EFFECTS OF SELECTED LANDUSE TYPES ON SOIL PHYSICAL AND CHEMICAL PROPERTIES OF COASTAL PLAIN SAND IN AKWA IBOM STATE

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ABSTRACT
Coastal plain sands are fragile ecosystems susceptible to degradation due to intensive land use practices. This study assessed the effects of selected land use types (cassava farm, rubber, oil palm plantation and fallow land) on soil physical and chemical properties in coastal plain sands. Eighteen (18) composite soil samples were collected from 0-15 and 15-30 cm depth and analyzed for selected physical and chemical properties. Bulk density, particle size distribution, soilpH, organic carbon, total nitrogen, available phosphorus, exchangeable bases, effective cation exchange capacity and base saturation. The result indicated that sand, silt and clay contents under different land uses investigated did not show any significant (p>0.05) difference at both 0-15 cm and 15-30 cm soil depth.The nutrient content of soil under fallow land and cassava farm were only marginally higher than those under oil palm and rubber plantations. Total porosity shows a positive and significant correlation with magnesium (Mg) (r =0.773, (p<0.05) and sodium (Na) (r = 0.946, ((p<0.01). This result implies that an increase in total porosity will subsequently increase the level of Mg and Na in the soil. Based on the findings from this study, it is imperative to adopt sustainable land use practices that prioritize soil conservation and environmental protection, to maintain soil health and mitigate degradation in coastal plain sands.

***Keywords**: Land use, Soil properties, Soil depth.*

INTRODUCTION

Agricultural activities such as deforestation, overgrazing and continuous cultivation have been known to have a noticeable effects on soil properties (Biro *et al.,* 2013). The effect of these changes differs depending on the type of land use, vegetation cover and management practices employed on the lands (Javad *et al.,* 2014; Josiah, *et al*.,(2021)). Land use according to (Ufot *et al*., 2016)is defined as the arrangements, activities and inputs people undertake in a certain land cover type to produce, change or maintain it. Several studies (Abo-Habaga *et al*.,2022 ; Oguike *et al*.,2009) amongst others, observed that land use affects all the chemical, physical and biological properties of the soil that tend to affect the quality attributes and fertility status of the soil. Girma *et al.,* (2012): Ovie *et al*.,(2013) and Mengistus and Dereje (2021) reported that deforestation and cultivation of forestlands leads to depletion of soil organic matter, plant nutrients such as N, Ca, Mg, K and increase soil bulk density. Getahun and Bobe (2015) indicated that the amount of organic matter, total nitrogen and cation exchange capacity in cultivated land have declined by about 79, 61 and 39%, respectively. Akpan *et al.*, (2020) reported low availability of nutrients under arable land due to continuous cropping while adequate nutrients were observed on fallow land due to accumulation of litter on surface of the soil which recycles nutrients and make them available in the soil system.

Akwa Ibom State is located in the South-South geopolitical zone in the Niger-Delta region of Nigeria. The predominant land use types include agricultural lands such as arable crops, plantation, fallow lands and forest lands etc. A coastal plain soil is among the soil found in Akwa Ibom State and is characterized with coarse texture coupled with severe leaching. The particle size is typically larger than that of loamy or clay soils, leading to quick drainage and reduced water retention capability (Huang *et al*., 2019). These soils have low nutrient-holding capacity, low levels of organic matter, which can limit its fertility status (Nassauer *et al*., 2020). Knowledge and understanding of land use and management effect on soil properties is crucial for sustainable soil management and agricultural productivity. Therefore, the objective of this study was to assess the effect of selected land use types on physical and chemical properties of coastal plain sand in Akwa Ibom State.

MATERIALS AND METHODS

The study was conducted in selected land use types (cassava farm, fallow land, rubber and oil palm plantation) in Akwa Ibom State. The state is geographically located between Latitude 4 32' and 5 30' N and longitude 7 25' and 8 25' E and has a tropical humid climate which is characterized by a longer wet season (April - October) and a shorter dry season (November - March).Annual rainfall in the state is usually high ranging from about 2500 to 3000mm (Enwezor *et al*., 1990).Soil samples were collected from the selected land use types at 0-15cm and 15-30 cm depth and replicated three times for the different sampling points for each land use. The sample were air-dried, grind, sieved using a 2mm sieve, carefully labeled and packaged and taken to the laboratory for analysis.

Laboratory Analysis

Soil samples were analyzed for selected physical and chemical properties as outlined by (Udoh *et al*., 2009). The soil samples were analyzed using standard procedures as outlined by Udo *et al.,*(2009). Particle size distribution was determined by the Bouyoucous hydrometer method. Soil pH was determined in 1:2.5 soil: water ratio with a pH meter. Organic carbon was determined by Walkley Black Dichromate Oxidation Method. Organic matter was obtained by multiplying %OC values with a factor 1.72. Total nitrogen (N) was determined by the micro kjeldahl method. Available phosphorous (P) was extracted by the Bray 2 extraction method, and the content of P was measured using Spectrophotometer. Electrical conductivity was measured in 1:2.5 soil/water suspension using an electrical conductivity meter. Exchangeable bases (K, Na, Ca and Mg) were extracted with 0. I. N ammonium acetate; K and Na were read with a flame photometer while Ca and Mg were determined through the EDTA titration method. Exchangeable acidity was determined by leaching the soils with I N KCl and titrating the aliquots with 0.01 NaOH. Effective cation exchange capacity (ECEC) was calculated as the sum of exchangeable bases and exchangeable acidity. Base saturation was calculated by dividing the sum of exchangeable bases by ECEC and multiplying by 100.

Statistical Analysis

The data collected were further subjected to statistical analysis, in which analysis of variance (ANOVA) was done, and the significant mean were separated using Fisher Least Significant Difference (F-LSD). Correlation analysis was also carried out to assess the relationship between soil physical and chemical properties.

RESULTS AND DISCUSSION

Effect of land use types on physical properties of soils formed on coastal plain sand Particle size distribution

The effects of different land use on soil physical properties are presented in Table 1.The result indicated that sand, silt and clay contents under different land uses investigated did not show any significant (p>0.05) difference at both 0-15 cm and 15-30 cm soil depth (Table 1). However, for top soil (0-15 cm depth), the highest sand contents were found in soil under cassava farm (91.4 %) followed by soil under rubber plantation (87.40 %) while the least sand contents were recorded in soil under fallow land (80.90). Similarly, the distribution of silt contents were in the order of Rubber plantation>Fallow land > Cassava farm ≥ ≥Oil palm plantation, with the highest value of 6.4 % recorded in rubber plantation and the lowest value of 1.4 % recorded in both cassava farm and Oil palm plantation. The order of clay distribution was Fallow land > Oil palm plantation > cassava farm > rubber plantation, with the highest value of 15.2 % recorded in fallow land and the lowest value of 5.2 % recorded in rubber plantation.

Furthermore, for sub-soil (15-30 cm depth), the highest sand contents were found in soil under rubber plantation (86.40 %) followed by soil under cassava farm (84.40 %) while the least sand contents were recorded in soil under fallow land (79.40). Similarly, the distribution of silt contents were in the order of Fallow land > Cassava farm > Rubber plantation ≥ ≥oil palm plantation, with the highest value of 6.4 % recorded in fallow land and lowest value of 3.4 % recorded in both rubber plantation and oil palm plantation.

Table 1: Effect of land use types on particle size distribution

Landuse	Sand (%)	Silt (%)	Clay (%)
0-15 cm			
Cassava	91.4	1.4	7.2
Fallow	80.9	3.9	15.2
Oil Palm	85.4	1.4	13.2
Rubber	87.4	6.4	5.2
P(<0.05)	4.992	6.464	5.197
15-30 cm			
Cassava	84.4	3.4	12.2
Fallow	79.4	6.4	14.2
Oil Palm	82.4	3.4	14.2
Rubber	86.4	3.4	11.2
P(<0.05)	2.25	9.28	5.663

The order of distribution for clay content was Fallow land ≥ ≥ Oil palm plantation > cassava farm > rubber plantation, with the highest value of 14.20 % recorded in both fallow land and oil palm plantation while the lowest value of 11.20 % was recorded in rubber plantation. The texture of the studied soil was mostly sandy, especially in cassava farm. Such texture is known to be fragile in nature and susceptible to leaching and erosion by surface run-off water. In addition, coastal plain soils are usually characterized by sandy texture (Ijah *et al*., 2021). The findings of this study corroborate with the observation of Umoh *et al.* (2021), who worked on soil with similar textural characteristics. In this study, soil texture remained largely unaffected by land use, as land use and other Agricultural practices primarily influence soil structure rather than the proportion of sand, silt, and clay. The result also corroborates with the report of (Amsili *et al.,* 2021) that soil texture is largely determined by the proportion of sand, silt, and clay and is less influenced by land use or soil amendments.

Bulk density

The effects of different land use on soil bulk density is presented in Table 2.The result indicated that soil bulk density under different land uses types did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 2). At (0-15 cm depth), the highest bulk density value was found in soil under oil palm plantation (1.86 g/cm ^{3}) which was at par with bulk density values in soils under cassava farm (1.32 g/cm ^{3}), fallow land (1.56 g/cm ^{3}), and rubber plantation (1.75 g/cm ^{3}). Similarly, for sub-soil (15-30 cm depth), the highest bulk density value was found in soil under fallow land (1.78 g/cm ^{3}) which was at par with bulk density values in soils under cassava farm (1.46 g/cm ^{3}), oil palm plantation (1.68 g/cm ^{3}), and rubber plantation (1.54 g/cm ^{3}). A higher bulk density in oil palm plantations suggests a more compacted soil structure, which can lead to several adverse effects. High bulk density often indicates soil compaction, which can restrict root growth and reduce the soil's ability to retain water and nutrients (Akinmutimi *et al.,* 2023). Compacted soils have lower porosity, leading to poor aeration and reduced microbial activity, both of which are critical for maintaining soil health.

Saturated hydraulic conductivity

The effect of different land use on soil saturated hydraulic conductivity (Ksat) is presented in Table 2. The result indicated that soil saturated hydraulic conductivity (Ksat) under different land uses did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 2). However, for top soil (0-15 cm depth), the highest saturated hydraulic conductivity(Ksat) value was found in soil under rubber plantation (0.47 m/s) , followed by soils under cassava farm (0.37 m/s), fallow land (0.39 m/s), and oil palm plantation (0.30 m/s). Similarly, for sub-soil (15-30 cm depth), the highest saturated hydraulic conductivity (Ksat) value was found in soil under cassava farm (0.42 m/s), fallow land (0.42 m/s), oil palm plantation (0.33 m/s) and rubber plantation (0.26 m/s).

Table 2: Effect of land use types on soil physical properties at different depth

Land use	Bulk density (g/cm3)	Ksat (m/s)	TP (%)
	0-15cm		
Cassava	1.32	0.37	50.19
Fallow	1.56	0.39	41.13
Oil Palm	1.86	0.30	38.87
Rubber	1.75	0.47	33.96
P(<0.05)	4.019	0.242	1.931
	15-30cm		
Cassava	1.46	0.42	44.91
Fallow	1.78	0.42	38.83
Oil Palm	1.68	0.33	36.23
Rubber	1.54	0.26	41.89
P(<0.05)	0.169	0.057	0.886

Total porosity

The effect of different land use types on soil total porosity (TP) is presented in Table.2. The result indicated that soil total porosity (TP) under different land use did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 2). However, for top soil (0-15 cm depth), the highest TP value was found in soil under cassava farm (50.19 %) which was at par with TP values in soils under fallow land (41.13 %), rubber plantation (33.96 %) and oil palm plantation (38.87 %). Similarly, for sub-soil (15-30 cm depth), the highest TP value was found in soil under cassava farm (44.91 %) which was at par with TP values in soils under fallow land (38.83 %), rubber plantation (41.89%) and oil palm plantation (36.23 %).

Effect of land use types on chemical properties of soils formed on coastal plain sand Soil pH

The effects of different land use on soil pH is presented in Table 3.The result indicated that soil pH under different land use types did not show any significant ($p>0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). However, for top soil (0-15 cm depth), the highest pH was found in soil under cassava farm (5.75) followed by soil under rubber plantation (4.7) while the least pH was recorded in soil under oil palm plantation (4.37). The order of distribution of pH was Cassava farm >Rubber plantation > Oil palm plantation > Fallow land > rubber plantation. Similarly, for sub-soil (15-30 cm depth), the highest pH was found in soil under cassava farm (4.75) followed by soil under rubber plantation (4.40) while the least pH was recorded in soil under fallow land (4.25). The order of distribution of pH in subsoil was Cassava farm > Rubber plantation > Oil palm plantation > fallow land.

The pH values for the cassava plot fall within a slightly acidic range, which is generally favorable for most crops, as optimal growth typically occurs at pH levels between 5.5 and 7.05. In contrast, the other land uses exhibit more acidic conditions, particularly the oil palm farm, which could hinder nutrient availability due to increased aluminum toxicity associated with lower pH levels (Amusan *et al.,* 2006; Ayodele *et al.,* 2019). Fallow land shows a notably low pH (4.50), which may indicate leaching or degradation of soil quality over time, potentially necessitating liming to improve conditions for subsequent crops (Zhou *et al.,* 2019; Ayodele *et al.,* 2019).

The subsoil results reflect an overall trend of decreasing pH values compared to the topsoil, particularly in the fallow land and cassava plot. The subsoil acidity may be attributed to organic matter decomposition and nutrient leaching, which are common in tropical environments (Zhou *et al.,* 2019). The critical threshold for soil health is often considered to be around pH 5.5; thus, all recorded subsoil values fall below this threshold, indicating a potential risk for nutrient deficiencies and reduced microbial activity essential for soil fertility (Ayodele *et al.,* 2019).

Table 3: Effect of land use types on chemical properties of soils formed on coastal plain sand

Land use	pH	TN (g/kg)	OC (g/kg)	OM (g/kg)	Ca (cmol/kg)	Mg (cmol/kg)	K (cmol/kg)	Na (cmol/kg)	EA (cmol/kg)	ECEC (cmol/kg)	Bs (%)
0-15 cm											
Cassava	5.75	0.06	0.74	1.28	2.2	1.4	0.13	0.16	1.72	5.62	69.37
Fallow	4.50	0.16	2.59	4.46	2.2	0.6	0.25	0.08	3.60	6.74	46.53
Oil Palm	4.37	0.07	1.55	1.55	2.4	0.8	0.14	0.08	2.08	5.50	62.23
Rubber	4.70	0.11	1.30	2.24	2.2	0.6	0.13	0.06	2.36	5.30	56.00
P(<0.05)	0.614	0.007	0.446	0.405	0.861	0.861	0.043	0.08	0.254	0.257	2.72
15-30 cm											
Cassava	4.75	0.08	0.72	1.24	2.6	1.4	0.12	0.05	1.96	6.15	68.06
Fallow	4.25	0.02	2.33	4.02	2.6	1.4	0.2	0.14	3.16	7.5	57.94
Oil Palm	4.35	0.05	0.66	1.20	3.0	1.0	1.0	0.07	2.24	6.42	65.16
Rubber	4.4	0.07	0.74	1.28	2.6	1.4	0.13	0.07	2.08	6.29	66.95
P(<0.05)	0.337	0.023	0.072	0.105	1.039	1.039	0.449	0.019	0.232	0.229	2.459

TN= Total nitrogen, OC= Organic carbon, OM=Organic matter, Ca= Calcium= Mg=Magnesium, K =potassium, Na =sodium, EA=Exchangeable acidity, ECEC= Effective cation exchange capacity

Total nitrogen

The effects of different land use on total nitrogen is presented in Table 3. The result indicated that total nitrogen (TN) under different land uses investigated showed significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). For top soil (0-15 cm depth), soil under fallow land had the highest TN (0.16 g/kg) that was significantly ($p<0.05$) higher than those observed in soil under cassava farm (0.06 g/kg), oil palm plantation (0.07 g/kg), and rubber plantation (0.11 g/kg). The result further indicated that the least TN was recorded in soil under oil palm plantation (0.07 g/kg). For the sub-soil (15-30 cm depth), soil under fallow land had the highest TN (0.20g/kg) that was significantly ($p<0.05$) higher than those observed in soil under cassava farm (0.08g/kg), oil palm plantation (0.05g/kg), and rubber plantation (0.07g/kg). The result further indicated that the least TN was recorded in soil under oil palm plantation (0.05g/kg).

The total nitrogen (TN) content in soil is a crucial indicator of soil fertility, influencing plant growth and ecosystem health. The TN content in the topsoil reveals that the fallow land has the highest nitrogen level at 0.16g/kg, which can be attributed to the accumulation of organic matter during the fallow period, allowing for increased nitrogen fixation and microbial activity (Lal, 2004). In contrast, the cassava plot shows the lowest nitrogen content at 0.06g/kg. This low level may indicate nutrient depletion due to continuous cropping or inadequate soil management practices. The oil palm farm (0.07g/kg) and rubber plantation (0.11g/kg) also demonstrate relatively low nitrogen levels compared to fallow land, suggesting that these systems may not be effectively replenishing nitrogen levels through organic matter inputs or cover cropping practices.

In the subsoil, the fallow land again exhibits the highest nitrogen content of(0.20g/kg), reinforcing the idea that resting periods can enhance soil fertility through natural processes such as organic matter accumulation and microbial activity (Biederbeck *et al.,* 1996). The cassava plot shows a slight increase in TN compared to its topsoil value (0.08g/kg), which may suggest some nitrogen leaching from surface layers or deeper rooting systems accessing nitrogen reserves. Conversely, both the oil palm farm and rubber plantation show significantly lower TN levels of (0.05g/kg and 0.07g/kg, respectively), indicating potential deficiencies in these systems that could impact crop yields and over all soil health.

Critical values for total nitrogen in agricultural soils typically range from 0.10g/kg to 0.25g/kg for optimal crop growth (Giller *et al.,* 1997). The results indicate that the fallow land is within or slightly above this optimal range, suggesting good fertility. The cassava plot's topsoil and subsoil values are below this threshold, indicating a potential deficiency that could limit crop productivity. The oil palm farm and rubber plantation consistently show low TN levels across both layers, which may necessitate interventions such as cover cropping, green manures, or organic amendment.

Organic carbon and organic matter

The effects of different land use on soil organic carbon (OC) and soil organic matter (OM) is presented in Table 3. The result indicated that soil organic carbon (OC) and soil organic matter (OM) under different land use types did not show any significant ($p<0.05$) difference at both soil depth (Table 3).However, for top soil (0-15 cm depth), the highest OC was found in soil under fallow land (2.59 g/kg) followed by soil under oil palm plantation (1.55 g/kg) while the least OC was recorded in soil under cassava farm (0.74 g/kg). The order of distribution of OC was Fallow land > Oil palm plantation > Rubber plantation > Cassava farm. More so, for top soil (0-15 cm depth), the highest OM was found in soil under fallow land (4.46 g/kg) followed by soil under oil palm plantation (1.55 g/kg) while the least OM was recorded in soil under cassava farm (1.28 g/kg). The order of distribution of OM was Fallow land > Oil palm plantation > Rubber plantation > Cassava farm.

For sub-soil (15-30 cm depth), soil under fallow land had the highest OC (2.33g/kg) that was significantly at par ($p>0.05$) with soil under cassava farm (0.72g/kg), oil palm plantation (0.66 g/kg), and rubber plantation (0.74 g/kg). The result further indicated that the least OC was recorded in soil under oil palm plantation (0.66 g/kg). Similarly, for sub-soil (15-30 cm depth), the highest OM was found in soil under fallow land (4.46 g/kg) which was significantly at par with soil under other land uses. Soil under rubber plantation had (1.28 g/kg), soil under cassava farm had (1.24 g/kg), while soil under oil palm plantation had the least OM of (1.2 g/kg).

The result indicates that the fallow land has the highest organic carbon content which can be attributed to the accumulation of organic matter during the resting period. Fallowing allows for the natural regeneration of soil nutrients and organic matter, enhancing soil structure and fertility (Lal, 2004). The low level OC in cassava plot may indicate nutrient depletion due to continuous cropping practices without adequate organic matter replenishment. Continuous cultivation of cassava can lead to soil degradation if not managed properly (Ayodele *et al.,* 2019).The oil palm farm (1.55g/kg) and rubber plantation (1.30g/kg) also exhibit moderate levels of organic carbon, suggesting that these systems may benefit from improved management practices to enhance organic matter inputs, such as cover cropping or the incorporation of crop residues.

In the subsoil, the fallow land again demonstrates higher organic carbon content (2.33g/kg). The cassava plot's subsoil value is slightly lower than its topsoil value (0.72g/kg), which may indicate some degree of leaching or reduced organic matter input over time. Conversely, both the oil palm farm and rubber plantation show lower OC levels in the subsoil (0.66g/kg and 0.74g/kg, respectively). These values suggest that these systems might not effectively retain or build organic carbon, which can lead to reduced soil fertility over time.

Critical values for organic carbon in agricultural soils generally greater than 1.5 g/kg for optimal soil health and fertility (Landon, 1991). Based on this range, the fallow land is well within this optimal range, indicating good soil health and fertility. The cassava plots, oil palm farm and rubber plantation exhibit lower OC levels than desirable, particularly in topsoil, highlighting potential deficiencies that could limit crop productivity.

Exchangeable calcium

The effect of different land use on soil exchangeable calcium (Ca) is presented in Table 3. The result indicated that soil exchangeable calcium (Ca) under different land use types did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). However, for top soil (0-15 cm depth), the highest Ca was found in soil under oil palm plantation (2.4 cmol/kg) which was significantly at par with soil under cassava farm (2.20 cmol/kg), fallow land (2.20 cmol/kg), and rubber plantation (2.20 cmol/kg). Also, for sub-soil (15-30 cm depth), the highest Ca content was found in soil under oil palm (3.0 cmol/kg) which was significantly at par with soil under cassava farm (2.60 cmol/kg), fallow land (2.60 cmol/kg), and rubber plantation (2.60 cmol/kg). The slightly higher exchangeable calcium in the oil palm plantation may be attributed to the organic matter inputs from decomposing palm fronds and other residues, which can enhance nutrient retention and availability in the soil. In contrast, cassava farms often exhibit lower organic matter due to continuous cropping practices that can deplete soil nutrients over time (Nwawuike, 2023; Akinmutimi *et al.,* 2023).

Exchangeable magnesium

The effect of different land use on soil exchangeable magnesium (Mg) is presented in Table 3. The result indicated that soil exchangeable magnesium (Mg) under different land use did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). However, for top soil (0-15 cm depth), the highest Mg was found in soil under cassava farm (1.4 cmol/kg) which was not significantly ($p>0.05$) different from Mg contents in soils under oil palm plantation (0.8 cmol/kg), fallow land (0.6 cmol/kg), and rubber plantation (0.6 cmol/kg). Similarly, for sub-soil (15-30 cm depth), the highest Ca contents of 1.4 cmol/kg were found in soil under cassava, fallow land and rubber plantation, which was significantly at par with soil under oil palm (1.0 cmol/kg).

Exchangeable potassium

The effect of different land use on soil exchangeable potassium (K) is presented in Table 3. The result indicated that soil exchangeable K under different land use showed significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). For top soil (0-15 cm depth), the highest exchangeable K was found in soil under fallow land (0.25 cmol/kg), which was significantly ($p<0.05$) higher than those observed in soil under cassava farm (0.13 cmol/kg), oil palm farm (0.14 cmol/kg), and rubber plantation (0.13 com/kg).

Furthermore, for sub-soil (15-30 cm depth), the highest exchangeable K was found in soil under oil palm farm (1.0 cmol/kg), which was significantly ($p<0.05$) higher than those observed in soil under cassava farm (0.12 cmol/kg), fallow land (0.20 cmol/kg) and rubber plantation (0.13 com/kg). The finding of this study is in line with those reported by Nwawuike (2023) and Ayodele *et al.* (2019).

Exchangeable sodium

The effect of different land use on soil exchangeable sodium (Na) is presented in Table 3. The result indicated that soil exchangeable sodium (Na) under different land use did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). However, for top soil (0-15 cm depth), the highest exchangeable Na was found in soil under cassava farm (0.16 cmol/kg) which was not significantly ($p>0.05$) different from Na contents in soils under palm plantation (0.08 cmol/kg), fallow land (0.08 cmol/kg), and rubber plantation (0.06 cmol/kg). The highest exchangeable Na sub-soil (15-30 cm depth), was found in soil under fallow land (0.14 cmol/kg) which was not significantly ($p>0.05$) different from Na contents in soils under cassava farm (0.05 cmol/kg), oil palm plantation (0.07 cmol/kg), and rubber plantation (0.07 cmol/kg). The result obtains from this study is in consonant with those reported by Zhou et al. (2019) and Ayodele *et al.* (2019).

Exchangeable acidity

The effect of different land use on soil exchangeable acidity (EA) is presented in Table 3. The result indicated that soil exchangeable acidity (EA) under different land uses investigated did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). However, for top soil (0-15 cm depth), the highest EA was found in soil under fallow land (3.60 cmol/kg) which was not significantly ($p>0.05$) different from EA contents in soils under oil palm plantation (2.08 cmol/kg), cassava farm (0.16 cmol/kg), and rubber plantation (2.36 cmol/kg). Similarly, for sub-soil (15-30 cm depth), the highest EA was found in soil under fallow land (3.16 cmol/kg) which was not significantly ($p>0.05$) different from EA contents in soils under oil palm plantation (2.24 cmol/kg), cassava farm (1.96 cmol/kg), and rubber plantation (2.08 cmol/kg).

Effective cation exchange capacity (ECEC)

The effects of different land use on soil effective cation exchange capacity (ECEC)is presented in Table 3. The result indicated that soil ECEC under different land use types did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). However, for top soil (0-15 cm depth), the highest ECEC was found in soil under fallow land (6.74 cmol/kg) which was not significantly ($p>0.05$) different from ECEC contents in soils under oil palm plantation (5.50 cmol/kg), cassava farm (5.62 cmol/kg), and rubber plantation (5.30 cmol/kg). Similarly, for sub-soil (15-30 cm depth), the highest ECEC was found in soil under fallow land (7.50 cmol/kg) which was not significantly ($p>0.05$) different from ECEC contents in soils under oil palm plantation (6.42 cmol/kg), cassava farm (6.15 cmol/kg), and rubber plantation (6.29 cmol/kg). The results reported in this study is in line with the study of Zhou *et al.* (2019) and Ayodele *et al., (*2019).

Base saturation

The effect of different land use on soil base saturation (BS) is presented in Table 3. The result indicated that soil BS under different land use types did not show any significant ($p<0.05$) difference at both 0-15 cm and 15-30 cm soil depth (Table 3). The result indicated that for top soil (0-15 cm depth), the highest BS was found in soil under cassava farm (69.37 %) which was not significantly ($p>0.05$) different from BS values in soils under oil palm plantation (62.23 %), fallow land (46.53 %), and rubber plantation (55 %). Similarly, for sub-soil (15-30 cm depth), the highest BS was found in soil under cassava farm (68.06 %) which was not significantly ($p>0.05$) different from BS values in soils under palm plantation (65.16 %), fallow land(57.94 %), and rubber plantation (66.95 %).

Relationship between soil physical and chemical properties

A bivariate correlation analysis result showing relationships between soil physical and chemical properties are presented in Table 4. Total porosity (TP) showed a positive and significant correlation with magnesium (Mg) ($r = 0.773$, $p<0.05$) and sodium (Na) ($r = 0.946$, $p<0.01$). This result implies that an increase in total porosity will subsequently increase the level of Mg and Na in the soil. Sand significantly and positively correlated with pH ($r = 0.773$, $p<0.05$), Mg ($r = 0.773$, $p<0.05$) and BS ($r = 0.946$, $p<0.01$), and negatively and significantly correlated with clay($r = -0.79$, $p<0.05$), Av.P ($r = -0.831$, $p<0.05$), TN ($r = -0.810$, $p<0.05$),OC($r = -0.955$, $p<0.01$), OM ($r = -0.833$, $p<0.05$), K ($r = -0.848$, $p<0.01$),EA($r = -0.859$, $p<0.01$), and ECEC ($r = -0.849$, $p<0.01$). A positive and significant relationship between sand and pH, Mg, and BS implies that an increase in sand content, will correspondingly increase the values of soil pH, Mg and BS and vice versa. Similarly, a negative and significant relationship between sand and clay, Av.P, TN, OC, OM, K, EA and ECEC, implies that an increase in clay content will correspondingly decrease the values of these properties.

The results further showed available phosphorus to be positive and significantly correlated with TN($r = 0.955$, $p<0.01$), OC ($r = 0.925$, $p<0.01$), OM ($r = 0.998$, $p<0.01$),K ($r = 0.943$, $p<0.01$), EA ($r = 0.981$, $p<0.05$), and ECEC ($r = 0.901$, $p<0.01$), and negatively and significantly correlated with BS ($r = -0.923$, $p<0.01$). This results implies that an increase in Av. Pcontent, will correspondingly increase the values of soil TN, OC, OM, K, EA and ECEC , and vice versa, while an increase in Av. P content will correspondingly decrease the values of BS, and vice versa. Other notably relationships were also observed in Table 4

Table 4: Correlation matrix between soil physical and chemical properties

	Bd	K	Tp	Sand	Silt	Clay	pH	Av.P	TN	OC	OM	Ca	Mg	K	Na	EA	ECEC	Bs
Bd	1																	
K	-0.681	1																
Tp	-0.299	-0.260	1															
Sand	-0.093	0.007	0.428	1														
Silt	-0.240	0.686	-0.566	-0.285	1													
Clay	0.267	-0.446	0.031	-0.790*	-0.344	1												
pH	-0.503	-0.008	0.769*	0.778*	-0.414	-0.492	1											
Av.P	-0.337	0.201	-0.205	-0.831*	0.302	0.597	-0.441	1										
TN	-0.339	0.369	-0.422	-0.810*	0.533	0.420	-0.547	0.955**	1									
OC	-0.042	0.064	-0.336	-0.955**	0.208	0.787	-0.683	0.925**	0.875**	1								
OM	-0.42	0.239	-0.235	-0.833*	0.358	0.566	-0.459	0.998**	0.967**	0.920**	1							
Ca	0.310	-0.595	-0.067	-0.155	-0.439	0.365	-0.046	-0.151	-0.212	-0.008	-0.180	1						
Mg	-0.100	-0.019	0.773*	0.721*	-0.361	-0.381	0.675	-0.553	-0.653	-0.631	-0.559	-0.453	1					
K	-0.213	-0.004	-0.020	-0.848**	0.191	0.719*	-0.418	0.943**	0.852**	0.897**	0.937**	-0.065	-0.435	1				
Na	-0.295	-0.167	0.946**	0.676	-0.510	-0.272	0.874**	-0.457	-0.608	-0.610	-0.477	-0.107	0.865**	-0.299	1			
EA	-0.187	0.131	-0.310	-0.859**	0.359	0.592	-0.551	0.981**	0.956**	0.930**	0.984**	-0.160	-0.601	0.932**	-0.552	1		
ECEC	-0.244	-0.064	0.165	-0.712*	0.047	0.688	-0.249	0.901**	0.759*	0.817*	0.888**	-0.175	-0.240	0.964**	-0.123	0.880**	1	
BS	0.134	-0.230	0.548	0.849**	-0.504	-0.469	0.664	-0.923**	-0.968**	-0.894**	-0.934**	0.144	0.739*	-0.816*	0.737*	-0.963**	-0.721*	1

Bd= Bulk density, Tp= Total porosity, Av.P=Available phosphorus, TN=Total nitrogen, OC= Organic carbon, OM= Organic matter, Ca= Calcium, Mg= Magnesium, K= potassium, Na=Sodium, EA=Exchangeable acidity, ECEC= Effective cation exchange capacity, BS= Base saturation

Conclusion and Recommendation

The result indicated that sand, silt and clay contents under different land use did not show any significant difference at both 0-15 cm and 15-30 cm soil depth. Soil pH, OC, available phosphorus, exchangeable cations (Ca, Mg, K, and Na), exchangeable acidity, ECEC and BS under different land use did not show any significant difference at both 0-15 cm and 15-30 cm soil depth, except exchangeable Na at 15-30 cm. However, total nitrogen (TN) under different land use showed significant difference at both 0-15 cm and 15-30 cm soil depth. For top soil, soil under fallow land had the highest TN that was significantly higher than those observed in soil under cassava farm, oil palm plantation and rubber plantation. The analysis of organic carbon across different land uses highlights significant disparities that impact soil fertility and agricultural sustainability. The fallow land stands out as a system capable of maintaining higher organic carbon levels, while cassava, oil palm, and rubber plantations exhibit lower OC values that may require management interventions to enhance soil health.

Based on the findings from this study, it is imperative to adopt sustainable land use practices that prioritize soil conservation and environmental protection. To mitigate soil degradation and promote eco-friendly land use, farmers should implement conservation tillage techniques that reduce soil disturbance, promote soil organic carbon and minimize erosion.

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