The Physicochemical Properties of Soil in Yenagoa and Amassoma Communities Under Selected Land-Use Types

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Abstract

Inappropriate land-use is a worldwide problem that negatively affects sustainable agriculture; hence this study, to recommend the preferred farming method. The study was carried out to determine the effect of different land-use system on selected soil physicochemical properties inYenagoa and Amassoma communities, in Yenagoa and Southern Ijaw Local Government Area of Bayelsa state. The study took into account four land-use regimes, including virgin land (VVL), plantain plantations (PPT), fallow land (FFL), and oil palm plantations (OPT). The result showed that the different land-use type had significant effect (P< 0.05) on some physiochemical properties. The virgin land showed higher mean values of the soil properties compared to fallow land, oil palm and plantain plantation; the trend is as follows: Base saturation (VVL-42.35% > OPT-31.73% > FFL-29.12 > PPT-23.67%), organic carbon/organic matter (VVL-21.67/43.33gcm^{-3}>OPT-17.33/34.67gcm^{-3}> FFL-11.67/23.33gcm^{-3}> PPT-7.33/14.67g/cm^{-3}), CEC (VVL–1.83 cMolkg^{-1}> OPP-1.10 cMolkg^{-1}> FFL – 0.87 cMolkg^{-1}> 0.66 cMolkg^{-1}), and exchangeable acidity.Land-use had a significant effect on bulk density and Porosity. The fallow land (FFL) showed less compaction with the lowest bulk density of 1.25gcm^{-3}< OPT (1.34gcm^{-3})<(VVL) (1.30gcm^{-3})< PPT (1.34gcm^{-3}). It is therefore recommended that conservative measures such as land fallowing be practiced to regenerate lost and depleted nutrients in the soil; and also,a call for reduced conversion of forested lands to cultivated land.

(Abbreviations: VVL-Virgin land, PPT- Plantain Plantation, OPT – Oil palm plantation, FFL – Fallow land, CEC, Cation Exchange Capacity, BD – Bulk Density, POR – Porosity, BS – Base saturation, Av.P – Available Phosphorus, ECEC- Effective Cation Exchange Capacity, EA – Exchangeable acidity, Org.C – organic carbon, Org.M – Organic matter, T_N – Total Nitrogen, EC – Electrical conductivity)

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INTRODUCTION

Sustainable agricultural production has focused on the global issue of environmental degradation brought on by inappropriate land-use. As people's arrangements, actions, and input in a particular piece of land are meant to produce, alter, or retain its worth (Ufot et al, 2016). In order for soil to be productive and sustainable, there must be a good ratio between its physical, chemical, and even biological qualities.

Land-uses continuously affect these qualities. Since soil can quickly lose its quality and quantity due to factors including heavy farming, leaching, and soil erosion, successful agriculture needs the sustainable use of soil resources (Kiflu and Beyene 2013).

Where there is a very high population density and a significant reliance on land resources, the ever-increasing human population poses the greatest challenges. This is a nasty threat because it compromises soil qualities, which causes land degradation and hinders the sustainability of soil resources (Yimer and Abdulkadir, 2011).

The primary causes of land degradation, the depletion of natural resources, and environmental deterioration include overgrazing and deforestation, farming on steep terrain, and irregular and torrential rainfall patterns (Aytenewand Kibret, 2016). Due to a rise in both human and animal populations, the growth of agricultural and pastoral areas has begun to have an impact on the soil's quality (Mustapha, 2007). This resulted in the spread of land-use change because the existing forestland was turned into cultivated land and grazing pastures (Chemada et al., 2017).

In Bayelsa State, there is an increasing rate of deforestation and farming in native forests leading to exposure of lands to erosion and decrease in fertility status. The emphasis is to investigate how different land-use practices affects the soil properties under different management operating within the same soil-forming factors, which will help farmers and land-usersrealize the extent of land degradation caused by human activities. Hence the aim of this study, to determine the effect of land-use system on some physical and chemical properties of soils in Yenagoa and Amassoma Communities, Bayelsa state, Nigeria.

MATERIALS AND METHODS

Description of the study area

For this research, the towns of Yenagoa and Amassoma in Bayelsa State were chosen. Bayelsa is located in the southern portion of the Nigerian Niger Delta Region, about in latitudes 4°55' 36.30"N and longitudes 6°16' 3.50"E, and at an elevation of around 206m above sea level. In Bayelsa, the year-round harsh conditions include hot, gloomy weather in both the wet and dry seasons. The predominant environment is characterized by a humid tropical climate with annual rainfalls of about 4900 mm and relative humidity of 85%. Maximum rainfall is acquired from June to September, while minimum rainfall is achieved from November to March, during the dry season. The annual minimum and maximum temperatures are 25°C and 31°C, respectively. The soils were created from kaolinitic parent materials (Agbai et al., 2022).

Shrubs found in the area include elephant grass *(Pennisetum purpureum L.)*, *Jatropha tanjorensis Ellis &Saroja*, *Costus afer Ker Gawl*, Goat weed (*Ageratum conyzoides L.*). Other trees found in the area include plantain (*Musa paradisiaca L.*), oil palm (*Elaeis guineensis Jacq.*) etc.Virgin land and fallow land are situated in Amassoma, while plantain plantation and oil palm plantation are in Yenagoa. The virgin area is located deep within Amassoma in the Southern Ijaw Local Government Area of Bayelsa State and has had only minimal and regulated human influence for more than 30 years. As the name suggests, the fallow land at the Niger Delta University, Amassoma has been left for more than 10 years to recover and reestablish its fertility. The plantain plantation has seen frequent weeding, fertilization, and harvesting whereas the oil palm plantation has endured for more than 20 years with regular pruning, fertilization, and weeding using herbicides (Agbai and Kosuowei, 2022).

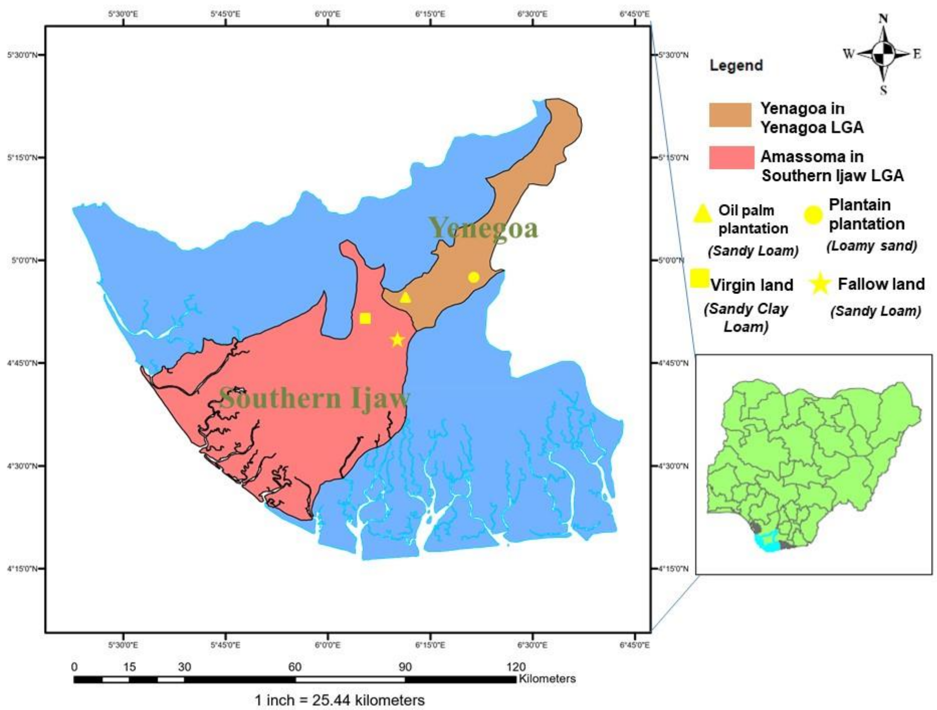

Figure 1. Map of Bayelsa State showing the two Local Government Areas housing the land-use types and the sampling points.

Sample collection

The sampling sites (virgin land, plantain plantation, fallow land, and oil palm plantation, respectively) each generated three replicate samples. Each land-use type had nine (9) samples collected from three depths (0-15 cm, 15-30 cm, and 30-45 cm). The nine replicated samples were further bulked to provide three composite samples per depth for each land-use type. Twelve composite samples in total were collected. Plantain plantations (4°59'45" N, 6°22'20" E) and oil palm plantations (4°58'50" N, 6°06'15" E) are located in Yenagoa, while virgin land (4°59'35" N, 6°07'21" E) and fallow land (4°53'06" N, 6°09'26" E) are located in Amassoma.

Three different sites at each land-use location were sampled using a single, 5-cm-diameter Edelman Eijkelkamp soil auger. The samples from the three locations were properly mashed and bulked with the hand to reflect the location. After being marked with a permanent marker, each soil sample was put into a clean polythene bag. The physical and chemical characteristics of the soil samples were then determined after they had been air-dried, crushed, and sieved through a 2mm sieve in the Niger Delta University's Soil Science Laboratory. At the depths of 0–15 cm, 15–30 cm, and 30–45 cm, respectively, samples for bulk density and porosity were taken using steel cores that were 5.8 cm in diameter and 6 cm high.

Dead plants, furrows, old manure, wet patches, regions close to trees, and compost pits were avoided during sample collection to minimize variations brought on by the addition of organic matter to the soil and to minimize possible errors during evaluation.

Soil Analysis and Evaluation

Soil texture was analyzed by Bouyoucous hydrometer method (1962) while the USDA soil textural triangle categorization method was used to identify the soil's textural class (USDA 2008). Bulk density was determined using ISO (2017), and total porosity (TP) was computed from bulk density values with an assumed particle density of 2.65 gcm^{-3} (Aikins and Afuakwa, 2012).

The soil organic carbon was determined using Walkley- Black wet oxidation methods (Walkley-Black 1934).The organic matters values were computed by multiplying the value of the organic carbon by a value of 1.725 Douglas (2010).The soil pH and Electrical Conductivity were determined with the use of pH meter and EC meter in a soil-water suspension using a 1:2.5 soil water ratio. Total Nitrogen was determined using the regular micro Kjeldahl method as reported by Bremmer and Mulvaney (1982).

Exchangeable cations, Ca, Mg, K and Na were extracted with 1N ammonium acetate solution (1N NH_4OAc) buffered at pH 7.0 the Ca and Mg were determined from the extract using 0.01m EDTA (ethylenediaminetra-acetic acid) titration method as described by Black (1965), while K and Na were determined using flame photometer (Jackson, 1962).Percent Base Saturation (BS) was calculated as the ratio of the sum of the base forming cations (Ca, Mg, K and Na) to the cation exchange capacity (CEC) to the sum of the soil and multiplied by 100.

Statistical Analysis

Randomized Complete Block Design was used to arrange the data gotten from the field. The data was kept in a Microsoft Excel file where it was used to analyze the overall significance of land-uses using Duncan Multiple Range Test on a grand mean data at the 5% level of probability ($p \leq 0.05$), and correlation analysis was carried out amongst selected soil properties using GenStat Statistical Package, 12thEdition.

RESULTS AND DISCUSSION

Table I shows some soil physicochemical properties under the different land-use types.

Plantain plantation

In the Plantain plantation, pH increased as depth increased, with a range of 4.4 - 4.7, with an average of 4.6. There was no significant difference at 15-30 and 30-45 cm depth. The pH was strongly acidic (4.4) at the surface soil (0-15 cm) and also in the subsurface (15-45 cm). The acidic state of the soils can cause stunted shoot and root growth in crops and also as such, some beneficial elements such as K, P, Ca, and Mg may become poorly available (Sanjay, 2022).

Electrical conductivity ranged from 30.4 1μScm^{-1}(0.0304 dSm^{-1}) – 53.1μScm $^{-1}$(0.053 dSm^{-1}). This value according to Ganjegunte*et al*. (2018) places the soil less than four (<4), which is non-saline. This indicates that there is no obstruction to the soil structure and is poses no threat to seedlings and salt-sensitive crops. EC value was highest at the depth of 30 – 45cm and lowest at 15-30cm.

Organic carbon and organic matter were low (11 & 22 gkg^{-1}) at the surface soils, and decreased as the depth increased. The low organic carbon and organic matter indicate reduced organic substrates and energy sources in the soils. There was a consistent significant reduction in their values from the surface soils (0-15 cm) downwards. The Total Nitrogen at the surface was also low and continuously reduced drastically at increasing depth. The low organic carbon and organic matter could be attributed to the continuous utilization of the land for agricultural purposes, therefore depletion of nutrients. The low organic matter content caused a lighter and loose texture for the soils, which gets heavier as the organic matter increases down the profile.

Oil palm plantation

In the Oil palm plantation, pH ranged from 4.3 – 4.5 with a mean of 4.43, which is strongly acidic. The soils from the depth of 0-15 cm and 15-30 cm recorded the highest values while the depth of 30-45 cm recorded to lowest value. The result showed that there was no significant difference in pH between the depth of 0-15 and 15-30cm. Electrical conductivity (EC) ranged from 36.3 μScm^{-1} (0.0363 dSm^{-1}) - 78.1 μScm^{-1} (0.0781 dSm^{-1}) with a mean of 54.17 μScm^{-1} (0.0542 dSm^{-1}). The surface soils (0-15 cm) recorded the highest EC value of 78.1 μScm^{-1} (0.0781 dSm^{-1}) which reduced downwards. The average organic carbon, organic matter, and total nitrogen were 17.33, 34.67, and 1.60 gkg^{-1}respectively. The organic carbon, organic matter, and total nitrogen were highest at the topsoil (36, 72, and 1 gkg^{-1}), which decreased constantly as depth increased. The organic matter content was high (72 gkg^{-1}) at the surface soil but drastically reduced downwards. This could be as a result of decomposing palm fronds and fertilizer application at the surface. Total nitrogen was moderately low (3.3 gkg^{-1}) at the surface soil but reduced drastically as the soil depth increased.

Virgin Land

In the virgin land, pH was 4.7 (acidic) with no significant change amongst the depths. The EC value showed that there was not salinity stress in the three depths: (74.3 μScm^{-1} (0.0743 dSm^{-1}) at 0-15 cm, 58 μScm^{-1} (0.0058 dSm^{-1}) at 15-30 cm and 68.2 μScm^{-1} (0.0682 dSm^{-1}) at 30-45 cm; with a mean of 66.83 μScm^{-1} (0.0668 dSm^{-1}).

The average organic carbon, organic matter, and total nitrogen value were 21.67, 43.33 and 1.97 gkg^{-1}respectively, with the surface soils having the higher values Organic matter was moderate at the surface soil (58 gkg^{-1}) and decreased downwards. Similar to the oil palm plantation, total nitrogen was low (2.6 gkg^{-1}) at the surface soil and was lowest (1.3 gkg^{-1}) at the subsurface (30-45cm).

Fallow land

Under the fallow land, pH of 4.5 showed no significant difference between the first and second depth but increased at the 30-45 cm depth. The average pH was 4.5 which is acidic. The lowest EC value (39.6 μScm^{-1} (0.0396 dSm^{-1}) was recorded in the subsurface soils at 30-45 cm, while the highest value (64.5 μScm^{-1} (0.0645 dSm^{-1}) was at the intermediate depth of 15 – 30 cm. EC recorded a mean of 50.10 μScm^{-1} (0.05010 dSm^{-1}) indicating no salinity threat. There was also a downward reduction in organic carbon, organic matter, and total nitrogen; the surface soils (0-15 cm) recorded the highest values (17, 34, and 1.5 gkg^{-1}) while the subsurface soils (30-45 cm) recorded the lowest values (7, 14, and 0.6 gkg^{-1}). The average organic carbon, organic matter, and total nitrogen value were 11.67, 23.33, and 1.03 gkg^{-1} respectively. The organic carbon and organic matter were moderately low through the three depths, while the total nitrogen was low.

Table 1. Physicochemical properties of the different land-use types

Land-use systems	Depth	pH	EC	Org.C	Org. M	T. N
			μScm^{-1}	gkg^{-1}		
$4^0 59'45"$N $6^0 22'20"$ E						
PPT1	0-15	4.4^a	41^b	11^c	22^c	1^c
PPT2	15-30	4.7^b	30.4^a	7^b	14^b	0.6^b
PPT3	30-45	4.7^b	53.1^c	4^a	8^a	0.4^a
	Mean	4.6	41.5	7.33	14.67	0.67
$4^0 58'50"$N $6^0 06'15"$ E						
OPP1	0-15	4.5^b	78.1^c	36^c	72^c	3.3^c
OPP2	15-30	4.5^b	36.3^a	11^b	22^b	1^b
OPP3	30-45	4.3^a	48.1^b	5^a	10^a	0.5^a
	Mean	4.43	54.17	17.33	34.67	1.60
$4^0 59'35"$N $6^0 07'21"$E						
VVL1	0-15	4.7^a	74.3^c	29^c	58^c	2.6^c
VVL2	15-30	4.7^a	58^a	22^b	44^b	2^b
VVL3	30-45	4.7^a	68.2^b	14^a	28^a	1.3^a
	Mean	4.7	66.83	21.67	43.33	1.97
$4^0 53'06"$N $6^0 19'26"$E						
FFL 1	0-15	4.5^a	46.2^b	17^c	34^c	1.5^c
FFL 2	15-30	4.5^a	64.5^c	11^b	22^b	1^b
FFL 3	30-45	4.6^b	39.6^a	7^a	14^a	0.6^a
	Mean	4.53	50.10	11.67	23.33	1.03

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land., EC – Electrical conductivity, Org. C – Organic Carbon, Org. M – Organic Matter, T.N – Total Nitrogen.Mean values with the same letters are not significantly different from one another at 5% level of probability

Table 2 shows that plantain plantation (PPT) had mean exchangeable acidity, sodium, Calcium, Magnesium, Available Phosphorus, Cation exchange capacity, and effective cation exchange capacity of 2.07, 0.14, 0.02, 0.28, 0.2, 1.68, 0.66 and 2.73 $cMolkg^{-1}$ respectively. These characteristics were highest at the surface soils (0-15 cm) and constantly decreased downwards, with the lowest values recorded at the subsurface (30-45 cm). Oil palm plantation, Virgin land, and fallow land displayed a similar trend with each depth significantly different from the other.

These elements were found to be very low which correlated with the low CEC and ECEC as classified by Adepetu *et al.* (2014).This can be attributed to the kaolinitic nature of the soils of this area and the low organic carbon and organic matter content as stated by (Kiflu and Beyene, 2013). Factors such as leaching, low content of basic cations in the parent material, and proportion of clay (Muche *et al.*,2015) might have contributed to the low CEC in the respective land-use system

Table 2. Some soil chemical properties under the different land-use system

	Depth	EA	Na	K	Ca	Mg	Av. P	CEC	ECEC
		cMol/kg							
PPT1	0-15	2.2^{b}	0.17^{c}	0.07^{c}	0.41^{c}	0.3^{c}	2.32^{c}	0.95^{c}	3.15^{c}
PPT 2	15-30	2^{a}	0.15^{b}	0.04^{b}	0.27^{b}	0.19^{b}	1.701^{b}	0.65^{b}	2.65^{b}
PPT 3	30-45	2^{a}	0.09^{a}	0.02^{a}	0.17^{a}	0.11^{a}	1.03^{a}	0.39^{a}	2.39^{a}
	Mean	2.07	0.14	0.043	0.28	0.2	1.68	0.66	2.73
OPP1	0-15	2.3^{c}	0.32^{c}	0.18^{c}	0.89^{c}	0.51^{c}	5.82^{c}	1.9^{c}	4.2^{c}
OPP2	15-30	2.1^{b}	0.19^{b}	0.07^{b}	0.41^{b}	0.27^{b}	2.24^{b}	0.94^{b}	3.04^{b}
OPP3	30-45	2^{a}	0.1^{a}	0.03^{a}	0.2^{a}	0.14^{a}	1.21^{a}	0.47^{a}	2.47^{a}
	Mean	2.13	0.20	0.09	0.50	0.31	3.09	1.10	3.24
VVL1	0-15	1.9^{b}	0.26^{b}	0.15^{c}	0.7^{c}	0.47^{c}	3.516^{c}	1.58^{c}	3.48^{c}
VVL2	15-30	1.9^{b}	0.25^{b}	0.11^{b}	0.64^{b}	0.45^{b}	3.37^{b}	1.45^{b}	3.35^{b}
VVL3	30-45	1.8^{a}	0.17^{a}	0.09^{a}	0.53^{a}	0.33^{a}	2.411^{a}	1.12^{a}	2.92^{a}
	Mean	1.87	0.23	0.12	0.62	0.42	3.10	1.38	3.25
FFL 1	0-15	2.1^{b}	0.18^{b}	0.05^{a}	0.32^{b}	0.24^{b}	1.722^{b}	0.79^{b}	2.89^{b}
FFL 2	15-30	2^{a}	0.11^{a}	0.04^{a}	0.22^{a}	0.15^{a}	1.642^{a}	0.52^{a}	2.52^{a}
FFL 3	30-45	2^{a}	0.2^{c}	0.1^{b}	0.61^{c}	0.39^{c}	3.143^{c}	1.3^{c}	3.3^{c}
	Mean	2.03	0.16	0.06	0.38	0.26	2.17	0.87	2.90

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land; Ca –Calcium; EA-Exchangeable acidity; Na-Sodium; K-Potassium; Mg –Magnessium; Av.P –Available Phosphorus; CEC, Cation Exchange Capacity; ECEC – Effective Cation Exchange Capacity. Mean values with the same letters are not significantly different from one another at 5% level of probability

The base saturation (BS) of the plantain plantation as indicated in Table 3 was highest at the surface depth of 0-15 cm (30.16%) and decreased with increasing depth, having the lowest (16.32%) at the subsoils (30-45 cm). The plantain plantation was dominated by the sand fraction with a mean of 820.08 g/kg, clay (1114.4 gkg^{-1}), and silt (68.53 gkg^{-1}).

The sand proportion decreased with an increase in depth, while clay increased with increasing depth depicting the process of illuviation. The first two depths were characterized to be loamy sand while the last depth was sandy loam indicating thickness in the soil structure. The bulk density value was lowest (1.22 gcm^{-3}) at the surface soils and was below the critical value of 1.63 gcm^{-3}(Weil et al., 2016), but increased with increasing depth; having an average of 1.34 gcm^{-3}. Porosity showed an inversely proportional relationship with the bulk density, an increase in the bulk density caused a reduction in the porosity values.

In the oil palm plantation, sandy loam dominated the three depths with an average of 736.73 gkg^{-1} of sand, 141.4 gkg^{-1} of clay, and 121.87 gkg^{-1} of silt. There was a significant decrease in sand and an increase in clay and silt indicating illuviation. Base saturation was also highest at the surface (45.24%) and decreased with increasing depth, having the lowest (19.03%) at the subsoils (30-45 cm). Similar to the plantain plantation, the bulk density value was lowest (1.24 g/cm^{-3}) at the surface soils and was below the critical value of 1.63 gcm^{-3}.Itincreased with increasing depth, having an average of 1.30 gcm^{-3}. Porosity showed an inversely proportional relationship with the bulk density, an increase in the bulk density caused a reduction in the porosity values

In the virgin land, the surface soils (0-15 cm) recorded the highest base saturation value of 45.4% and decreased consistently with increase in depth, therefore having the lowest value (38.4%) at 30-45 cm. The texture in the virgin land changed from sandy loam to sandy clay loam as the depth increases, indicating an increase in the clay content and a decrease in sand particles. The bulk density of the surface soils (0-15 cm) recorded the lowest values and the porosity recorded the highest value (53%). The highest bulk density value was found in the 15-30cm depth having the lowest porosity of 49%.

In the fallow land, base saturation was highest (39.4%) at the subsurface (30-45 cm) and was lowest (20.6%) at the 15-30 cm depth. Bulk density was found to be higher (1.30 g/cm^3) in the subsurface soil (30-45 cm) and lowest (1.26 gcm^{-3}) at the 15-30 cm depth. Porosity followed the inversely proportional trend, recording the highest porosity of 55% at the 15-30 cm depth and the lowest porosity of 51% at the 30-45 cm subsoil depth. The entire soil depth was dominated by sandy loam with evidence of illuviation.

Table 3. Some soil physicochemical properties of the different land-use types

	Depth (cm)	BS (%)	Sand	Clay	Silt	soil texture	BD (g/cm^{-3})	POR (%)
			gkg^{-1}					
PPT1	0-15	30.16^c	853.4^c	91.4^a	55.2^a	loamy sand	1.22a	54c
PPT2	15-30	24.53^b	813.4^b	111.4^b	75.2^b	loamy sand	1.38b	48b
PPT3	30-45	16.32^a	793.4^a	131.4^c	75.2^b	sandy loam	1.41c	47a
	Mean	23.67	820.08	111.4	68.53		1.34	49.7
OPP1	0-15	45.24^c	773.4^c	111.4^a	115.2^a	sandy loam	1.22a	54c
OPP2	15-30	30.92^b	723.4^b	151.4^b	125.2^b	sandy loam	1.30b	51b
OPP3	30-45	19.03^a	713.4^a	161.4^c	125.2^b	sandy loam	1.33c	50a
	Mean	31.73	736.73	141.4	121.87		1.28	51.7
VVL1	0-15	45.40^c	693.4^c	191.4^a	115.2^b	sandy loam	1.24a	53c
VVL2	15-30	43.28^b	683.4^b	211.4^b	105.2^a	sandy clay loam	1.36c	49a
VVL3	30-45	38.36^a	653.4^a	221.4^c	125.2^c	sandy clay loam	1.30b	51b
	Mean	42.35	676.73	208.07	115.20		1.30	51
FFL 1	0-15	27.34^b	733.4^c	141.4^a	125.2^a	sandy loam	1.26b	52a
FFL 2	15-30	20.63^a	723.4^b	151.4^b	125.2^a	sandy loam	1.20a	55b
FFL 3	30-45	39.39^c	703.4^a	161.4^c	135.2^b	sandy loam	1.30b	51a
	Mean	29.12	720.07	151.40	128.53		1.25	52.7

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land, BD – Bulk Density, POR – Porosity.Mean values with the same letters are not significantly different from one another at 5% level of probability

Effect of different land-use types on pH and Exchangeable acidity

Table 4 shows that pH had significant differences ($p \leq 0.05$) amongst the different land-use systems, acidity was lowest (4.7) in Virgin land and was highest (4.4) in the oil palm plantation. The land-use systems therefore had a significant effect on the pH. The high acidity could be attributed to the long period the oil palm plantation has been cultivated causing high removal of the basic cations (Selassie *et al.*, 2015), and is indirectly proportional to the fallow land and virgin land with pH of 4.5 and 4.7 which has been left unutilized for some time. The result agrees with (Habitamu, 2014) who stated that H^+ released by nitrification of NH^{4+} from chemical fertilizer lowers the pH value of cultivated land as compared with non-cultivated land.

On the other hand, exchangeable acidity was lowest (1.87 cMolkg^{-1}) on the Virgin land and was highest (2.13 cMolkg^{-1}) at the oil palm plantation. This indicates that exchangeable H^+ was readily available in the oil palm plantation and was reduced in virgin land. This could be because the oil palm plantation has experienced consistent cultivation and utilization over a long period.

Effect of different land-use types on Electrical Conductivity

Electrical conductivity amongst the four land-use types was significantly different from each other, salinity was at its non-hazardous state in all the land-use systems. EC followed this order from highest to lowest: VVL>OPT>FFL>PPT.

Effect of different land-use types on Organic carbon, organic matter, and total nitrogen

The average organic carbon, organic matter, and total nitrogen were significantly different ($p \leq 0.05$) amongst the four land-use systems. The virgin land (VVL) recorded the highest organic carbon, organic matter, and total nitrogen values of 21.7, 43.3, and 1.97 g/kg, while the plantain plantation recorded the lowest values of 7.3, 14.7, and 0.67 gkg^{-1} respectively. The Oil palm plantation recorded average organic carbon, organic matter, and total nitrogen of 17.3, 34.7 & 1.60 gkg^{-1} while fallow land follows at 11.7, 23.3, and 1.03 gkg^{-1}. The higher organic carbon, organic matter, and total nitrogen in the Virgin land could be attributed to the mineral release from the decomposition of leaves consistently falling from trees in the area. Amusan *et al.* (2006) observed a similar trend in their study, they reported the lowest organic carbon and organic matter content in the cultivated plot. Jamala and Oke (2013) reported higher soil organic carbon under natural forest compared with cropped land and fallow land respectively. The result of this study agrees with other studies that land-use type can markedly affect organic carbon and organic matter content (Houghton, 2003; Li *et al.*, 2014; Alcantara *et al.*, 2016).

The relatively low total nitrogen content recorded in the soils of the cultivated land could be attributed to the rapid mineralization of soil organic matter. Brady and Weil (2005) reported that the distribution of soil nitrogen paralleled that of soil organic mattersince nitrogen along with other nutrients, is present in organic combination and is slowly released by the process of mineralization; which was also supported by Matsumoto (2004).

Effect of different land-use types on basic cation, Effective Cation Exchange Capacity, and Base Saturation

Table 4 shows that the basic cation state of the four land-use types was generally low. Nevertheless, the highest value of Na, K, Ca, and Mg were found in the virgin land with 0.23, 0.12, 0.62, and 0.42 $cMolkg^{-1}$ while Plantain plantation recorded the lowest values of 0.14, 0.04, 0.28 and 0.2 $cMolkg^{-1}$. Virgin land was followed by oil palm plantation and then the fallow land. The low basic cation effect also affected the effective cation exchange capacity (ECEC), as the ECEC was also found to be lowest in the Plantain plantation with 2.73 $cMolkg^{-1}$ and highest at the Virgin land (3.25 $cMolkg^{-1}$).

These low values ultimately affected the base saturation of the different land-use in the following order: Virgin land (42.35%) > oil palm plantation (31.72%) > fallow land (29.12%) > plantain plantation (23.67%). The low basic cations and ECEC can be attributed to the kaolinitic nature of the soils of this area. Cation exchange capacity has been established to increase and decrease with soil organic carbon content (Kiflu and Beyene, 2013) and the result confirms it: as organic matter decreases, so does the basic cations and cation exchange capacity.

Furthermore, the continuous cultivation and the use of acidic inorganic fertilizers have been reported to deplete the cation exchange capacityof continuously cropped land-use, as indicated in the cation exchange capacity, and organic matter result of the plantain plantation and oil palm plantation (Wakene and Heluf, 2003). The study shows that land-use type influences the cation exchange capacity, effective cation exchange capacity, basic cation, and base saturation amongst the soils of the area. (Awdenegest et al., 2013).

Effect of different land-use types on bulk density and porosity

The result showed that the land-use types had significant effect on bulk density and porosity (Table 5). The fallow land showed less compaction with the lowest bulk density of 1.25 gcm^{-3}< oil palm plantation (1.28 gcm^{-3}) < virgin land (1.30 gcm^{-3}) < plantain plantation (1.34 gcm^{-3}). Porosity showed its inverse proportion correlation with the bulk density, the lowest bulk density of 1.25 gcm^{-3} in the fallow land was followed by the highest porosity of 52.7%, while the others followed suit: Oil palm plantation (1.28 gcm^{-3}: 54.7%), virgin land (1.30 gcm^{-3}: 51%) and plantain plantation (1.34 gcm^{-3}: 49.7%). None of the soil bulk density values were above the critical value of 1.63 gcm^{-3}(Weil et al., 2016) at which hindrance to root penetration and seed emergency are likely to occur. The result of this study corroborates the findings of Amusan *et al*. (2006) and, Tellen and Yerima (2018) who both reported that the highest bulk density was found in continuously cultivated plots.

The decrease in bulk density was due to the higher organic matter content, better soil aggregate, and increased root growth (Bandyopadhyay *et al*., 2010). A well-aggregated soil, loose and porous has high organic matter and lower bulk density while poorly aggregated soil has low organic matter content and high bulk density that make total pore spaces greater (USDA, 2017).

Table 4. Influence of the different Land-use systems on some soil chemical properties

	pH	EC	Org.C	Org. M	T. N	EA	Na	K	Ca	Mg	Av. P	CEC	ECEC	BS
Land use		μScm^{-1}	gkg^{-1}			$cMolkg^{-1}$								(%)
PPT	4.6c	41.5a	7.3a	14.7a	0.67a	2.07c	0.14[a]	0.04a	0.28a	0.2a	1.68a	0.66a	2.73a	23.67a
OPT	4.43a	54.17c	17.3c	34.7c	1.60c	2.13d	0.20c	0.09c	0.50c	0.31c	3.09c	1.10c	3.24c	31.73c
VVL	4.7d	66.83d	21.7d	43.3d	1.97d	1.87a	0.23[d]	0.12d	0.62d	0.42d	3.10c	1.38d	3.25c	42.35d
FFL	4.53b	50.10b	11.7b	23.3b	1.03b	2.03b	0.16[b]	0.06b	0.38b	0.26b	2.17b	0.87b	2.90b	29.12b

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land. Mean values with the same letters are not significantly different from one another at 5% level of probability

Table 5. Influence of the different Land-use systems on some soil physical properties

	Sand	Clay	Silt	BD	POR
Land use		gkg^{-1}		gcm^{-3}	%
PPT	820.08d	111.4a	68.53a	1.34d	49.7a
OPT	736.73c	141.4b	121.9c	1.28b	51.7c
VVL	676.73a	208.1d	115.2b	1.30c	51b
FFL	720.07b	151.4c	128.5d	1.25a	52.7d

VVL – Virgin land, OPT – Oil Palm Plantation, PPT – Plantain Plantation, FFL – Fallow land. Mean values with the same letters are not significantly different from one another at 5% level of probability

Correlation Studies

The correlation matrix in Table 6 showed that Base saturation had a strongly positive correlation (r=0.85) with Available Phosphorus.

Cation Exchange Capacity (CEC) had a strongly positive relationship with Available phosphorus and base saturation. Calcium positively correlated with Available Phosphorus (r=0.95), base saturation (r=0.97), and Cation Exchange Capacity. Effective Cation Exchange Capacity (ECEC) also showed a positive and strong correlation coefficient with available phosphorus, base saturation, CEC, Calcium, Clay, and Electric conductivity at r = 0.99, 0.84, 0.93,0.95, 0.72 and 0.87 (Agbai and Kosuowei, 2022).

Clay correlated with available phosphorus at r=0.71, base saturation at 0.97, CEC (0.90) and calcium at 0.89. Exchangeable acidity showed a negative correlation with Base saturation, CEC, Calcium, and Clay at r = -0.77, -0.62, -0.59, and -0.86. An increase in exchangeable acidity will cause a decline in base saturation, CEC, and calcium.

Electrical conductivity (EC) showed strongly positive correlations with Available Phosphorus, Base saturation, CEC, Calcium, and clay at r = 0.87, 0.99, 0.99, 0.98, 0.96; while it showed a negative relationship with Exchangeable acidity. An increase in exchangeable acidity will foster a negative change in the electrical conductivity of the soil (Musa et al., 2021)

Potassium showed a strong positive correlation with available phosphorus, base saturation, CEC, Clay, Calcium, electrical conductivity, and ECEC but showed a negative correlation with Exchangeable acidity. An increase in the exchangeable acidity will cause a decrease in the cation exchange and retention of basic cations in the soil(Musa et al., 2021).

Magnesium, sodium, organic carbon, and organic matter showed a positive correlation with Available phosphorus, base saturation, CEC, Calcium, Clay, and Electrical conductivity but a negative correlation with exchangeable acidity (r = -0.71, -0.55, -0.75, and -0.75).

Magnesium positively correlated with ECEC, sodium with ECEC & Potassium; Sodium with potassium and magnesium, organic carbon with potassium, Mg, and Na; organic matter with K, Mg, Na, and Organic Carbon.

Porosity showed a strong negative correlation with bulk density at r = -0.99

Sand indicated a negative correlation with available phosphorus, base saturation, CEC, Calcium, clay, ECEC, K, Mg, Na, organic carbon, organic matter, and porosity but responded with a positive correlation with only bulk density and exchangeable acidity. Silt correlated positively with Available phosphorus, base saturation, CEC, Calcium, EC, ECEC, K, Mg, Na, organic carbon and matter, and porosity; while it negatively correlated with bulk density, and Sand at r=-0.92 and -0.83.

Total nitrogen correlated positively with all the variables except exchangeable acidity and sand (r = -0.53 and -0.85).

pH correlated positively with clay and EC at r=0.55 and 0.79 while it showed a negative correlation at r= -0.56 base saturation and Exchangeable acidity at r =-0.88.

Table 6. Correlation matrix of some soil physicochemical properties

	Av_P	BD	BS	CEC	Ca	Clay	EA	EC	ECEC	K	Mg	Na	Org_C	Org_M	POR	Sand	Silt	T_N	pH
Av_P	1.00																		
BD	-0.34	1.00																	
BS	0.84*	-0.21	1.00																
CEC	0.93*	-0.25	0.98*	1.00															
Ca	0.95*	-0.26	0.97*	0.99*	1.00														
Clay	0.71*	-0.29	0.97*	0.90*	0.89*	1.00													
EA	-0.30	-0.04	-0.77*	-0.62*	-0.59*	-0.86*	1.00												
EC	0.87*	-0.28	0.99*	0.99*	0.98*	0.96*	-0.73*	1.00											
ECEC	0.99*	-0.33	0.84*	0.93*	0.95*	0.72*	-0.30	0.87*	1.00										
K	0.93*	-0.19	0.96*	0.99*	0.99*	0.88*	-0.59*	0.97*	0.93*	1.00									
Mg	0.88*	-0.20	0.99*	0.99*	0.99*	0.95*	-0.71*	0.89*	0.88*	0.98*	1.00								
Na	0.94*	-0.18	0.95*	0.99*	0.99*	0.86*	-0.55*	0.96*	0.95*	1.00*	0.98*	1.00							
Org_C	0.96*	-0.28	0.95*	1.00*	1.00*	0.87*	-0.75*	0.97*	0.96*	0.98*	0.97*	0.99*	1.00						
Org_M	0.96*	-0.28	0.95*	1.00*	1.00*	0.87*	-0.75*	0.97*	0.96*	0.98*	0.97*	0.99*	1.00	1.00					
POR	0.34	-0.99*	0.20	0.25	0.26	0.28	0.06	0.27	0.32	0.21	0.20	0.19	0.27	0.27	1.00				
Sand	-0.78*	0.61*	-0.90*	-0.88*	-0.87*	-0.93*	0.65*	-0.92*	-0.78*	-0.84*	-0.88*	-0.82*	-0.87*	-0.86*	-0.61*	1.00			
Silt	0.66*	-0.92*	0.53*	0.59*	0.60*	0.56*	-0.15	0.59*	0.65*	0.55*	0.54*	0.54*	0.61*	0.61*	0.93*	-0.83*	1.00		
T_N	0.97*	-0.26	0.95*	0.99*	1.00*	0.85*	-0.53*	0.96*	0.97*	0.99*	0.97*	0.99*	1.00*	1.00*	0.25	-0.85*	0.60*	1.00	
pH	-0.07	0.46	-0.56	0.29	0.25	0.55*	-0.88*	0.79*	-0.05	0.28	0.40	0.25	0.20	0.20	-0.46	-0.22	-0.32	0.19	1.00

CONCLUSION

The research showed that the different land-usehad significant effects on the soils. pH was generally strongly acidic at the surface soils but reduced (acidic) downwards. The Electrical Conductivity of the soils showed no salinity threat to prospective crops to be planted. Organic matter was generally low to moderate at the surface soils but reduced drastically through the subsoils.The virgin land and fallow land showed higher values of basic cations, organic matter, cation exchange capacity, base saturation; and lower exchangeable acidity as compared to oil palm and plantain plantations. The bulk density of the soils under the different land-use systems was within the normal range, indicating that heavy-duty machines have not been used or consistently utilized over the years, also activities such as overgrazing have been curtailed.This indicates that the conversion of the natural ecosystem into cultivated land will result in the deterioration of the fertility status, structure, and quality of the soil. Also, sustainable and conservative management practices such as land fallow systems will help regenerate depleted nutrients in the soil.

In general, the information generated from the study will be helpful for the proper management of land in the area. It is therefore recommended that soil conservative measures such as land fallowing be practiced to regenerate lost and depleted nutrients in the soils,and heavy machinery and overgrazing be controlled to the minimum to increase soil pore space distribution for free root penetration and growth.

REFERENCES

Adepetu J.A., Adetunji M.T. & Ige D.V. 2014. *Soil Fertility and Crop Nutrition*. Printed by Jumak Nigeria Limited, Ibadan, pp. 108–439.

Agbai W.P. & Kosuowei M.T., 2022. Influence of land-use systems on hydraulic properties of soils in Yenagoa and Amassoma, Bayelsa State, Nigeria. *International Journal of Environment*,*11*(1):23-45, DOI: https://doi.org/10.3126/ije.v11i1.45838. ISSN 2091-2854.

Agbai W.P., Kosuowei M.T. & Efenudu U.I. 2022. The Infiltration Capacity of Soils Under Different Land-Use Systems in Yenagoa and Southern Ijaw Local Government Areas of Bayelsa State. *African Journal of Agriculture and Food Science 5*(1), 17-28. DOI: 10.52589/AJAFS-LIAII98M.

Aikins S.H.M.&Afuakwa J.J., 2012. Effect of four different tillage practices on soil physical properties under cowpea. *Agriculture and Biology Journal of North America*, *3*(1): 17-24.

Alcantara V., Don A., Well R. & Nieder R. 2016. Deep ploughing increases agricultural soil organic matter stocks. *Global Change Biol*.. *4* (6), 116–122.

Amusan A.A., Shittu A.K., Makinde W.O. & Orewole O. 2006. Assessment of changes in selected soil properties under different land-use in Obafemi Awolowo University, Ile-Ife, Nigeria. Electron. *Journal of Environment and Agriculture*. Food Chemistry. 1178–1184.

Awdenegest M., Melku D. & Fantaw Y. 2013. Land-use effects on soil quality indicators: a case study of Abo-Wonsho Southern Ethiopia. *Applied Environmental Soil Science*. *9* (Article ID784989): http://dx.doi.org/10.1155/2013/784989

Aytenew M. & Kibret, K., 2016. Assessment of soil fertility status at Dawja watershed in Enebse Sar Midir district, Northwestern Ethiopia. *International Journal of Plant and Soil Science,11*(2): 1-13.

Bandyopadhyay K. K., Misra A. K., Ghosh P. K. & Hati K. M. 2010. Effect of integrated use of farmyard manure and chemical fertilizers on soil physical properties and productivity of soybean. *Soil Tillage Research,110*, 115-125. https://doi.org/10.1016/j.still.2010.07.007

Black C.A. 1965. *Methods of Soil Analysis:* Part I, Physical and Mineralogical Properties. *American Society of Agronomy*, Madison, Wisconsin.

Bouyoucos G.J. 1962. Hydrometer method improved for making particle size analysis of soils. *Agronomy Journal54*(5): 464-465.

Brady N.C. & Weil R.R. 2005. *The Nature and Properties of Soil*, 12th ed.; Prentice Hall: Upper Saddle River, NJ, USA

Bremner J.M. & Mulvaney C.S. 1982. Nitrogen-Total. In: Methods of soil analysis. Part 2. Chemical and microbiological properties, Page, A.L., Miller, R.H. and Keeney, D.R. Eds., *American Society of Agronomy, Soil Science Society of America,* Madison, Wisconsin, *2*: 595-624.

Chemada M., Kibret K. & Fite T. 2017. Influence of different land-use types and soil depths on selected soil properties related to soil fertility in Warandhab Area, HoroGuduruWallaga Zone, Oromiya, Ethiopia. *International Journal of Environmental Sciences and Natural Resources,4* (2): 555-634.

Douglas W.P. 2010. A Critical review of the conventional SOC to SOM conversion factor. *Geoderma*, *156*: 75- 83.

Ganjegunte G.K., Clark J.A., Parajulee M.N., Enciso J. & Kumar S. 2018. Salinity management in pima cotton fields using sulfur burner. *Agrosystems, Geosciences and Environment, 1*: 180006.

Habitamu A. 2014. Fertility Status of Soils under Different Land-uses at Wujiraba Watershed, North-Western Highlands of Ethiopia Agriculture, Forestry and Fisheries. *3*(5):410. Available at: http://www.sciencepublishinggroup.com/journal/paperinfo.aspx?journalid=119&doi= 10.11648/j.aff.20140305.24.

Houghton R.A. 2003. Revised estimates of the annual net flux of carbon to the atmosphere from changes in land-use and land management 1850–2000. *Tellus* 55 (2): 378-390.

Jackson M.L.1962. Soil chemical analysis. Prentice Hall, new York.pg. 263-268.

Jamala, G.Y., & Oke, D.O., 2013. Soil organic carbon fractions as affected by land-use in the Southern Guinea Savanna ecosystem of Adamawa State, Nigeria. *Journal of Soil Science and Environmental Management, 4*(6), 116-122, DOI 10.5897/JSSEM2013.0400.

Kiflu A. & Beyene S. 2013. Effects of different land-use systems on selected soil properties in South Ethiopia. *Journal of Soil Science and Environment Management,4*(5): 100-107. Doi: 10.5897/JSSEM12.20.

Li Y.F., Zhang J.J., Chang S.X., Jiang P.K., Zhou G.M., Shen Z.M., Wu J.S., Lin L.,Wang Z.S. & Shen M.C. 2014. Converting native shrub forests to Chinese chestnut plantations and subsequent intensive management affected soil C and N pools. *Forr. Eco. Mgt* 312, 161–169.

Matsumoto S. & Ae N. 2004. Characteristics of extractable soil organic nitrogen determination using various chemical solutions and its significance for nitrogen uptake by crops. *Soil Science and Plant Nutrition*, *50*: 1-9.

Muche M., Kokeb A. & Molla E. 2015. Assessing the physicochemical properties of soil under different land-use types. *Journal of Environmental Analysis and Toxicology*. 5, 309.

Musa J. J., Akpoebidimiyen O. E., Dada P. O. O., Adewumi J. K. & Gupa Y. U. 2021. Effect of Land Management on Soil Hydraulic Conductivity in Gidan Kwano, Niger State, Nigeria. *Open Journal of Forestry*, 11,108-116. https://doi.org/10.4236/ojf.2021.112008

Mustapha S. 2007. Physico-chemical properties and fertility status of some Haplic Plinthaquults in Bauchi local government area of Bauchi State, Nigeria. *International Journal of Soil Science2*(4): 314-315.

Sanjay S. 2022. Managing Soil Acidity for Optimizing Crop Production.*Soil and Water Conservation Today*(17). 02-03.

Selassie Y.G., Anemut F. & Addisu S. 2015. The effects of land-usetypes,management practices and slope classes on selected soil physicochemicalproperties in Zikre watershed, North-Western Ethiopia. *Environ. Syst. Res*. *4*(1):3. Available at:http://www.environmentalsystemsresearch.com/content/4/1/3.

Tellen V.A. & Yerima B.P.K. 2018. Effects of land-use change on soil physicochemical properties in selected areas in the North West region of Cameroon. *Environ. Syst. Res*., *7* (3), 1–29.

Ufot U.O., Iren O.B. & Chikere-Njoku C.U.2016. Effects of land-use on soil physical and chemical properties in Akokwa area of Imo state, Nigeria. *International of Life Sciences Scientific Research*,*2*(3): 273-278.

USDA 2017. Soil quality kit, guide for educators. National resources conservation services. Available onhttps://www.nrcs.usda.gov [accessed on 03/09/2014/7].

Wakene N.C. & Heluf G. 2003. The Impact of Different Land-use Systems on Soil Quality of Western Ethiopian Alfisols. Bako Agricultural Research Center, West Shoa, Ethiopia, pp. 2-6.

Walkley A. & Black I.A. 1934. An examination of Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science37*(1):29-37.

Weil N.C., Brady R.R. & Weil R.R. 2016. The Nature and Properties of Soils. Fifteenth Edition, Pearson, Columbus.

Yimer F.& Abdulkadir A. 2011. The effect of cropland fallowing on soil nutrient restoration in the Bale Mountains, Ethiopia. *Journal of Science and Development*,*1*(1): 43-51.