (SOC): It was observed that the dumpsite soil had the lowest organic carbon content with a mean value of 1.08%, while Pineapple orchard (1.77%) and coconut plantation (1.67%) were observed to have moderate organic carbon content (Table 5). However, palm plantation (2.11%) had the highest organic carbon content (Table 5), above a critical value of 2 percent soil organic carbon that is universally accepted and that explains a significant variation in the functionality of soil properties (Loveland and Webb,2003). The overall mean result of SOC is below the critical threshold of 10 to 15 g/kg(1.0%–1.5%), which is necessary for the reduction of the hazards of soil degradation and strategies for reversing degradation trends (Vanlauwe *et al*., 2012).The very low organic carbon observed within the refuse dump sites is at variant with the findings of Amos-Tauta *et al*. (2014) who revealed extremely high organic matter in waste dump sites in Yenegoa, as a result of the presence of degradable and compostable wastes.

Soil Organic Matter (SOM). The highest soil average organic matter content of 3.21% was observed in Palm Plantation soils while the lowest organic matter content of 1.84% was recorded in the dump site soils (Table 5). It is evident from this that oil palm, because of its canopy-like nature and age, had the highest organic matter contents. The result was further buttressed by Li *et al*. (2013), that increased organic matter and nutrient input from litter fall has a positive impact on soil organic matter and is a reliable indicator of the availability of nutrients in the soil, the improvement of soil qualities, and the prevention of soil erosion. (Nave *et al.,* 2010). Trees can affect soil properties in a variety of ways, including species-specific impacts on the amount and quality of leaf and root litte (Talkner *et al.,* 2009; Wang *et al*., 2011; Kagambèga *et al.*, 2011;). It is possible that the lack of trees at the waste dump site is the cause of the lowest SOM values (Tebebu *et al.*, 2017). The observation is in line with Kassa *et al*. (2017), Gao *et al*. (2017) who found that soil fertility is significantly reduced when forests are converted to other land uses.

The results were consistent with Bizuhoraho *et al*. (2018). The results of SOM fall within <2 to 2.4 critical limits, expressed as very low to low values (FAO,2004). The incessant cultivation of land is linked to the decrease in organic matter content of the topsoil (Ross, 1993; Singh and Singh, 1996), resulting to a decline in productivity (Singh and Singh, 1996). Hence, exposure of soil properties to soil erosion, which is a primary cause of soil deterioration (Ahukaemere *et al*., 2012; Ubuoh *et al.,* 2018).

Exchangeable Bases (EB): The exchangeable bases (Ca^{2+}, $Mg^{2+,}$ K^+, Na^+) such as the mean exchangeable Calcium content of the soils ranged from 4.75Cmol/kg in the pineapple orchard to 11.65cmol/kg in the soils of the dumpsite (Table 5). The Mean Exchangeable Magnesium content of the soils for coconut plantation, Palm Plantation, Pineapple Orchard and Dump Site were 3.20Coml/kg, 2.85Cmol/kg, 3.30cmol/kg and 6.00cmol/Kg respectively. The highest mean Exchangeable Potassium content of the soils was (0.32Cmol/Kg) in Oil Palm plantation soil and lowest (0.14Cmol/kg) in dumpsite soils and coconut plantation. The mean Sodium content of the soils was 0.14Cmol/Kg, 0.17Cmol/Kg, 0.18Cmol/Kg and 0.11Cmol/Kg in Coconut plantation, Palm Plantation, Pineapple orchard and dumpsite respectively. The Ca:Mg ratio is an index of the relative proportion of available calcium and magnesium in the soil. It is globally very low (Ca:Mg< 1.5) to moderately low (1.5 <Ca:Mg< 3.5) corresponding to less favourable ratio, except for one soil sample where this ratio is very favourable (3.5 <Ca:Mg< 6) (Landon, 1991). The low value suggests that there is a significant amount of Mg in the soil solution along with low Ca amount. Calcium is adsorbed by plants as Ca^{2+} (Akpan-Idiok and Ofem, 2014). It's been suggested that the predominance of kaolinite clay in tropical soils' fine earth fraction accounts for their low CEC (Uzoho *et al*., 2007).

Exchangeable Acidity (EA): The mean result of EA indicates that Coconut plantation recorded highest value of 1.19cmolkg$^-$, oil Palm Plantation 0.79cmolkg$^-$, while pineapple Orchard being the lowest had a value of 0.59cmolkg^{-}after waste dumpsite which recorded 0.83cmolkg^{-}.Meanwhile, these values are contrasted with a 2.1–4 cmol kg-1 medium range (Holland *et al*., 1989), they are low. Low values of Ca^{2+} and Mg^{2+} in the study area may introduce Al^{3+} into the soil solution in all the land use types studied, resulting to low exchangeable acidity in the soils (Akpan-Idiok and Ofem, 2014). One possible explanation for the increase in exchange acidity at lower depths could be the elements leaching there as a result of heavy rainfall. (Fatubarin and Olojugba, 2014). The EA showed significant different among land use types at p> 0.05level.

Effective Cation Exchange Capacity (ECEC): Effective cation exchange capacity (ECEC) signifies the summation of all exchangeable bases (Ca^{2+}, $Mg^{2+,}$ K^{+} and Na^{+}). The mean result of ECEC indicates that dumpsite summed up the highest value of 18.70cmolkg, followed by Coconut (11.15 cmolkg^{-}), Oil palm plantation (10.14 cmolkg^{-}), and then pineapple Orchard being the lowest value (9.28 cmolkg^{-}), all the land use types are within the 6-12 cmolkg^{-} ECEC medium critical values (Esu, 1991) except for dumpsite.

Base Saturation (BS): The mean value of BS in coconut plantation 89.13%, oil palm plantation 90.27%, pineapple orchard 93.25% and waste dumpsite 94.76%, all greater than 71.76-87.52% of BS obtained from the SIWES Farm, University of Agriculture Makurdi (Ibrahim and Idoga, 2013), and greater than 80 % (highest critical value) (FAO, 2004).

Table 5: Chemical Properties of Soils under different land use systems in the study sites

=	pH	P(%)	N(%l)	OC(%)	OM(%)	(<------------------------- Cmol/kg------------------- >) CEC				EA	ECEC	BS
						Ca(cmol/kg)	Mg(cmol/kg)	K(cmol/kg)	Na(cmol/kg)			
Coconut palm plantation(Cocos nucifera L.)												
Cp 0-15	4.45	39.50	0.17	1.82	2.30	6.50	3.10	0.13	0.15	1.51	11.01	86.08
Cp 15-30	5.15	34.10	0.13	1.51	2.61	6.90	3.30	0.15	0.12	0.87	11.28	92.17
Mean	4.80±2.40^{c}	36.80±0.27^{bc}	0.15±0.16^{c}	1.67±4.75^{c}	2.46±4.32^{c}	6.70±3.45^{b}	3.20±1.50^{c}	0.14±2.14^{c}	0.14±1.56^{c}	1.19±3.36^{a}	11.15±6.36	89.13±45.80
Oil Palm Plantation (OPP) *Elaeisguineensis*												
PP 0-15	3.40	42.35	0.20	2.40	4.12	5.60	2.40	0.40	0.17	0.87	9.23	90.17
PP 15-30	3.45	38.45	0.15	1.82	2.30	6.20	3.30	0.23	0.17	0.71	11.05	90.37
Mean	3.43±1.53^{d}	40.40±0.36^{a}	0.18±0.17^{a}	2.11±.1.19^{a}	3.21±2.14^{a}	5.90±5.45^{c}	2.85±1.43^{d}	0.32±0.17^{a}	0.17±2.54^{b}	0.79±2.51^{c}	10.14±5.24	90.27±40.21
Pineapple Orchard (PO) Pineapple *[Ananascomosus* (L.*) Merr.]*												
Pin Orch 0-15	5.40	41.10	0.18	2.09	3.73	4.20	3.10	0.14	0.18	0.55	8.24	93.28
Pin Orch 15-30	5.45	32.30	0.13	1.44	2.52	5.30	3.50	0.21	0.17	0.63	10.31	93.22
Mean	5.43±2.58^{b}	36.70±0.14^{cb}	0.16±0.14^{b}	1.77±0.14^{b}	3.13±1.69^{b}	4.75±2.54^{d}	3.30±1.50^{b}	0.18±0.16^{b}	0.18±3.52^{a}	0.59±2.36^{d}	9.28±4.21	93.25±53.4
Waste dumpsite (WD)												
Dump Site 0-15	7.60	31.40	0.13	1.44	2.44	16.20	7.10	0.14	0.11	0.79	24.33	96.37
Dump Site 15-30	6.80	20.50	0.08	0.72	1.24	7.10	4.90	0.14	0.11	0.87	13.07	93.14
Mean	7.20±4.65^{a}	25.95±0.58^{d}	0.11±0.91^{d}	1.08±3.30^{d}	1.84±0.57^{d}	11.65±6.85^{a}	6.00±3.00^{a}	0.14±1.19^{c}	0.11±0.02^{d}	0.83±0.01^{b}	18.70±9.82	94.76±52.90

Different letters on the same column means there is a significant increase at $P \leq 0.05$level.

Potentially Toxic Elements in Soil

Nickel (Ni): Dumping of waste at the dumpsite led to significantly ($P \leq 0.05$) highest nickel content of 20.63mg/kg. While the lowest (0.64mg/kg) Nickel content of soils was observed in coconut plantation (Table 6, Fig 2). The highest concentration of Nickel in the dumpsite could be attributed to disposal of Nickel containing wastes in the dumpsite. Such wastes include alloys, stainless steel, batteries etc. (Pascual *et al*., 2002; Amadi, 2011). In this study, concentration of Nickel recorded was above the **0.02** WHO detection limit in all soil samples investigated from the various land uses with the dump site having the highest Nickel content.

Manganese (Mn): Mean Manganese level ranged from 0.06mg/kg in the pineapple orchard to 0.36mg/kg in the Palm Plantation. The manganese levels of the soils were significantly ($P \leq 0.05$) different (Table 6, Fig 3). The high level of manganese in the palm plantation soils could be attributed to various agro chemicals likely used in the plantation because manganese compounds are used in fertilizer, fungicides and as livestock feeding supplements. It can be adsorbed onto soil depending on organic content, pH, grain-size and cation exchange capacity (CEC) of the soil. In this study, concentration of Manganese recorded was within the **0.05 – 0.5** WHO detection limit in all soil samples investigated from the various land uses with the dump site having the highest value.

Iron (Fe): The mean iron concentration ranges from 2.62mg/kg in the palm plantation to 8.92mg/kg in the dumpsite. The dumpsite soil had significantly ($P \leq 0.05$) higher iron content (Table 6, Fig 4). Total Iron content in soils of various land use types studied were above the critical concentration of 0.3 - 1 mg/kg (WHO, 1996).

Chromium (Cr): The mean Chromium concentration ranges from 0.22mg/kg in the Pineapple orchard to 1.70mg/kg in the dumpsite. The dumpsite soil had significantly($P \leq 0.05$) higher chromium content (Table 6, Fig 5), which could be attributed to dumping of electronic wastes or metal wastes containing chromium (Lin *et al*., 2002). Chromium is carcinogenic by inhalation and corrosive to tissue (Aboud and Nandini, 2009). In this study, concentration of chromium recorded was above the WHO detection limit in all soil samples investigated from all the studied land use systems with the dump site having the highest value.

Zinc (Zn): Mean Zinc value in the study ranged between 1.88mg/kg in the Coconut plantation to 7.34mg/kg in the dump sites. The dumpsite soil had significantly ($P \leq 0.05$) higher Zinc content (Table 6, Fig 6). Zinc is an essential growth element for plants and animals but can be toxic at elevated concentration. Therefore, the disposal of wastes containing such materials could have led to the high Zinc content observed in the dumpsite soils. Excessive concentration of Zn in soil leads to phyto-toxicity as it is a weed killer (Preda and Cox, 2002; Aboud and Nandini, 2009). In this study, the mean concentration of Zinc was above the **2.0 WHO** detection limit in almost all soil samples investigated except for coconut plantation.

Lead (Pb): The results show that the mean lead concentration deposited at the dumpsite was highest with a value of 1.40mg/kg (Table 6, Fig 7) above the **0.05 WHO critical limit,** while the mean lead concentration deposited at the coconut plantation, oil palm plantation and pineapple orchard were all below the limit. Significantly high lead value obtained for dump site soils can be attributed to disposal of lead containing wastes on the soil (Ubuoh *et al*., 2013). High lead level obtained in the dumpsite soils is of health implication as it could seep into ground water (Ubuoh *et al*., 2019). High concentration of Pb in drinking water may result in metallic poisoning that leads to tiredness, lassitude, slight abdominal discomfort, irritation, and anemia (Cecil *et al.*, 2008).

Copper (Cu): Mean Concentration of copper varied from 0.72mg/kg in the dumpsite soils to 0.11mg/kg in the pineapple orchard (Fig 8). Copper containing materials deposited in the dumpsites increased the copper content of the dumpsite soils. Such wastes include fungicides, algaecides, insecticides, wood preservatives, electroplated materials, dye manufacture, engraving, lithography, petroleum refining and pyrotechnics. It is also added to fertilizers and animal feeds as a nutrient to support plant and animal growth (Pascual *et al*., 2002). In this study, concentration of Cu in the investigated soil samples were below the permissible limit set by FAO/WHO (2002).

Table 6: Mean ±SD of heavy metal content of soils from various land use systems study sites

Land use types	Ni (Mg/kg)	Mn (Mg/kg)	Fe (Mg/kg)	Cr (Mg/kg)	Zn (Mg/kg)	Pb (Mg/kg)	Cu (Mg/kg)
CP: 0-15cm (SSP_1)	0.17±0.00	0.10±0.00	3.29±0.41	0.31±0.01	1.62±0.02	0.03±0.00	0.38±0.00
15-30cm	1.11±0.00	0.33±0.04	5.44±0.62	0.22±0.02	2.14±0.05	0.01±0.00	0.26±0.01
Mean value	0.64±0.36^{d}	0.22±0.92^{c}	4.37±0.30^{b}	0.27±0.50^{b}	1.88±0.55^{d}	0.02±0.66^{c}	0.32±0.97^{b}
OPP: 0-15cm (SSP_2)	16.47±14.80	0.70±0.00	4.13±0.18	0.42±0.02	3.10±0.00	0.24±0.07	0.23±0.00
15-30cm	9.28±0.39	0.02±0.00	1.10±0.00	0.11±0.01	1.81±0.01	0.17±0.03	0.16±0.00
Mean value	12.88±0.50^{b}	0.36±0.46^{a}	2.62±0.74^{d}	0.27±0.26^{b}	2.46±0.29^{b}	0.21±0.05^{b}	0.20±0.02^{c}
PO: 0-15cm (SSP_3)	0.29±0.00	0.01±0.00	0.06±0.01	0.31±0.01	1.37±0.03	0.01±0.02	0.13±0.00
15-30cm	7.02±0.02	0.10±0.01	8.44±0.62	0.13±0.00	2.51±0.01	0.01±0.30	0.08±0.00
Mean value	3.66±0.44^{c}	0.06±0.94^{d}	4.25±0.51^{c}	0.22±0.78^{c}	1.94±0.85^{c}	0.01±0.07^{d}	0.11±0.15^{d}
WD: 0-15cm (SSP_4)	21.23±0.32	0.31±0.01	8.40±0.56	0.62±0.02	6.93±0.04^{g}	1.04±0.06	0.91±0.01
15-30cm	20.02±0.02	0.31±0.01	9.43±0.60	2.78±3.13	7.75±0.07^{h}	1.75±0.07	0.53±0.04
Mean value	20.63±0.12^{a}	0.31±0.32^{b}	8.92±0.65^{a}	1.70±0.47^{a}	7.34±0.74^{a}	1.40±0.09^{a}	0.72±0.01^{a}
WHO standard	0.02	0.05 – 0.5	0.3 – 1	0.05	2	0.05	0.05 – 1.5

Different letters on the same column means there is a significant increase at P≤0.05 between the soil heavy metal properties

Table 7: The abundance of potentially toxic elements in soils influenced by land use systems are as follows:

1.	Nickel (Ni)	WD ≥	OPP≥	P O	≥ CP	(Fig.2)
2.	Manganese (Mn)	OPP≥	WD ≥	CPO.	≥ PO	(Fig.3)
3.	Iron (Fe)	WD ≥	CP≥	PO	≥ OPP	(Fig.4)
4.	Chromium (Cr)	WD ≥	CP≥	OPP	≥ PO.	(Fig.5)
5.	Zinc (Zn)	WD ≥	OPP≥	PO	≥ CP	(Fig.6)
6.	Lead (Pb)	WD ≥	OPP≥	CP	≥ PO	(Fig.7)
7.	Copper (Cu):	WD≥	CP≥	OPP	≥ PO.	(Fig.8)

From the above ranking, it could be inferred that waste dump land use type had the most elevated levels of all the heavy metals studied more than other land use types except for Orchard pineapple plantation that seems to have manganese in its highest level. Based on the summary above, Begum and HariKrishna (2010) observed high content of heavy metals in soil (Bellandur lake) where coconut was planted in order of: (Cr > Cu> Ni> Pb> Cd> Fe). The maximum accumulated concentration of metals such as iron, Chromium, nickel and copper in coconut root and leaf extract was 100,47.9, 30.8 and 24.5 mg/l; 122.6, 36.9,28.6 and 21.6 mg/l respectively. Coconut water contained 7.6 mg/l of iron, 4.5 mg/l of Zinc; 5.7 mg/l of chromium and 3.5 mg/l of cadmium (Begum and HariKrishna , 2010).

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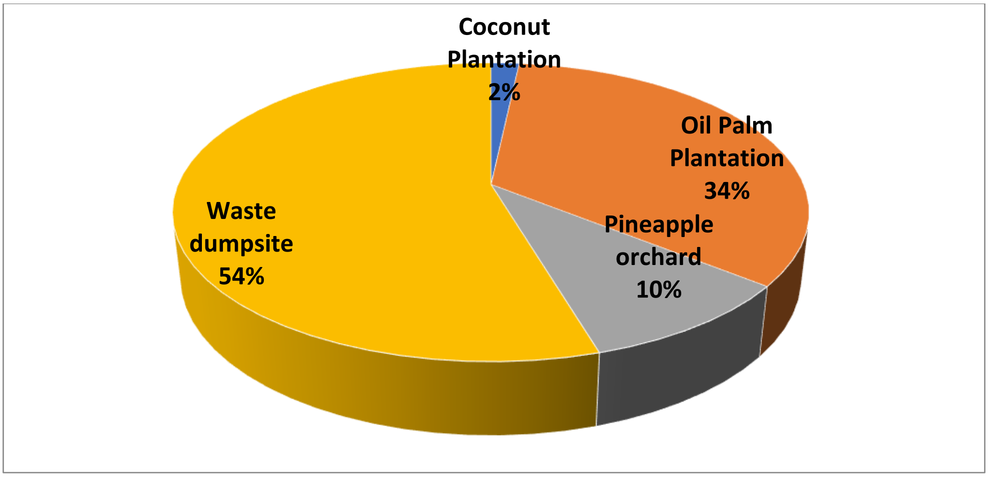

Figure 2: Percentage contribution of Ni in Soils by Landuse practices

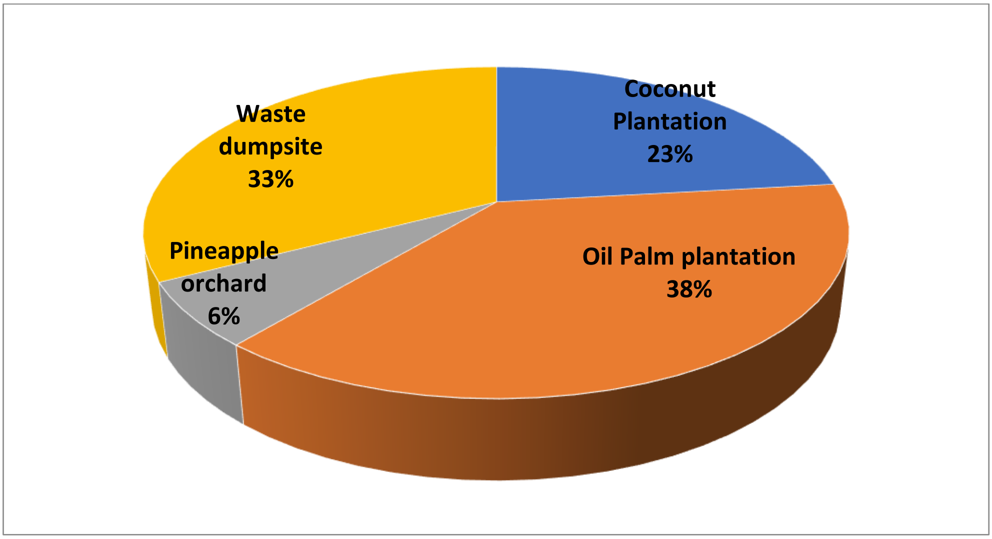

Figure 3: Percentage Contribution of Mn in Soil by Landuse Practices

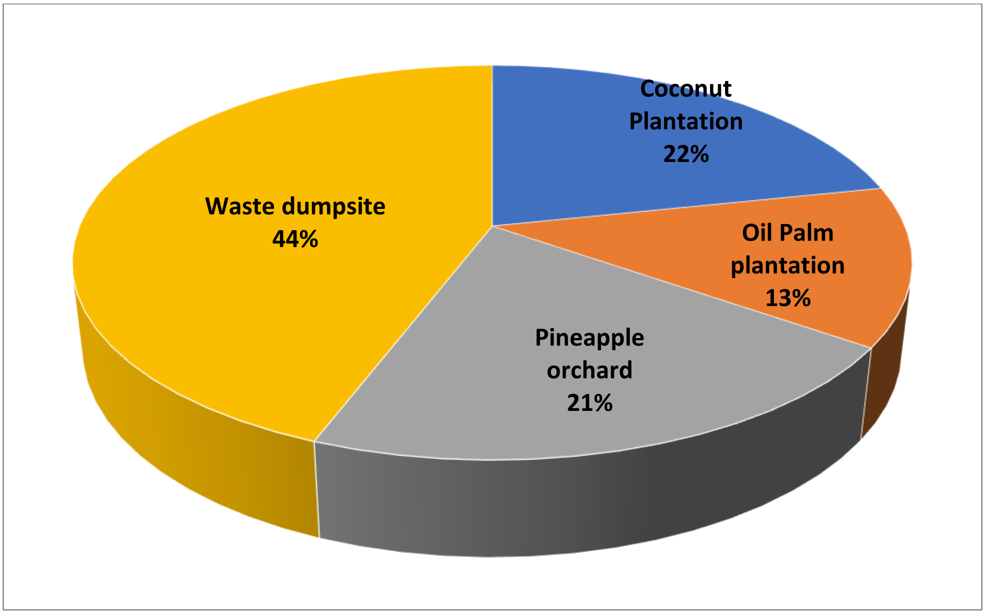

Fig.4: Percentage Contribution of Fe in Soil by Landuse Systems

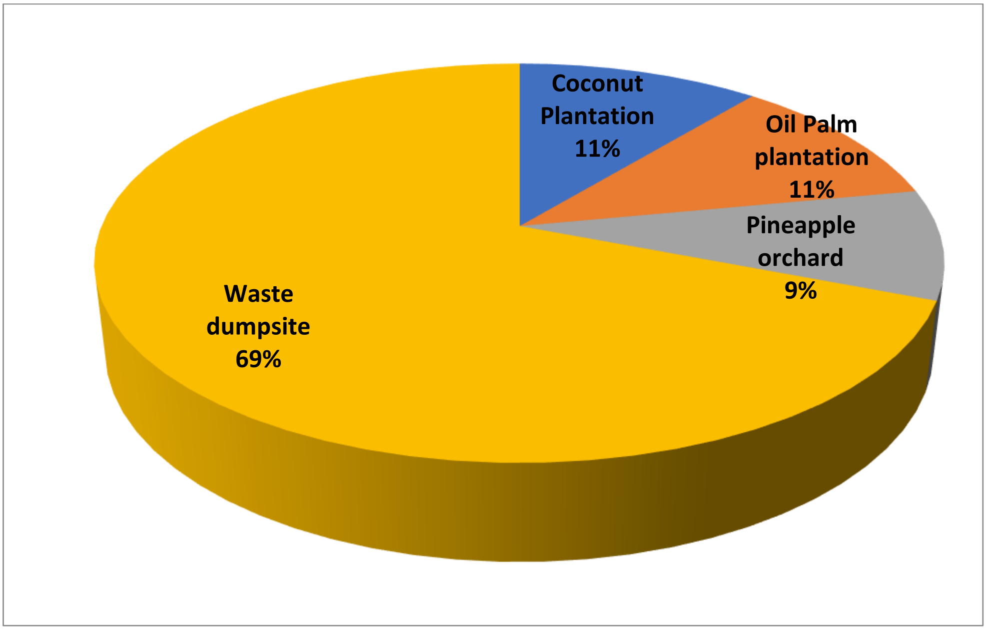

Fig 5: Percentage contribution of Cr in Soil by Landuse practices

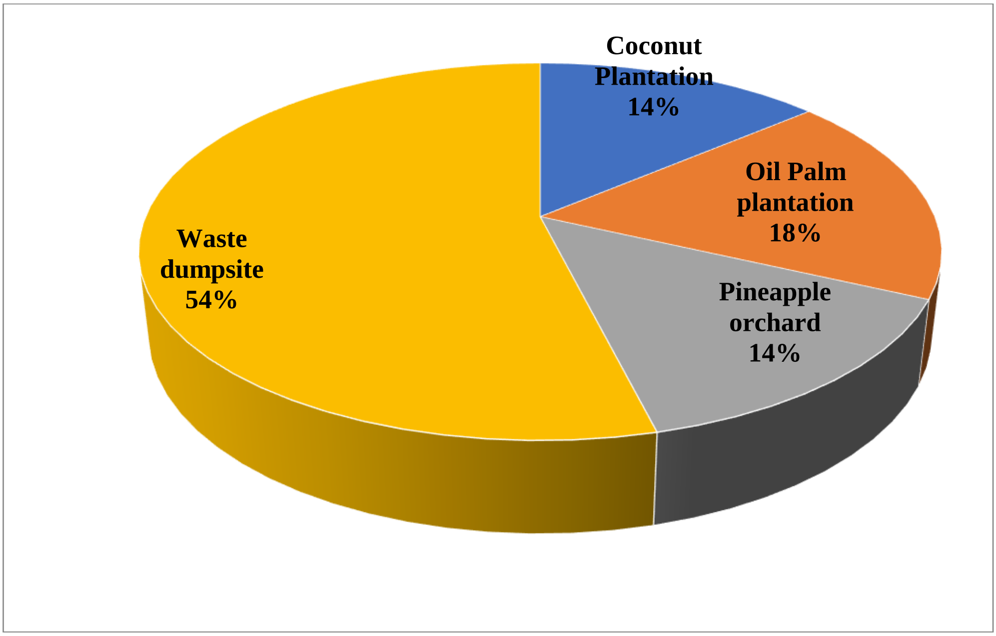

Fig 6: Percentage contribution of Zn in Soil by Landuse practices

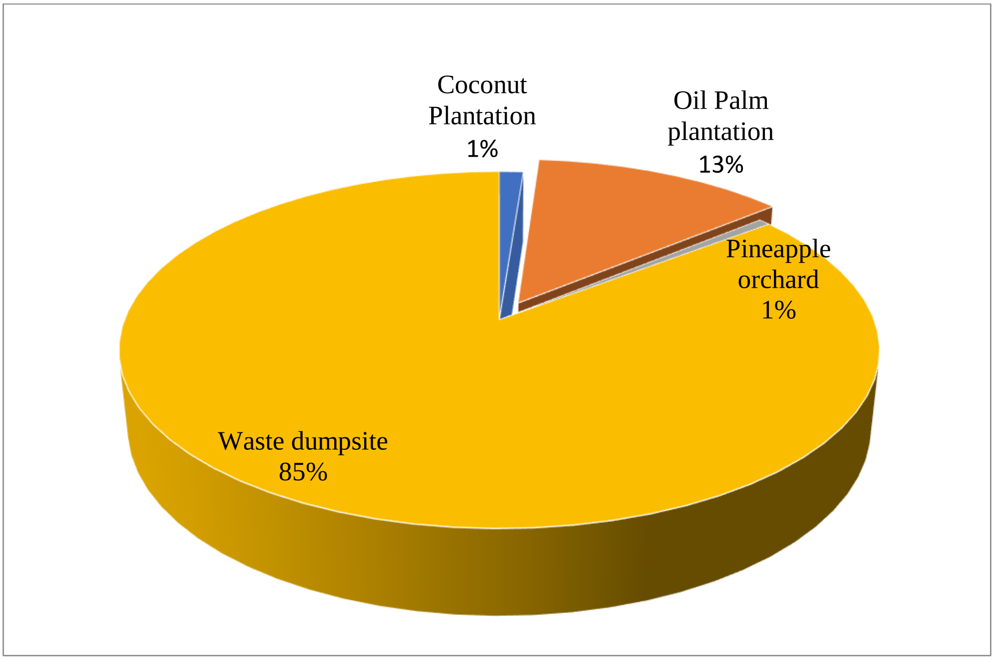

Fig.7: Percentage contribution of Pb in Soil by Landuse practices

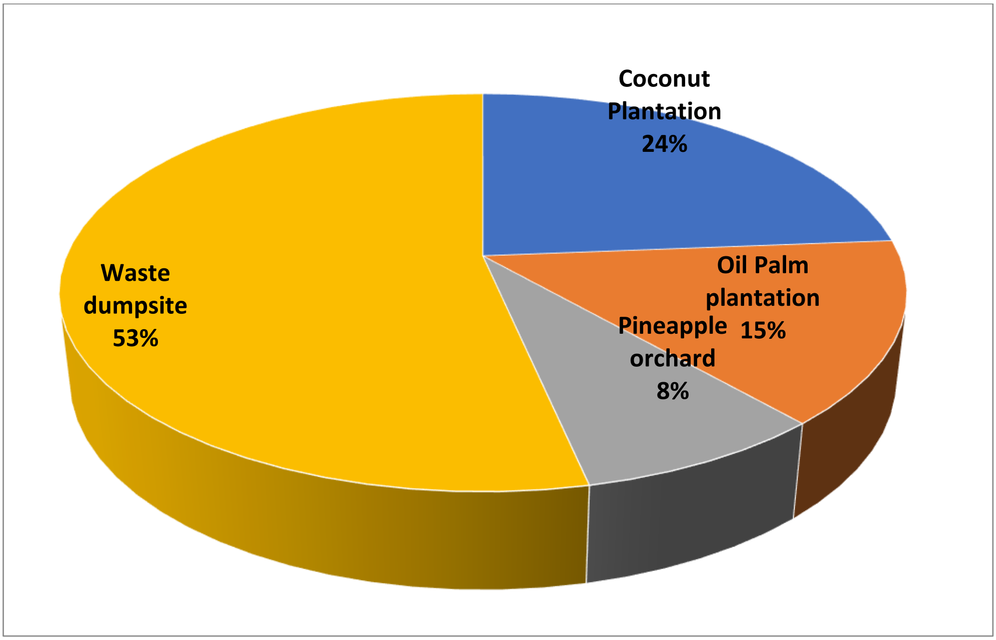

Fig. 8: Parentage of Cu in Soil by Landuse Systems

Table 7: Result showing land-use systems and biochemical indicators for soil degradation assessment in the selected sites

Land **use systems**	Soil depth	Selected chemical indicators									Biological Indicator
		P	N	OC	Ca	Mg	K	Na	CEC	BS	OM
(CP): Soil sample point (SSP)	0-15cm	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	1(NSD)	3(HD)
	15-30cm	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	1(NSD)	3(HD)
Mean value	-	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	1(NSD)	2 (MD)
Oil palm plantation (OPP): oil sample point (SSP$_2$)	0-15cm	1(NSD)	1(NSD)	1 (NSD)	1(NSD)	1(NSD)	1(NSD)	1(NSD)	2 (MD)	1(NSD)	1(NSD)
	15-30cm	1(NSD)	2 (MD)	2 (MD)	1(NSD)	1(NSD)	2 (MD)	1(NSD)	1(NSD)	1(NSD)	2 (MD
Mean value	-	1(NSD)	1(NSD)	1(NSD)	1(NSD)	1(NSD)	1(NSD)	1(NSD)	2 (MD)	1(NSD)	1(NSD)
Pineapple orchard (PO): oil sample point (SSP$_3$)	0-15cm	1(NSD)	1(NSD)	1(NSD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	1(NSD)	1(NSD)
	15-30cm	1(NSD)	2 (MD)	1(NSD)	1(NSD)	1(NSD)	2 (MD)	1(NSD)	2 (MD)	1(NSD)	1(NSD)
Mean value	-	1(NSD)	1 (NSD)	1(NSD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	1(NSD)	1(NSD)	1(NSD)
Waste dumpsite (WD): oil sample point (SSP$_4$)	0-15cm	1(NSD)	2(MD)	3(HD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	2 (MD)	1(NSD)	3(HD)
	15-30cm	1(NSD)	3(HD)	3(HD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	2 (MD)	1(NSD)	4(VHD)
Mean value	-	1(NSD)	2 (MD)	3(HD)	1(NSD)	1(NSD)	3(HD)	1(NSD)	2 (MD)	1(NSD)	3(HD)

1 = None to slightly degraded soils (NSD), 2 = Moderately degraded soils (MD), 3 = Highly degraded soils (HD) , 4 = Very highly degraded soil (VHD)

Chemical Soil Degradation Assessment

Based on soil degradation assessment in Table 7, the four types of land use systems sampled indicate that the soils are degraded, ranging from none to slightly degraded with respect to avail.P, Ca, Mg, Na and BS (Table 7). With respect to Organic carbon and K, only pineapple orchard had a mean severity index of 1 (none to slightly degraded soils). Dumpsite soils and coconut plantation soils had mean severity index of 3 (Highly degraded) while Palm plantation had mean severity index of 2 (Moderately degraded). The low and moderate severity index (OC and K) were obtained from pineapple orchard and palm plantation respectively.

Biological Soil Degradation Assessment

Based on biological property, the mean severity indices of pineapple orchard and palm plantation is 1 (none to slightly degraded soils) while the mean severity indices of coconut plantation and dumpsite soils is 2 (moderately degraded) (Table 7). The severity index of 2 (moderately degraded) obtained for the coconut plantation could be as a result of continuous use of agro chemical such as pesticides, herbicides and chemical fertilizers. The severity index of 2 (moderately degraded). Obtained for the dumpsite could be as a result of the destructive potentials of wastes dumped on the soil of the dumpsite, because some solid wastes are not easily degraded/non degraded.

Above all, the overall assessment of soil degradation indicates that degradation of Coconut plantations' soil constituted 26.7%, oil palm plantation 20.8%, pineapple Orchard 20% and waste dumpsite 32.5 % respectively, with organic matter as biological indicator highly affected. The result is in line with the finding of Onet *et al*. (2018), who reported biological indicator as the main soil degradation problems that diminishes soil biological activity that affects soil quality regeneration.

CONCLUSION

This study centred on the assessment of the impact of land use systems on soil degradation within Umuahia, Abia state, Southeastern Nigeria. The findings of the study have shown that various land use systems have different effects on soil quality dynamics and soil degradation potentials. From the study, the use of land from dumpsite has serious negative effects on soil properties, with potentially toxic elements (Ni, Mn, Fe, Cr, Zn and Pb), that are above critical limits. Accordingly, land use types and agricultural activities through organic and agro-chemical applications also played a role in soil physical and chemical quality dynamics. The degradation level of the considered land use type was in the order: Waste dumpsite (WD) > Coconut plantation (CP)> Oil palm plantation (OPP)> Pineapple orchard constituting 32.5%, 26.7%, 20.8% and 20% respectively.

Based on the findings, waste separation and recycling should be encouraged to avert soil toxicity in organic agriculture. Agro-forestry alongside arable cropping, animals 'husbandry as indices of land management should be encouraged to increase organic matter, either in the form of surface litter or soil carbon content for soil fertility improvement. From the findings, improper waste management and negative effects of land use practices on soil acidity, organic matter content, CEC, sum of exchangeable cations, etc were observed. Since soil quality is fundamental for sustainable agriculture development for food security, therefore, land should be used based on its capacity to meet basic needs of man to ensure the sustainability of ecosystems for food security.

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