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Influence of Land Use on Soil Physiochemical Properties in Semi-Humid Nsukka Area of Southeastern Nigeria

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ABSTRACT

The influence of four land uses (cultivated arable land, grassland, oil palm plantation and rubber plantation) on physical and chemical properties of coarse-textured acid soils was assessed in the semi-humid Nsukka area. Soil auger and core samples were used to achieve surface sampling at the depth intervals of 0-20 and 20-40cm in each land use type. Four diagnostic horizons were identified and sampled in each profile pit dug in each land use, which gave six samples per land use. Results showed that sand (90%) and silt (12%) fraction mean werehighest in oil palm plantation and rubber plantation respectively. The highest clay mean values were obtained from the surface samples (13%) of grassland land and the profile (24%) of rubber plantation. The oil palm plantation silt/clay (0.50) was less than unity and recorded the highest bulk density mean value (1.55 g/cm^3). The highest value of saturated hydraulic conductivity (113.4 cm/hr) and available water capacity (53%) was recorded in the rubber plantation. The pH of the cultivated (5.7-6.8) and rubber plantation (6.2-6.3) soil increased with depth in contrast to grassland and oil palm plantation. The soil organic carbon and total nitrogen generally decreased with depth across the four land uses. The highest cation exchange capacity mean value was obtained from the surface samples of grassland (19 cmol/kg) and the profile of rubber plantation (16 cmol/kg). This shows that assessment of soil properties under different agronomic land uses will guide decisions on soil degradation associated with land uses

1.0. Introduction

Soil and agricultural land use pattern study is essential for the prevention of soil degradation. Soil is a mass of particles with complex matter and comprises minerals, soil organic matter, water and air. These fractions greatly influence the soil properties (Harsha and Jagadeesh, 2017). The soil is the product of the interaction of physical, chemical and biological processes, with rocks, minerals and organic matter over sometime (Obi, 2004). This weathering process affects the soil component and its properties, for example, soil texture, which is said to be an index of soil properties.

The soil properties determine its capacity to support whatever use the soil is subjected to, but these properties have been greatly influenced in many ways. Spatial variability in the soil exists at many scales with different dominant controlling factors. The understanding of this variability and distribution of the soil properties as influenced by site characteristics (controlling factors), including climates, landscape features, and land use, is critical for assessing the future land use change in soil properties (Kosmas et al., 2000). Land use is the use in which a tract of land is put into (Ezeaku, 2011). The different land use systems have their peculiar effect on the soil properties of that location. Land use change is the main component of environmental change in every region. The conversion of forest reserve to other land use has caused many complex changes in forest ecosystems whose impact raises various ecological problems (Henrik et al., 2010; Awotoye et al., 2013). Land use involves land management, which must be planned to allocate land to its most suitable use (Akamigbo, 2010).

Several studies have been conducted around the world in various biomasses to evaluate the pedological properties of soil on different land uses (Ezeaku et al., 2012, Henrik et al., 2010). These studies reported that changes like conversion of land from forest or grassland to agricultural use are done primarily to improve the people's livelihood in an

environment. These changes from particular land use to another have consistently reduced land per capita. As a result of this, land physicochemical properties are always on decline or degradation. Chibsa and Ta'a (2009) noted that the distribution and abundance of soil organic carbon were varied independently in all land use systems. Onwudike et al. (2017) reported a high concentration of copper and iron in an oil palm plantation, while the highest concentration of zinc and manganese was recorded in plantain plantation.
It was reported that soil properties under fallow had the highest contents of chemical properties and hence improved soil fertility (Ezeaku *et al.,* 2015). The lower content of some of the measured soil properties observed in the cultivated soil was associated with land use modification compared to the soil properties under 10 years of fallow land use. These reports are made for soils outside Nsukka, hence the conduct of this study to examine the influence of Rubber plantation, oil palm plantation, cultivated arable land and grassland on soil physical and chemical properties and to correlate the soil properties across land use types.

2.0. Materials and methods

2.1 Study site
The study was conducted at the Teaching and Research-Farm of the Faculty of Agriculture, University of Nigeria, Nsukka, using four different land uses (Figure 1). The location is at latitude 06°52'N and longitude 07°24'E, with an altitude of 400 m above sea level. The mean annual total rainfall of Nsukka is about 1600 mm, of which distribution is bimodal, with a peak during July and October in the first and second phases, respectively. Mean annual values of minimum and maximum temperature are 24.0 and 32.0°C, respectively, while relative humidity ranges between 70 to 80% (Oko-Ibom and Asiegbu, 2006). The soil of the study location is an ultisol characterized as low activity clays (Ezeaku, 2006). Vegetation ofthe Nsukka area is largely secondary due to man's influence through bush burning, clearing, and land cultivation (Asadu and Akamigbo, 1987) and can be best described as derived savannah.
2.2 Site selection
At the beginning of the study, a general visual field (reconnaissance) survey of the area was carried out, to have a general view of the variation in the study location. A representative field was selected for each land use type: rubber plantation, oil palm plantation, cultivated arable land (cassava/maize cropping system), and Grassland. They were selected based on their predominance in the location
2.3Soil sampling
A profile pit was dug in each of the land use types. The soil sample was collected in each identified horizon of the profile pit, and a soil auger was also used to achieve surface sampling at intervals of 0-20 cm and 20-40 cm. The two depth intervals were chosen because most roots of arable crops concentrate within the 40 cm depth for their nutrient extraction and utilization (Asadu and Akamigbo, 2001). Undisturbed soil samples were also collected within 0-20 and 20-40 cm depth intervals using a core sample of 98.21 cm^3 volume. A geographical positioning system (GPS) was used to determine the coordinates of each of the soil sampling areas. The soil samples collected were analyzed in the soil laboratory of the Department of Soil Science, University of Nigeria, Nsukka.

2.4 Laboratory analysis
Particle size distribution was determined by Bouyoucos hydrometer method (Gee and Bauder, 1986) and soil bulk density as described by the core method (Blake and Hartage, 1986). Total porosity was determined using the relationship;

$$\text{Soil porosity (\%)} = 1 - \left(\frac{BD}{PD}\right) x\ 100;$$

Where BD = Bulk density (gcm^{-3}), PD = Particle density (gcm^{-3}).
Saturated hydraulic conductivity (K_s) was determined as described by Klute and Dirksen (1986) and calculated using Darcy's equation:

$$K_s\ (\text{cm h}^{-1}) = \frac{Q}{At} \times \frac{L}{\Delta H};$$

Where $Q$is the steady-state volume of flow (cm^2), L is the length of core sample (cm), A is cross-sectional area (cm^3), t is change in time interval (h), and Δ H is hydraulic head change (cm). Erosive index (erodibility index) was calculated as the ratio of sand + silt to clay (Hudson and Voorees, 1995).Using a digital pH meter, soil pH was determined in a 1:2.5 soil water ratio (McLean, 1982). Exchangeable acidity was extracted using 1M potassium chloride solution and determined by titration using sodium hydroxide (Logan et al., 2008). Soil organic carbon (SOC) was determined by the modified Walkey and Black wet digestion and oxidation method (Nelson and Sommers, 1996). Total nitrogen was determined by the micro-Kjeldahl digestion and distillation method as described by Bremner (1996). Available phosphorus was extracted using Bray-2 as described by Juoet al. (1996). Available phosphorus extract was determined by the blue colour method (Olson and Sommers, 1982). Exchangeable bases were extracted with neutral ammonium acetate (NH_4OAc). Exchangeable calcium and magnesium were determined in the extract by EDTA titration. Potassium and sodium were determined by the use of a flame photometer (Reeuwijk, 2002). Cation exchange capacity (CEC) was determined using the ammonium acetate displacement method described by Rhodes (1982). The exchangeable potassium percentage in soils was determined with the following formula (USDA, 1954).

$$EPP = \frac{ExchangeableK}{CEC} \times 100;$$

Where EPP is exchangeable potassium percentage, K is exchangeable potassium, CEC is cations exchange capacity.The potassium adsorption ratio in selected soils was calculated by the following formula (USDA, 1954).

$$PAR = \frac{K}{\sqrt{\frac{(Ca+Mg)}{2}}};$$

Where PAR is potassium adsorption ratio, Ca is exchangeable calcium, Mg is exchangeable magnesium. Effective cation exchange capacity (ECEC) was obtained by summation method as thus:

$$ECEC = TEB + EA;$$

Where TEB is the total exchangeable bases, and EA is the exchangeable acidity. Base Saturation (BS) was determined through a calculation using the formula as thus;

BS= $\left(\frac{summationofexchangeablebases}{ECEC}\right) \times 100$;

Where *ECEC* is effective cation exchange capacity.

2.5 Statistical analysis

Expressing variability is a function of mean and standard deviation values of the soil properties in the statistical sample populations. The following functions derived them:

Population sample $(n) = x1, x2 \ldots \ldots xn;$

Mean $(u)\frac{\varepsilon xn}{n}$ (to estimate the average value of the parameter);

Standard deviation ($\sigma) = \frac{\Sigma(xn-v)2}{(n-1)\,1/2}$ (to give a range or scatter of the parameter)

Coefficient of variation $(cv) = (\frac{\sigma}{\mu}$) 100% (to express variability on a relative scale).

Soil properties with larger CV values are more variable than those with smaller CV values. The ranking of the variability was done using the classification scheme by Wilding (1985) as follows: Little variation (CV =<0-15%), moderate variation (CV = 16-35%) and high variation (CV => 36%). Correlation analysis was done across the four land use systems using a statistical package for the Social Science software (SPSS, 2015). The values obtained in the study were compared with the established critical limit (Table 1) of the soil element from various pieces of literature.The suggested critical limit for some soil chemical properties from other literature includes: Soil organic matter (15-20g/kg), Total nitrogen (1.5 g/kg), Available phosphorous (8-12 mg/kg) (Enwezor et al., 1989). Ca, Mg, K= 2.0, 0.4, 0.2 cmol/kg (Adeoye and Agboola, 1984), CEC= low (less 6 cmol/kg) Meduim= (6-12 cmol/kg), High= (greater than 12 cmol/kg). (Adepetu et al., 1979)

3.0. Results and Discusion

3.1 Physical properties of surface soil as influenced by land use types

The results of the distribution of soil surface physical properties within the different agronomic land use types are presented in Table 2. It can be observed that the oil palm plantation had the highest sand fraction of 91% both in the surface (0-20cm) and subsurface (20-40cm) depths. The lowest sand fraction was recorded in the grassland soil, which had 79% and 81% at the subsurface (20-40cm) and surface (0-20cm) depth, respectively. The silt content decreased with depth, and clay fraction increased with

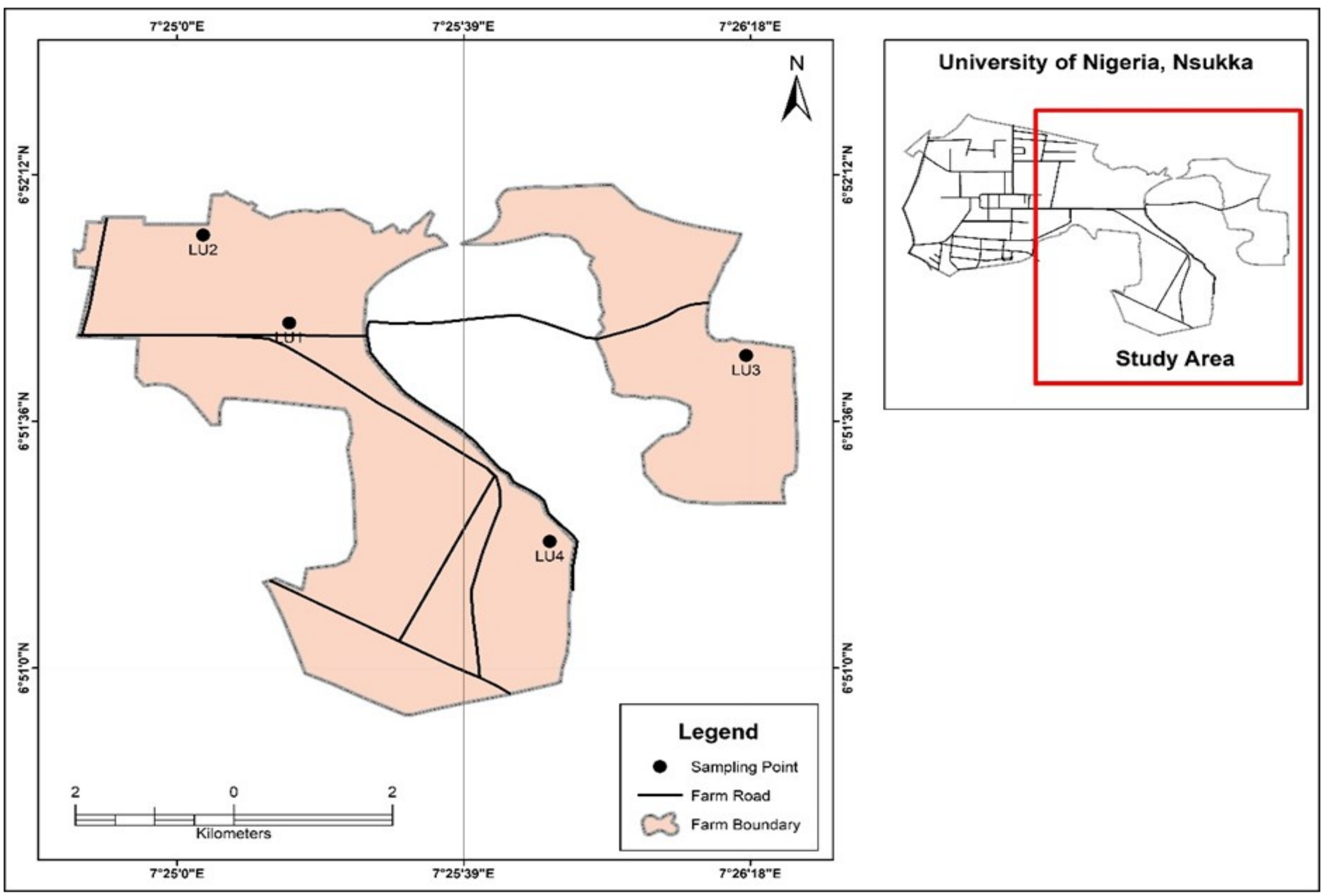

Figure 1: Map of University of Nigeria, Nsukka showing the Sampling Point

NB: LU1=cultivated arable land (cassava/maize cropping system), LU2=grassland,LU3=oil palm plantation and LU4=rubber plantation

Table 1: Suggested critical limits of some soils physicochemical properties

Limitation	Texture	Ksat	pH	Surface SOM
None	Loam	<0.8	6.0-7.0	5-10
Slight	Sil, si, si, cl	0.8-2	5.8-6.0, 7.0-7.4	3-5
Moderate	Cl, sl	2-6 mod	5.4-5.8, 7.4-7.8	1-3
Severe	Si, cl, ls	6-8 Mod. Rapid	5.0-5.4, 7.8-8.2	0.5-1
Extreme	Cs	8-12.5 Rapid; >12.5 very rapid	<5.0, 8.2	< 0.5

NB:Ksat=saturated hydraulic conductivity, SiI =silt loam, Si= silt, Sicl= silt clay loam, Cl=clay loam, Sl= sandy loam, Sicl=silty clay,Ls=loamy sand, C= clay, S=sand, Mod= moderate, SOM =soil organic matter (Lal, 1994; Landon 1984).

Table 2: Physical properties of surface soil as influenced by land use types

Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	Silt/clay	EI	Bulk density (g/cm^3)	Total porosity (%)	Ksat (cm/hr)	AWC (%)
Cultivated										
0-20	85	7	8	LS	0.88	11.50	1.56	41	81.31	34
20-40	85	5	10	LS	0.50	9.00	1.42	46	77.78	37
Mean	85	6	9		0.69	10.25	1.49	43.50	79.55	35.5
Grassland										
0-20	81	7	12	LS	0.58	7.33	1.48	44	30.3	38
20-40	79	7	14	SL	0.50	6.14	1.52	43	14.14	36
Mean	80	7	13		0.54	6.74	1.50	43.50	22.22	37
Oil palm										
0-20	91	3	6	S	0.50	15.67	1.5	43	131.31	35
20-40	91	3	6	S	0.50	15.67	1.6	40	75.76	31
Mean	91	3	6		0.50	15.67	1.55	41.50	103.54	33
Rubber										
0-20	81	13	6	LS	2.17	15.67	1.15	57	151.51	58
20-40	81	11	8	SL	1.38	11.50	1.28	52	75.76	48
Mean	81	12	7		1.78	13.59	1.22	54.50	113.64	53

NB:**EI**= erodibility Index, **Ksat**= saturated hydraulic conductivity**,** AWC= available water capacity, **LS**= loamy sand,**SL**= sandy loam**. S**=sandy

depth in the cultivated and rubber plantation land use types. Meanwhile, the grassland and oil palm plantation soil had the same silt content on surface and subsurface depths. The clay content also increases with depth in cultivated (8-10%), grassland (12-14%) and rubber plantation (6-8%) but remained the same both in surface and subsurface in oil palm plantation. The particle size distribution of soil under the various agronomic land uses indicated preponderance of sand, an indication that the soil skeletal structures arecoarse with restricted silt content. This implies that soils are easily detached by the agents of erosion, but the transportation of the particles will be low (Oku and Babalola, 2009). However, the variation of soil textural class from sandy, sandy loam and loamy sand could be attributed to the nature of parent materials and high rainfall that could favour washing away and leaching of silt-sized and clay-sized fractions (Mbagwu, 1995; Lal, 1988).

The mean of silt/clay ratio obtained in oil palm plantation (0.50), cultivated (0.54)and grassland(0.69) were less than unity which indicated high weatherability of the soil and, in contrast, greater than unity in rubber plantation soil (1.78) which indicated low weatherability of the soil and pedogenesis under land use. This finding corroborates Ezeaku *et al*., (2015) report. The erodibility index (Ei) of the soil, decreased with soil depth in cultivated (11.50-9.00), grassland (7.33- 6.14) and rubber plantation (15.67-11.50) but remain the same on surface and subsurface in oil palm plantation soil.

The bulk density highest mean value (1.55 g/cm^3) was recorded in the oil palm plantation, and the lowest mean (1.22 g/cm^3) bulk density was recorded in rubber plantation soil. The low bulk density of the rubber plantation soil could result inhigh organic matter content in the soil and higher pore space (Igwe, 2001). The mean bulk density of the cultivated land is 1.49 g/cm^{3,} and this is capable of impeding crop root growth and development, thereby reducing crop yield (Landon, 1991). The mean soil porosity ranged from 41.5% (oil palm plantation), 43.5% (cultivated), 43.5% (grassland) to 54.5% (rubber plantation). The low porosity in oil palm plantations could be a result of high bulk density and also applies to the high porosity in rubber plantations, which is a result of low bulk density (Mbagwu, 1989; Ezeaku *et al.*, 2012).The highest value of saturated hydraulic conductivity (113.4 cm/hr.) was recorded in rubber plantation, which shows higher water conductivity compared to oil plantation, cultivated and grassland soil with 103.54 cm/hr, 79.55 cm/hr, and 22.22 cm/hr. respectively. All the land use soils had a Ksat value greater than 12.5 cm/hr, indicating that the soils have very rapid water transmission(Landon, 1984). The implication of a high flow of water in the soils of all the land use types is that crop production may be limiteddue to the unavailability of water in the root zone(Ezeaku and Anikwe, 2006). The lowest value of saturated hydraulic conductivity was obtained in grassland soil which couldbe a low water transmission rate due to clay accumulation and siltation of the pedogenic horizons (Ezeaku, 2013). The mean value of available water capacity ranged from 33%, 36%, 37%, to 53% in oil palm plantation, cultivated land, grassland and rubber plantation, respectively. The low available water capacity in oil palm plantations could be attributed to the low organic matter content of the soil, which is similar to what was reported by Wakene (2001) and Ahmed (2002).

3.2 Chemical properties of surface soil as influenced by land use types

The surface soil chemical properties values of the four land uses are shown in Table 3. The pH of the cultivated

Table 3: Chemical properties of surface soil as influenced by land use types

Depth (cm)	pH (H_2O)	H^+	Al^{3+} (cmol/ kg)	O.C	TN (g/kg)	Ca^{2+}	Mg^{2+}	Na^+ (cmol/ kg)	K^+	CEC	BS (%)	AV. P (mg/ kg)	EPP (%)	PAR
Cultivated														
0-20	5.7	2.2	0.4	11.3	1.26	1	1.4	0.05	0.06	9.2	27	3.73	0.65	0.04
20-40	6.8	3	0.6	7.60	0.84	2	1.2	0.04	0.07	19.2	17	2.8	0.35	0.04
Mean	6.25	2.6	0.5	9.45	1.05	1.5	1.3	0.045	0.065	14.2	22	3.265	0.5	0.04
Grassland														
0-20	4.9	7.6	2.8	9.4	1.54	0.2	1.4	0.05	0.08	24.4	7	10.26	0.34	0.06
20-40	4.8	4.4	2.8	6.9	0.98	0.6	1	0.04	0.07	13.6	13	6.53	0.49	0.05
Mean	4.85	6	2.8	8.15	1.26	0.4	1.2	0.045	0.075	19	10	8.395	0.415	0.055
Oil Palm														
0-20	5.8	1.4	1	5	0.84	0.8	1.6	0.02	0.04	6.4	38	12.12	0.58	0.02
20-40	5.7	1.6	1.4	4.4	0.56	0.4	1	0.03	0.05	10	14	1.87	0.52	0.04
Mean	5.75	1.5	1.2	4.7	0.7	0.6	1.3	0.025	0.045	8.2	26	6.995	0.55	0.03
Rubber														
0-20	6.2	1.8		16.7	1.96	2.8	2.6	0.07	0.74	16.4	38	0.93	4.54	0.32
20-40	6.3	1.4	0.4	9.1	0.84	1.6	0.4	0.03	0.37	11.2	21	0.93	3.32	0.26
Mean	6.25	1.6	0.4	12.9	1.4	2.2	1.5	0.05	0.555	13.8	29.5	0.93	3.93	0.29

NB: H^+= exchangeable hydrogen ion,Al^{3+} =exchangeable aluminum, O.C= organic carbon, TN= total nitrogen, Ca^{2+}=exchangeable calcium, Mg^{2+} = exchangeable Magnesium,Na^+= exchangeable sodium, K^+= exchangeable potassium, CEC= cation exchange capacity, BS= percentage base saturation, AV. P= available phosphorus, PAR=potassium adsorption ratio, EPP= exchangeable potassium percentage

and rubber plantation soil increased with depth, with each having 5.7-6.8 and 6.2-6.3.The soil pH of grassland (4.9-4.8) and oil palm plantation (5.8-5.7) decreased with depth. Following the classification described by Foth and Ellis (1997) Brady and Weil (2002), and Ezeaku (2013), the variation in pH could be due to the displacement function by hydrogen ions in the soil.The exchangeable acidity mean values show that grassland soil had the highest AL^{3+} and $H^{+,}$which showsthe highest acidity when compared to cultivated, oil palm and rubber plantation soil. The soil organic carbon generally decreased with depth in grassland, oil palm, rubber, and cultivated with the mean of 8.15, 4.7, 12.9 and 9.45 g/ kg, respectively. The values of organic carbon and total nitrogen were higher in thegrassland due to the fact that the land surface had dense grasses and leaching losses of the element are minimal, while that of oil palm plantation may be due to mulching and green legume growth. The high value of organic carbon recorded in rubber plantation maybe due to the decomposition of leaves in the plantation hence increasing the fertility of the soil because soil fertility is linked to soil organic carbon, whose status depends on biomass input, mineralization, leaching and erosion (Roose and Barthes 2001; Nandwa 2001). The total nitrogen generally decreased with depth across the four land uses. The highest total nitrogen value obtained in rubber plantation soil maybe as a result of nutrient cycling since the amount extracted is returned to the soil as litter (Ezeaku and Iwuanyawu, 2013).

The mean exchangeable calcium value was highest in rubber plantation (2.2 cmol/kg) and lowest in grassland soil (0.4 cmol/kg). The exchangeable magnesium generally decreased with depth across the four land uses. However, the highest value (1.5 cmol/kg) was recorded in the rubber plantation. The exchangeable sodium decreased with depth in all land use types except in oil palm plantain soil, where the reverse was the case. The lowest mean value was 0.025 cmol/kg was recorded in oil palm, and the exchangeable potassium means value (0.555 cmol/kg) was seen to be highest in rubber plantation, while the lowest mean value of 0.045cmol/kg was observed in oil palm plantation. The highest value of Ca, Mg and k that were observed in rubber plantation could be due to the high organic matter content in the soil. The mean values of calcium and potassium across the four land use were below the critical limit of 2.0 and 0.2 cmol/kg except that of rubber plantation, which had a mean value of 2.2 and0.56 cmol/kg,respectively. In contrast,the mean values of magnesium in the four land uses were above the critical limit of 0.4 cmol/kg (Adeoye and Agboola, 1984).

The mean value of CEC was highest in grassland (19.0 cmol/ kg) and lowestin oil palm plantation (8.20 cmol/kg).This is due to an increase in clay content and an increase in organic matter content with depth. Based on the CEC range for Nigerian soils (Adepetu*et al*., 1979; Ojanuga and Awojuola, 1981), the mean value of cultivated land (14.2 cmol/kg), grassland (19.0 cmol/kg) and rubber plantation (13.8 cmol/ kg) soil are high, while that of oil palm (8.2 cmol/kg) is medium. Decreasing CEC suggestsa decrease in buffering capacity (Ezeaku *et al.*, 2002).

The decreasing order of the mean value of percentage base saturation across the four land uses was rubber (29.5 %) > oil palm (26 %)> cultivated (22 %) > grassland (10 %). The high percentage base saturation in rubber plantation soil could be a result of high exchangeable bases and high organic carbon content. The grassland soil had the highest available phosphorous mean value (8.40 mg/kg), while that of rubber plantation mean value (0.93 mg/kg) was the lowest. The high available phosphorous in grassland was in line with the findings of Urioste et al. (2006), which stated that grassland affected the distribution of available phosphorous in the soil of the semi-arid region of Argentinan Pampas. The highest mean value of exchangeable potassium percentage (EPP) was obtained from oil palm plantation with 0.55 %, while the lowest mean value (3.93 %) was obtained from the rubber plantation. The high EPP in the oil palm plantain soil could be due to the high exchange site offered for potassium. The highest mean value ofpotassium adsorption ratios (PAR) was obtained in rubber plantation (0.29) compared to grassland (0.06), cultivated (0.04) and oil palm plantation s (0.03) soil. The highest value of PAR in rubber plantation could be due to the high adsorption site offered for potassium (Harsha and Jagadeesh, 2017).

3.3 Physical properties of soil profile as influenced by different land use types

The representative soil profile physical properties are presented in Table 4. It was generally observed that sand fraction decreased with depth and conversely for clay fraction. Silt fraction varied within the profile of the four land use types. The highest sand fraction mean value was recorded in oil palm plantation soil (82.25 %) as compared to cultivated (81.5 %), grassland (78.5 %) and rubber plantation soil (71 %). But the lowest mean value of clay fraction was recorded

Table 4: Physical properties of soil profile as influenced by different land use types

Horizon	Depth (cm)	Sand (%)	Silt (%)	Clay (%)	Texture	Silt/Clay	EI	Bulk Density (g/cm3)	Total Porosity (%)	KST (cm/hr)	AWC (%)
		Cultivated									
Ap	0-20	87	5	8	LS	0.62	11.50	1.41	49	7.59	33
B	20-40	85	3	12	LS	0.25	7.33	1.35	51	8.02	40
Bt	40-70	85	3	12	LS	0.25	7.33	1.31	53	10.09	42
Bt_2	70-190	69	5	26	SCL	0.2	2.85	1.39	50	7.12	37
Mean		81.5	4	14.5		0.33	7.25	1.365	50.75	8.205	38
STDEV		8.3865	1.1547	7.8951		0.1948	3.5325	0.0443	1.7078	1.3093	3.9158
CV(%)		10.2902	28.8675	54.4493		59.0196	48.7071	3.2489	3.3652	15.9575	10.3047
Grassland											
Ap	0-20	79	7	14	SL	0.50	6.14	1.08	59	12.63	47
B	20-45	81	5	14	SL	0.35	6.14	1.44	46	9.09	29
BC	45-100	79	3	18	SL	0.17	4.56	1.41	47	7.58	32
C	100-180	75	3	22	SCL	0.14	3.55	1.47	45	9.09	31
Mean		78.5	4.5	17		0.29	5.0975	1.35	49.25	9.5975	34.75
STDEV		2.5166	1.9149	3.8297		0.1679	1.2724	0.1816	6.5511	2.1433	8.2614
CV(%)		3.2059	42.5523	22.5277		57.9064	24.9620	13.4562	13.3017	22.3321	23.7737
Oil Palm											
Ap	0-25	89	1	10	LS	0.10	9.00	1.55	42	12.63	28
Bt	25-85	83	5	12	LS	0.42	7.33	1.47	45	9.09	29
Bt_2	85-130	82	1	20	SCL/SL	0.05	4.15	1.34	49	7.07	38
Bc	130-200	75	1	24	SCL	0.04	3.16	1.42	47	15.15	34
Mean		82.25	2	16.5		0.1525	5.91	1.445	45.75	10.985	32.25
STDEV		5.7373	2	6.6081		0.1803	2.7218	0.0881	2.9861	3.6043	4.6458
CV(%)		**6.9754**	**100**	**40.0489**		**118.1996**	**46.0542**	**6.0989**	**6.5270**	**32.8105**	**14.4055**
Rubber											
Ap	0-20	89	3	8	S	0.40	11.50	1.52	43	2.02	27
Bt	20-50	73	9	18	SL	0.50	4.56	1.25	53	2.53	46
Bt_3	50-115	59	5	36	SC	0.14	1.80	1.49	44	1.01	34
B	115-180	63	3	34	SCL	0.10	1.94	1.33	50	1.26	40
Mean		71	5	24		0.2850	4.95	1.3975	47.5	1.705	36.75
STDEV		13.3666	2.8285	13.3666		0.1955	4.5474	0.1289	4.7959	0.6979	8.1394
CV(%)		18.8262	56.5685	55.6943		68.6082	91.8672	9.2263	10.0965	40.9284	22.1481

NB:STDEV=standard deviation, CV(%) = coefficient of variability,EI=erodibility index, Ksat= saturated hydraulic conductivity, AW C= available water capacity, LS=loamy sand, SL=sandy loam, SCL sandy clay loam, SC= sandy clay, S= sandy

in cultivated (14.5 %), compared to oil palm (16.5%), grassland (17.0 %) and rubber (24 %). The mean value of silt content was the highest (5%) inthe rubber plantation.The increase in clay content down the profile could be associated with the elluviation -illuviation processes and underlying geology through weathering (Idoga and Azagaku, 2005; Ezeaku*et al*., 2015). The textural class varied from sandy, sandy loam, sandy clay, sandy clay loam to loamy sand, while sandy clay loam dominated the last horizons in the four land use types. The different textural classes could be attributed to the parent material bedrockderived from them, such as schists (Vinay, 2007).

The highest mean value of silt clay ratio was obtained in cultivated soil (0.33) compared to grassland (0.30), rubber (0.29) and oil palm (0.15) soil. The silt clay ratios across the profile of the four land uses were less than unity which signifies high weatherability of soils and pedogenesis under the four land uses (Nwaka and Kwari 2000). The erodibility index generally decreased with an increase in depth. This can be attributed to an increase in clay content down the profile (Ezeaku *et al*., 2015).

The bulk density varied within the profile of the four land uses, and it was observed that the mean bulk density ranged from 1.35 g/cm^3, 1.37g/cm^3, 1.40/cm^3 to 1.45g/cm^3 in grassland, cultivated, rubber and oil palm plantation, respectively. The lower the bulk density, the higher the porosity value of the soil and the higher the rating of the soil for crop production (Oku *et al*., 2015). It was also observed that the bulk density of the surface horizon was higher than others in all land use except that of grassland soil, and this could be a result of the compaction by a different form of soil disturbance. The saturated hydraulic conductivity varied within the profile of all the land uses. The mean values of saturated hydraulic conductivitywere in the following decreasing order of 10.99 cm/hr> 9.60 cm/hr> 8.21 cm/hr. > 1.71 cm/hr. with their respective land uses as oil palm, grassland, cultivated and rubber plantation soil. The soil of the oil palm, grassland and cultivated land saturated hydraulic conductivity fall within the critical value of moderately rapid, while that of the rubber plantation falls within the critical level of slight limitation (Lal,1994; Landon,1984) classification. Hence oil palm will conduct more water than other land uses. The mean valuesof available water capacity were in the following decreasing order of 38.0 %(cultivated) >37.0 %(rubber plantation) >35.0 %(grassland) > 32.25 %(oil palm).The low available water capacity of the oil Palm plantation soil could be due to high bulk density and low porosity (Ezeaku and Egbemba, 2014). The soil physical properties with a larger coefficient of variation value are more variable than those with smaller CV% value, based on the classification scheme by Wilding (1985).

3.4 Chemical properties of soil profile as an influence by different land use types

The soil pH value across the land uses ranged from strongly acidic (4.5-5.0) to neutral (6.6-7.3) (Table 5). The pH of cultivated soil ranged from 5.6 to 6.70, that of grassland was 4.8 to 5.0, oil palm plantation was 4.8 to 5.3 and rubber plantation soil was 5.6 to 5.9, which accords to the pH rating of Lal (1994); Foth and Ellis (1997) and Brady and Weil (2002). The exchangeable acidity (H^+ and Al^{3+}) var-

Table 5: Chemical properties of soil profile as influence by different land use types

Horizon	Depth (cm)	pH (H_2O)	H^+	Al^{3+} (cmol/kg)	O.C	TN (g/kg)	Ca^{2+}	Mg^{2+}	Na^+ (cmol/kg)	K^+	CEC	BS (%)	AV. P (mg/kg)	EPP (%)	PAR
Cultivated															
Ap	0-20	5.90	1.4	0.6	8.4	0.84	1.6	1.2	0.03	0.04	17.2	18	6.53	0.26	0.04
B	20-40	5.60	1	0.4	5.1	0.84	1.6	1.4	0.09	0.07	12.8	25	1.87	0.52	0.04
Bt	40-70	6.70	1.6	0.6	4.4	0.42	2.2	0.8	0.05	0.03	14.8	21	1.87	0.2	0.02
Bt_2	70-190	6.60	3.8	0.4	2.2	0.7	1	0.8	0.07	0.07	13.6	14	0.93	0.55	0.06
Mean		6.2067	1.95	0.5	5.025	0.7	1.6	1.05	0.06	0.0525	14.6	19.5	2.8	0.3825	0.04
STDEV		0.5454	1.2583	0.1154	2.5669	0.1979	0.4898	0.3	0.0258	0.02061	1.9183	4.6547	2.5258	0.1782	0.0163
CV(%)		8.6444	64.5285	23.0940	51.0833	28.2842	30.6186	28.5714	43.0332	39.2676	13.1393	23.8705	90.2086	46.5905	40.8248
Grassland															
Ap	0-20	4.80	8.00	1.60	12.80	1.26	0.60	1.20	0.04	0.04	12.40	15.00	0.93	0.36	0.03
B	20-45	4.8	3.6	2.4	5.4	0.56	0.6	1	0.06	0.07	14.4	12	4.66	0.52	0.06
BC	45-100	4.8	2	2.8	9.4	0.42	0.4	0.8	0.08	0.11	13.6	10	0.93	0.82	0.1
C	100-180	5	4.2	2	1.8	0.42	0.4	1.4	0.06	0.09	9.2	21	0.93	0.97	0.07
Mean		4.85	4.45	2.2	7.35	0.665	0.5	1.1	0.06	0.0775	12.4	14.5	1.8625	0.6675	0.065
STDEV		0.1000	2.5423	0.5164	4.7788	0.4021	0.1155	0.2582	0.0163	0.0299	2.2862	4.7958	1.865	0.2775	0.02887
CV(%)		2.0619	57.1305	23.4726	65.0173	60.4691	23.0940	23.4726	27.2166	38.5301	18.4370	33.0747	100	41.5781	44.4116
Oil Palm															
Ap	0-25	4.9	3.6	2.4	5.4	0.56	0.4	0.6	0.06	0.06	10.4	11	3.73	0.57	0.06
Bt	25-85	4.8	3.2	2.4	5.4	0.28	0.6	1.2	0.03	0.04	18	10	0.93	0.25	0.03
Bt_2	85-130	5.3	3	1.6	2.5	0.56	0.4	1.4	0.06	0.07	7.2	27	2.8	0.93	0.05
Bc	130-200	4.8	2.4	4	2.2	0.42	0.4	1.4	0.06	0.07	12	16	2.8	0.62	0.06
Mean		4.95	3.05	2.6	3.875	0.455	0.45	1.15	0.0525	0.06	11.9	16	2.565	0.5925	0.05
STDEV		0.2380	0.5000	1.0066	1.7652	0.1340	0.1000	0.3786	0.015	0.0141	4.5299	7.7889	1.1749	0.2784	0.0141
CV (%)		4.8090	16.3934	38.7171	45.5528	29.4593	22.2222	32.9210	28.5714	23.5702	38.0664	48.6805	45.8036	46.9656	28.2843
Rubber															
Ap	0-20	5.9	1.4	1.4	4.7	1.54	0.8	2.8	0.06	0.07	20.8	18	1.87	0.36	0.04
Bt	20-50	5.6	2	1.8	6.2	1.12	0.6	2.2	0.04	0.05	17.2	17	0.93	0.3	0.03
Bt_3	50-115	5.8	1.4	0.6	5.8	0.98	1.4	1.6	0.03	0.03	15.2	20	0.93	0.2	0.02
B	115-180	5.8	1.2	0.4	2.5	0.42		2.4	0.04	0.04	11.2	33	1.86	0.4	0.02
Mean		5.775	1.5	1.05	4.8	1.015	1	2.25	0.0425	0.0475	16.1	22	1.3975	0.315	0.0275
STDEV		0.1258	0.3464	0.6608	1.6593	0.4626	0.3651	0.5000	0.0126	0.0171	4.0050	7.4387	0.5398	0.0870	0.0096
CV (%)		2.1789	23.0940	62.9341	34.5691	45.5730	36.5148	22.2222	29.6072	35.9542	24.8758	33.8120	38.6288	27.6148	34.8155

NB:**STDEV** =standard deviation**, CV(%)** = coefficient of variability, **H** $^+$=exchangeable hydrogen ion,**Al^{3+}** =exchangeable aluminum, **O.C**= organic carbon, **TN**= total nitrogen, **Ca^{2+}**=exchangeable calcium, **Mg^{2+}** = exchangeable magnesium**, Na^+**= exchangeable sodium, **K^+**= exchangeable potassium, **CEC**= cation exchange capacity, **BS**= percentage base saturation, **AV. P**= available phosphorus, **PAR**= potassium absorption ratio**, EPP**= exchangeable potassium percentage.

ied across the different land use profile depths. The H^+ mean values range from 1.0 cmol/kg - 8.0 cmol/kg with the lowest mean value of 1.5 cmol/kg recorded in rubber plantation soil and Al^{3+} lowest mean value was observed in cultivated soil (0.5 cmol/kg), the exchangeable acidity was increasing, and the soil pH was decreasing (Spark, 1995; Ezeaku *et al*., 2015).The soil total organic carbon generally decreased with soil depth in cultivated and oil Palm plantation while varied within the profile of grassland and rubber plantation. The value ranged from 1.8 to 12.80 g/kg. It was generally observed that the lowest soil organic carbon across all the land uses was recorded at the last horizon of each profile in the respective land use. The highest value of organic carbon (12.80 g/kg) was recorded on the surface horizon of the grassland soil, which could be due to the low extraction of the nutrient from the soil compared to other land uses.The total nitrogen value decreased with the depth in cultivated and rubber plantation soil and varied within the profile of grassland and oil palm. It was generally observed that the higher the organic carbon content the higher the total nitrogen. The total nitrogen at the surface horizon is higher than that of the last horizon in the four land uses (Buol et al., 2003).

The exchangeable bases had the following decreasing order of mean value of calcium cultivated> rubber >grassland > oil palm corresponding to 1.6 cmol/kg, 1.0 cmol/kg, 0.5 cmol/kg and 0.45 cmol/kg. According to the critical value of 2.0, 0.4 and 0.2 cmol/kg for calcium, magnesium and potassium, respectively (Adeoye and Agboola, 1984), the value obtained across the land uses showed that exchangeable calcium is limiting in the four land uses. This low calcium across the four land uses could be due to the leaching of calcium. The highest mean value of magnesium was obtained from the rubber plantation (2.25 cmol/kg), and the mean value of magnesium in the four land uses wasabove the critical limit of 0.4 cmol/kg. The highest mean value of sodium was recorded in cultivated and grassland soil compared to oil palm and rubber plantation soil which had 0.05 cmol/kg and 0.04 cmol/kg. The mean values of exchangeable potassium in the four land uses were 0.07 cmol/kg (grassland), 0.05 cmol/kg (cultivated), 0.04 cmol/kg (rubber) and 0.01cmol/kg (oil palm). The exchangeable potassium was generally below the critical limit of 0.2 cmol/kg in all land use types, and this could be due to low fixation and leaching of potassium.

The mean value of cation exchange capacity CEC was highest at the rubber plantation soil (16.1 cmol/kg) when compared to cultivated soil (14.6 cmol/kg), grassland (12.4 cmol/kg) and oil palm (11.9 cmol/kg). The low CEC in oil palm could be because the soil is coarser and has a high sand and low organic matter (OC) content (Berthrong et al.,2009; Harsha and Jagadeesh, 2017). The percentage base saturation was 22%, 19.5%, 16% and 14.5% at rubber, cultivated, oil palm and grassland soil, respectively. High base saturation in rubber plantation soil could be associated with the old root and leaves litter fall that decomposesand adds organic matter, calcium and magnesium to the soil. The base cation increase the buffer capacity of the soil against high leaching due to rainfall (Ezeaku, 2013).The available phosphorous mean value ranged from 2.8, 2.6, 1.86 to 1.40 mg/kg in cultivated, oil palm, grassland and rubber plantation soil, respectively. The values are lower than the critical limit (8 -12 mg/kg) for Nigerian soil. The low content of phosphorous in soils has been related to leaching by intense rainfall, high weatherability of the soils as shown by high values of erodibility index, presence of kaolinite clay as the dominant mineral and adsorption reaction by soil constituent (Enwerzor et al., 1989).The exchangeable potassium percentage (EPP) mean value ranged from 0.67%, 0.59%, 0.38% to 0.32% in grassland, oil palm, cultivated and rubber plantation soil. The high value of EPP in grassland soil could be due to the high exchange site offered for potassium in the grassland soil. (Laurenson et al., 2011; Harcha and Jagadeesh, 2017).The potassium adsorption ratio varied within the soil profile across the different land use types. The potassium adsorption ratio means value was of the following decreasing order 0.07%> 0.05% > 0.04%> 0.02% in grassland, oil palm, cultivated and rubber plantation soil, respectively. The highest mean obtained in grassland could be due to the high adsorption site offered for potassium and leaching of calcium ions from the soil surface (Parfitt, 1992; Harsha and Jagadeesh, 2017).The soil chemical properties with amore significant coefficient of variation value are more variable than those with smaller CV% value, based on the classification scheme by Wilding (1985).

3.5 Correlation matrix of soil physical properties across the four land use

The results obtained in Table 6 showed a negative significant (-0.958**) correlation between sand and clay, while a positive significant (0.866**) correlation occurred between sand and erodibility index. Silt and silt/clay ratio had positive significant (0.718**) correlation, while silt/clay ratio and erodibility index had negative significant (-0.604*and -0.902** respectively) correlation with clay. A significant positive correlation occurred between erodibility index and silt/clay ratio (0.633**), between available water capacity and total porosity (0.924**).Again,a significant negative correlation occurred between total porosity and bulk density (-0.977**) as well between available water capacity and bulk density(-0.918**). No significant correlation occurred in other parameters.

3.6 Correlation matrix of soil chemical properties across

Table 6: Correlation matrix of soil physical properties across the four land use

	Sand (%)	**Silt (%)**	**Clay (%)**	**Silt/Clay**	**EI**	**BD (g/cm^3)**	**TP (%)**	**Ksat (cm/hr)**	**AWC (%)**
Sand(%)									
Silt(%)	-0.262								
Clay(%)	-0.958**	-0.014							
Silt/Clay	0.381	0.718**	-0.604*						
EI	0.866**	-0.026	-0.902**	0.633**					
BD(g/cm^3)	0.128	-0.49	-0.018	-0.306	0.195				
TP(%)	-0.085	0.483	-0.032	0.344	-0.132	-0.977**			
Ksat(cm/hr)	-0.453	-0.313	-0.392	-0.073	0.15	-0.097	0.124		
AWC(%)	-0.29	0.447	0.192	0.144	-0.323	-0.918**	0.924**	-0.065	

NB: **EI**= erodibility index, **Ksat**= saturated hydraulic conductivity,**AWC =** available watercapacity**, TP=**total porosity**, BD =**bulk density
**=correlation is significant at 0.01 level (2-tailed), *=correlation is significant at the 0.05 level (2-tailed)

Table 7: Correlation matrix of soil chemical properties across the four land use

	pH (H_2O)	H^+ (cmol/kg)	Al^{3+} (cmol/kg)	O.C (g/kg)	TN (g/kg)	Ca^{2+} (cmol/kg)	Mg^{2+} (cmol/kg)	Na^+ (cmol/kg)	K^+ (cmol/kg)	CEC (cmol/kg)	BS (%)	AV. P (mg/kg)	EPP (%)	PAR
pH(H_2O)														
H^+(cmol/kg)	-0.446													
Al^{3+}cmol/kg)	-0.794**	0.261												
O.C(g/kg)	-0.279	0.379	0.026											
TN(g/kg)	0.22	0.093	-0.305	0.418										
Ca^{2+} (cmol/kg)	0.774**	-0.482	-0.767**	0.001	0.08									
Mg^{2+} (cmol/kg)	0.167	-0.354	-0.19	-0.189	0.526*	-0.004								
Na^+ (cmol/kg)	-0.67	-0.082	0.144	-0.218	-0.122	-0.156	-0.239							
K^+(cmol/kg)	-0.382	0.033	0.464	-0.153	-0.185	-0.564	-0.147	0.792**						
CEC (cmol/kg)	0.287	-0.322	-0.131	0.298	0.484	0.29	0.345	-0.331	-0.296					
BS(%)	0.398	-0.368	-0.559*	-0.421	0.008	0.407	0.511*	-0.35	-0.227	-0.357				
AV.P (mg/kg)	-0.048	-0.173	0.038	0.049	-0.079	0.13	-0.196	-0.104	-0.097	0.014	-0.035			
EPP(%)	-0.425	0.203	-0.054	-0.325	-0.378	0.601*	-0.219	0.633**	0.829**	-0.721**	0.06	-0.054		
PAR	-0.449	0.142	0.073	-0.025	-0.327	-0.58*	-0.431	0.659**	0.92**	-0.319	-0.455	0.073	0.783**	

NB: **H^+**=exchangeable hydrogen ion**,Al^{3+}** =exchangeable aluminum, **O.C=** organic carbon, **TN=** total nitrogen**, Ca^{2+}**=exchangeable calcium, **Mg^{2+}** = exchangeable magnesium**, Na^+**= exchangeable sodium, **K^+**= exchangeable potassium, **CEC=** cation exchange capacity, **BS=** percentage base saturation, **AV. P=** available phosphorus, **PAR=** potassium adsorption ratio**, EPP=** exchangeable potassium percentage.
**=correlation is significant at 0.01 level (2-tailed), *=correlation is significant at the 0.05 level (2-tailed)

the four land use

Results in Table 7 showed negative significant correlation between pH and Al^{3+}(-0.794**) and between cation exchange capacity and exchangeable potassium percentage (-0.721**). Positive significant ($p<0.01$) correlation occurred between calcium and pH, exchangeable potassium percentage and sodium, potassium and exchangeable percentage, sodium and potassium adsorption ratio, potassium and sodium, as well as between potassium adsorption ratio and exchangeable potassium percentage. Negative significant correlation occurred between Al^{3+} and base saturation (-0.559*) and between potassium adsorption ratio and calcium (-0.58*).A positive significant ($p<0.05$) correlation occurred between calcium and exchangeable potassium percentage, between base saturation and magnesium, and between total nitrogen and magnesium (0.526*).While other parameters had no significant correlation.

4.0. Conclusion and recommendation

The findings of this study revealedthat soil physical and chemical properties were influenced by the land use type, and these physicochemical properties varied within the four land use. The fluctuation in the soil physical and chemical properties down the soil profiles suggest that the soil nutrients were not evenly distributed in the profiles of the four land use. At both surface and soil profile horizons sampling, most values of soil pH, calcium, total nitrogen, cation exchange capacity, base saturation, total porosity, available water capacity, silt content, bulk density and exchangeable acidity were obtained in rubber plantation. In contrast,the least soil physical and chemical properties were obtained from oil palm plantation soil.The soil properties of the cultivated, grassland and oil palm plantation soil were negatively affected, and these showed overall change towards the direction of loss of their fertility when compared to the soil physical and chemical properties of rubber plantation. These effects are attributed to the higher soil organic matter content in the rubber plantation, continuous crop removal, and frequent soil disturbance, especially by tillage operation in cultivated soiland poor management of oil palm plantation soil.

The correlation data, which provided estimation on the contribution of the variation to the explanation of the performance of land use types, revealed that some of the properties positively correlated significantly in relation to the land use, which means that both elements may have influenced the land use performance, which is in contrast to negative correlation. Non-significant correlated parameters showed that the element influencing the land use acted independently.The information generated from the study will assist in developing sustainable and ecologically stable land use management strategies for the study area. These will serve as a means to guide them on how best to adopt specific management strategies for each land use type to ensure its optimum and sustainable performances while ensuring social environmental conditions.

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