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Effects of Land Use on Soil Physical and Chemical Properties in Akokwa Area of Imo State, Nigeria

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ABSTRACT- The physico-chemical properties of four lands use types in Akokwa of Ideato North, Imo State, Nigeria were determined. The land use patterns were fallow land (FL), cassava continuously cultivated land (CL), Oil palm plantation (OPL) and Yam plot (YL). Composite samples were collected from various depths (0–15 cm, 15–30 cm, 30–45 cm) across these land use patterns and analyzed in the laboratory. Data generated were subjected to analysis of variance. Results obtained showed significant difference ($P \leq 0.05$) in soil bulk density, organic carbon (OC), total nitrogen (TN), available phosphorus (Av. P) and ECEC across the four land use types. The bulk density value was highest at 30–45 cm depth by CL (1.93 g/cm^3), followed by YL (1.89 g/cm^3), OPL (1.70 g/cm^3) and FL (1.68 g/cm^3). The TN content of the soil was highest in the FL at 0–15 cm depth (0.25%) while the lowest was found in the CL plot (0.03%). The soil Av. P content was higher in the FL at 0–15 cm depth (9.63 mg/kg) while the lowest value was obtained in CL plot (1.16 mg/kg). The values of OC at the depths of 0–15 cm, 15–30 cm and 30–45 cm in the FL (1.03%, 0.49%. 0.45%) were found to be significantly different ($P \leq 0.05$) from the CL (0.39%, 0.15%, 0.13%) land use type. Results obtained showed that different land use types have varying effects on soil physical and chemical properties. The fallow land had on the surface (0–15 cm) the highest content of soil chemical properties and lowest bulk density. Therefore, farmers may periodically fallow their lands to build up organic matter, stabilize soil aggregates, improves nutrient cycles for sustainable productivity.

Key-Words: Land use, Soil chemical properties, Bulk density, Fallow land, Cassava land, Yam land, Oil palm land

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INTRODUCTION

In the southeastern ecological zone of Nigeria, especially the Akokwa area of Ideato North in Imo State, Nigeria, human population is considered to be the noticeable modifications in land use patterns. However, local demographic factors as well as per capital consumption and its variability do modify the effect of human population on land. In the past with wider land: man ratio, the common land management method for sustainable crop production was the shifting cultivation to follow fallow system (Osakwe 2014, Akamigbo and Ukaegbu, 2003). However, narrowing land: man ratio has resulted in alteration of land use pattern and management method such as clearing of forest and continuous cropping with or without the use of external inputs.

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This high population increase has posed a number of threats, notably the provision of adequate food, the management of the soil resources to support food production, adequate soil information, the development of appropriate technologies for sustainable agricultural production and meeting the challenges of intensive agriculture. To understand and appreciate the burning issue of sustainability of soil productivity, we need to keep in mind the two determinant components, the chemical properties (soil fertility) and physical properties of the soil (Ahukaemere *et al.*, 2012). Singh (1997) reported that agricultural quality of a land can be judged by the physico-chemical properties of its soils which provide anchorage, water and nutrients to the plants.

The most prevalent land use patterns in the high density population, area of southeastern Nigeria like Akokwa in Imo State include continuous cassava cultivation, yam cultivation and oil palm plantation.

There seems to be little or no information on the effect of these land use patterns on soil physico-chemical properties, hence food security. It therefore becomes necessary to study the effect of land use systems on physical and

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chemical properties of soil in Akokwa Area of Imo State, Nigeria.

The result of the research finding is very crucial to the development of new strategies which will arrest or reverse the trend in soil degradation associated with the current land use practices. The objective of this study was to determine the status of the physico-chemical properties associated with the current land use types in the study area at different depths and ascertain the land use systems most appropriate for soils of Akokwa-Ideato area of Imo State for sustainable agricultural production.

MATERIALS AND METHODS

The study was conducted in Akokwa-Ideato area of the Northern Imo State, Nigeria. Imo state lies between latitudes 6^0 30′ and 5^0 54′N and longitudes 6^0 57′ and 7^0 43′E. The study area is located within humid tropical climate, having a mean annual rainfall range of 2000 to 2,250 mm. The mean annual temperature ranges between 27–28^{0}C and relative humidity vary with seasons from 80–90% in the rainy season while 60–80% relative humidity recorded during the dry season. The rainy season starts in April and ends in October with a peak in June and July while dry season last from November to March.

The dry season is usually accompanied by a dry, cold harmattan period, which prevails during the month of December and January (FDALR, 1985). The soils are derived from coastal plain sands of sedimentary origin and are highly weathered and dominated by low activity of clay minerals (Akamigbo, 2000; Ufot *et al.,* 2001). The soils have low contents of organic matter, base status and water storage capacity, and are highly susceptible to accelerated erosion and degradation (Enwezor *et al.,* 1981). The native tropical rainforest vegetation has been almost completely replaced by secondary forest of predominantly wild oil palm trees of various densities of coverage, and woody shrubs as *Chromolaenu odorata* (Siam weed) and various grass undergrowth. The land use patterns in the area are dominantly the fallow and continuous cropping systems and the major food crops grown are cassava, yam, maize and vegetables.

Soil samples were collected from four different land use patterns: 2 years fallow land (secondary forest) with predominantly trees, grasses and shrubs (FL), four years continuously cultivated cassava farm land (CL), 15 years oil palm plantation (OPL) and 2 years continuously cultivated yam plot (YL). The samples were collected using systematic random sampling from each of the land use pattern. Soil auger was used to collect soil samples from each of the land use pattern at three (3) different depths: 0–15 cm, 15–30 cm and 30–45 cm. The samples from each land use at different depths were composited, mixed thoroughly and sub-sampled. The soil samples collected were stored in sampling bags for onward laboratory analysis.

LABORATORY ANALYSIS

Soil samples collected were air-dried, gently crushed and sieved with a 2 mm sieve. Particle size analysis was determined using the Bouyoucous hydrometer method (Dane and Topp, 2002). Bulk density was determined by oven-drying the core samples to constant weight at 105^{0}C and bulk density computed as described by Klute (1996). Porosity was inferred from values carried out as described by IITA (1979) and Sparks (1996). The soil pH was measured in 1:2.5 soil: water suspension. The suspension was also used to measure the electrical conductivity using an electrically conductive bridge. Soil organic carbon was determined using Walkley and Black wet oxidation method as modified by Nelson and Sommers (1986) and organic matter was calculated by multiplying the value of organic carbon by a factor of 1.725 (Van Bermelen’s factor). Exchangeable bases: Ca, Mg, Na, K was extracted using normal ammonium acetate (Thomas, 1982). The Exchangeable K and Na were determined by flame photometer while Ca and Mg were determined by Atomic absorption spectrophometer (AAS).

RESULTS AND DISCUSSION

Results of soil physical and chemical properties at 0–15 cm, 15–30 cm and 30–45 cm depths are shown in Tables 1, 2 and 3 respectively. Particle size distribution was dominated by the sand fractions. The texture of the surface soils was generally loamy sand. The high percentage sand observed in all the land use patterns could be attributed to the geology of the area. The geology of the area is coastal plain sands which are characterized by sandy soils over a wide expanse of land (Akamigbo and Ukaegbu, 2003). However, silt fraction was significantly ($P \leq 0.05$) higher in FL (8.00%) than in CL (6.00%), OPL (6.20%) and YL (6.00%). The continuous destruction of soil structure as well as the deposition of silt-size particles from runoff water must have led to the decrease in silt content of CL and YL. The opposite is seen in FL which was not disturbed for many years. The clay fraction was significantly ($P \leq 0.05$) higher in FL and OPL; this suggests that the vegetation cover may have reduced the rate at which water flowed into the soil, thus the reduction in the amount of translocation in FL. Bulk density was significantly ($P \leq 0.05$) higher in CL (1.78 g/cm^3) and YL (1.73 g/cm^3) than in OPL (1.64 g/cm^3) and in FL (1.57 g/cm^3). The slaking siltation and compaction of soil in CL and YL may have led to higher bulk density. Ahukaemere *et al*. (2012) equally recorded consistently higher bulk density in continuously cultivated land than in oil palm plantation and organic matter content has also been reported by Akamigbo (2000) and Onweremadu *et al*. (2009) to influence soil bulk density. Bulk density was inversely proportional to total porosity.

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Organic carbon (OC) was significantly (P≤ 0.05) affected by land use type with FL (1.03%) being the highest, followed by OPL (1.01%), YL (0.75%) and CL (0.39%). Fallow land (FL) and OPL had higher OC content compared to YL and CL because of the continuous addition of soil organic matter (SOM) to FL and OPL and subsequent mineralization of the added SOM. Ahukaemere *et al* (2012) recorded higher OC in fallow and oil palm plantation soils compared to continuously cultivated soil. However Onyekwere *et al.* (2003) pointed out that, the low level organic carbon in the cassava plot is a reflection of continuous cultivation and pedogenic processes.

Generally, pH was slightly acidic with the highest value of 6.60 recorded in FL, also the highest value of ECEC (7.56 cmol/kg) was recorded in FL (secondary forest) and the least (4.24 cmol/kg) in the cassava continuously cultivated land at similar depths (Table 1). The FL recorded the highest nitrogen content of 0.25% in 0-15 cm soil depth; the CL (continuously cassava cultivated land) had the least mean percentage value of total nitrogen (0.03%). Soil properties decreases consistent with increasing soil depth under all land use systems (Tables 2 & 3). The total nitrogen (TN) also correlated positively with organic matter, bulk density and ECEC (Table 4). The result of the present study agrees with the findings of Gbadegesin *et al*. (2001) who attributed the decrease in total nitrogen with increasing depth to declining humus with depth.

TABLE 1: Physico-chemical properties of various land use types at 0-15 cm depth

	LAND USE TYPES				
Soil properties	**FL**	**OPL**	**YL**	**CL**	**LSD (0.05)**
Sand (%)	76.80^{d}	79.80^{c}	82.80^{b}	83.80^{a}	0.01
Silt (%)	8.00^{a}	6.20^{b}	6.00^{b}	6.00^{b}	0.891
Clay (%)	15.2^{a}	14.00^{b}	11.20^{c}	10.20^{d}	0.891
Texture	SL	SL	LS	LS	-
BD (g/cm^{3})	1.57^{c}	1.64^{b}	1.73^{a}	1.78^{a}	0.01
Porosity (%)	34.20^{a}	33.80^{b}	25.72^{d}	28.00^{c}	0.02
Soil pH (H_2O)	6.60^{a}	5.18^{c}	5.42^{b}	5.13^{d}	0.01
O.C (%)	1.03^{a}	1.01^{b}	0.75^{c}	0.39^{d}	0.01
TN (%)	0.25^{a}	0.07^{b}	0.06^{b}	0.03^{c}	0.02
Av. P (mg/kg)	9.63^{a}	7.36^{b}	7.02^{c}	5.16^{d}	0.01
ECEC (cmol/kg)	7.56^{a}	5.52^{b}	4.43^{c}	4.24^{d}	0.01
TEA (cmol/kg)	0.80^{a}	0.70^{b}	0.60^{c}	0.70^{b}	0.01
Al (cmol/kg)	0.60^{a}	0.40^{b}	0.50^{a}	0.50^{a}	0.198
Ca (cmol/kg)	4.20^{a}	3.00^{b}	2.00^{c}	2.00^{c}	0.891
Mg (cmol/kg)	2.20^{a}	1.40^{b}	1.40^{b}	1.20^{c}	0.198
K (cmol/kg)	0.28^{a}	0.27^{b}	0.24^{c}	0.18^{d}	0.01
Na (cmol/kg)	0.12^{d}	0.18^{a}	0.15^{c}	0.16^{b}	0.01
BS (%)	89.40^{a}	87.30^{b}	85.40^{c}	83.40^{d}	0.09
H (cmol/kg)	0.20^{b}	0.30^{a}	0.10^{c}	0.07^{d}	0.01

Means with the same alphabet are not significantly (P≥0.05) different. OPL = Oil palm plantation, FL = Fallow land (secondary forest), CL = Cassava cultivated land, YL=Yam cultivated land

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TABLE 2: Physico-chemical properties of various land use types at 15 – 30 cm depth

	LAND USE TYPES				
SOIL PROPERTIES	FL	OPL	YL	CL	LSD (0.05)
Sand (%)	76.80^{a}	64.80^{c}	68.80^{b}	58.80^{a}	0.01
Silt (%)	6.00^{C}	8.00^{b}	10.00^{a}	4.00^{d}	0.01
Clay (%)	23.20^{c}	27.20^{b}	21.20^{d}	41.20^{a}	0.01
Texture	SCL	SCL	SCL	SCL	-
BD (g/cm^3)	1.59^{d}	1.70^{c}	1.85^{b}	1.88^{a}	0.891
Porosity (%)	34.90^{a}	32.88^{b}	22.10^{d}	32.10^{c}	0.198
Soil pH (H_2O)	5.42^{b}	4.80^{c}	5.84^{a}	4.28^{a}	0.01
O.C (%)	1.49^{a}	0.29^{b}	0.17^{c}	0.15^{d}	0.01
TN (%)	0.17^{a}	0.016^{c}	0.03^{b}	0.015^{c}	0.014
Av. P (mg/kg)	4.45^{a}	3.14^{b}	1.86^{c}	1.72^{d}	0.015
ECEC (cmol/kg)	3.74^{c}	4.17^{b}	3.38^{d}	4.28^{a}	0.01
TEA (cmol/kg)	0.60^{c}	0.90^{b}	1.10^{a}	0.90^{b}	0.01
AI (cmol/kg)	0.40^{c}	0.60^{b}	0.69^{a}	0.40^{c}	0.01
Ca (cmol/kg)	1.60^{a}	2.00^{a}	1.20^{a}	1.80^{a}	0.891
Mg (cmol/kg)	1.20^{a}	1.00^{a}	0.80^{a}	1.40^{a}	0.891
K (cmol/kg)	0.15^{c}	0.18^{a}	0.16^{b}	0.21^{d}	0.01
Na (cmol/kg)	0.19^{a}	0.11^{c}	0.12^{b}	0.06^{d}	0.01
BS (%)	83.90^{a}	78.50^{b}	67.40^{c}	78.90^{b}	6.03
H (cmol/kg)	0.20^{b}	0.30^{b}	0.30^{b}	0.500^{a}	0.198

Means with the same alphabet are not significantly ($P \geq 0.05$) different. OPL = Oil palm plantation, FL = Fallow land (secondary forest), CL = Cassava cultivated land, YL=Yam cultivated land

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TABLE 3: Physico-chemical properties of various land use types at 30 – 45cm depth

	Land use types				
Soil properties	**FL**	**OPL**	**YL**	**CL**	**LSD (0.05)**
Sand (%)	64.80[b]	64.80[b]	66.80[a]	56.80[c]	0.01
Silt (%)	4.00[a]	2.00[b]	4.00[a]	4.00[a]	0.01
Clay (%)	31.20[c]	33.20[b]	29.20[d]	39.20[a]	0.01
Texture	SCL	SCL	SCL	SCL	-
BD (g/cm^3)	1.69[d]	1.70[c]	1.89[b]	1.93[a]	0.230
Porosity (%)	37.90[a]	36.63[b]	30.28[c]	30.28[c]	0.01
Soil pH (H_2O)	5.74[b]	4.77[d]	3.64[c]	4.20[a]	0.089
O.C (%)	0.45[a]	0.21[b]	0.02[d]	0.13[c]	0.01
TN (%)	0.11[a]	0.01[b]	0.02[b]	0.013[b]	0.01
Av. P (mg/kg)	2.90[a]	0.85[b]	2.29[b]	2.23[b]	0.09
ECEC (cmol/kg)	3.75[a]	3.74[b]	2.76[c]	4.43[d]	0.01
TEA (cmol/kg)	0.90[a]	1.00[a]	0.90[a]	1.60[a]	0.983
AI (cmol/kg)	0.50[c]	0.80[b]	1.70[a]	1.20[b]	0.230
Ca (cmol/kg)	1.20[a]	1.80[c]	1.60[a]	1.20[b]	0.198
Mg (cmol/kg)	1.20[a]	1.60[a]	1.00[a]	1.20[a]	0.891
K (cmol/kg)	0.26[a]	0.21[b]	0.09[d]	0.16[c]	0.01
Na (cmol/kg)	0.18[a]	0.15[b]	0.15[c]	0.16[b]	0.01
BS (%)	75.90[a]	74.20[a]	63.60[b]	61.90[c]	2.19
H (cmol/kg)	0.22[b]	0.20[b]	0.20[b]	0.30[a]	0.071

Means with the same alphabets are not significantly ($P \geq 0.05$) different. OP = Oil palm plantation, FL = Fallow land (secondary forest), CL = Cassava cultivated land, YL=Yam cultivated land

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TABLE 4: Correlation matrix of the soil physico-chemical properties

	SAND	SILT	CLAY	BD	TP	pH	OC	Ca	Mg	K	Na
Sand	1.000										
Silt	0.748**	1.000									
Clay	0.040	-0.070	1.000								
BD	0.612**	0.717**	0.265	1.000							
TP	0.612**	-0.717**	0.265	-1.00**	1.000						
pH	-0.005	-0.110	0.445	0.136	0.136	1.000					
OC	0.518*	-0.601**	0.206	-0.606**	0.605**	0.128	1.000				
Ca	0.054	-0.292	0.227	0.405	0.406	0.062	0.210	1.00			
Mg	-0.454	0.062	0.548*	0.586*	0.585*	0.317	0.333	0.197	1.000		
K	-0.005	0.2318	0.242	0.366	0.367	0.198	0.024	0.401	0.150	1.00	
Na	0.044	0.200	0.185	0.210	0.210	0.479*	0.036	0.246	0.096	0.151	1.00
ECEC	0.057	0.249	0.162	0.029	0.029	0.225	0.338	0.79888	0.433	0.095	0.219

BD=Bulk density, TP=Total porosity, OC=Organic carbon, ECEC=Effective cation exchange capacity

CONCLUSIONS

In conclusion, land use types influence soil properties. The studied sites, especially cassava land and yam plot seems to have low TN, OC, available P, ECEC and exchangeable bases. The result of the research findings also revealed that the fallow (secondary forest) land had the highest content of organic carbon, total nitrogen, available phosphorus and effective cation exchange capacity. This is attributed to the accumulation of litter on the surface of the soil, which recycles nutrients and makes them available in the soil. Therefore, farmers may periodically fallow their lands to sequester organic matter, stabilize soil aggregates, improves nutrient cycles for sustainable agricultural production.

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