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INFLUENCE OF LAND USE ON SOIL PROPERTIES OF THE HUMID TROPICAL AGROECOLOGY OF SOUTH EASTERN NIGERIA

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ABSTRACT

Soils under two major land use types; the forest land use and traditionally cultivated land use; were investigated in two rainfall regime belts of the agroecological region of southeastern Nigeria, to investigate the influence of these land use types on selected soil properties. Twenty locations were studied, ten in a higher rainfall regime belt and another ten in a lower rainfall regime belt. The forest land use type was selected from clusters of forest housing shrines of local deities which have remained 'virgin' for the past 100 -150 years while the adjoining farmed lands were studied for the cultivated land use type. Profile pits were sited in both the forest and cultivated lands within intervals of 100 - 200 m between the pits in order to achieve homogeneity in parent materials and macroclimate.

Data on morphological, physical and chemical properties indicate that there was a marked difference between the soils of the two land use types. The differences were in A-horizon thickness, colour of the A-horizon, root density, macropore population, soil consistence, bulk density, total porosity, soil reaction, thickness of subsoil, amount of clay fraction in Bt-horizon, TEB, ECEC, exchangeable acidity and organic carbon percent. Taxonomical classifications of the pedons did not vary widely, although, there was a tendency of alteration in certain diagnostic properties.

Pedogenic processes are active and clay eluviation, migration and illuviation seem more pronounced in the cultivated soils while leaching seems more intense in the forest soils. Cultivation has accelerated certain pedogenic processes and influenced certain soil properties which may lead to soil deterioration. The implication of the results is discussed and recommendation proposed.

INTRODUCTION

Food and fibre production is as yet dependent on tilling the soil to create a favourable environment for crop root development and growth. In Nigeria, especially southeastern agroecological zone, the introduction of the use of heavy machinery such as tractors in ploughing, harrowing and sowing is recognized as a new technology that could revolutionize agriculture and make for the achievement of self-sufficiency in food and fibre production. The introduction of farm machinery in land preparation and crop harvesting would greatly reduce the drudgery in arable agriculture. According to recent studies in southeastern Nigeria, about 59 - 66% of the farmers are 50 years of age and above (Onweremadu, 1994; Akamigbo, 1994). These studies also showed that farm labour constituted a major constraint to agricultural production as 68% of the labour used in farming operations is hired; and 92% of the tools used are traditional hand tools.

However, the introduction of the use of modern heavy machinery in cultivation activity in these areas should take cognizance of the deleterious side-effects of the conventional machinery in use in developed countries, since the ultimate aim should also include the stability of the soils and the sustainability of the land for future generation.

Evidence abounds in literature of the adverse influence of converting a forest land into arable land, for example, there are depletion of important soil nutrients and alteration of some soil properties (Gillman, 1983; Pushparajah, 1983; Parker and Chartres, 1983). The use of heavy farm machinery is likely to lead to increased compaction, reduced hydraulic conductivity and increased soil erosion (Babalola and Obi, 1981, and again land use pattern can influence both the physical and chemical properties of the soil (Babalola, 1988, Enwezor, (1976). Soil erosion has always accompanied certain land use management practices (Parker and Chartres, 1983 and Foth, 1984). Fertile lands have changed to their present barren state through improper land use (Chepil and Woodruff, 1963), and in parts of Nigeria, many hectares of arable land have become gullied due to the destructive .anthropogenic activities (Akamigbo, 1993).

Only about 7% of farmer interviewed during a recent survey in the study area use machinery for their farm work (Akamigbo, 1994 and Onweremadu, 1994), and there is a dearth of research findings on the adverse effect of the use of heavy machinery on the properties of the soils of southeasteern Nigeria. Secondly, Nigerian soils have not been mapped at a scale where technology transfer from developed world can be applied appropriately. Yet, there is an increased effort on the part of government to reduce drudgery in tilling the earth by the introduction of tractor hiring services. According to Greacen and Richards, (1983), the soil is expectedtocarrywithout de-formation the machinery used to create a favourable root zone environment; and it is becoming increasingly necessary that tractor power will have to replace human power to make arable agriculture attractive to the youth. This is likely to precipitate adverse consequence considering the fragile nature of the soils of the investigated area. In view of this anticipation, the influence of two land use types, forest land use and traditional cultivated land use types were investigated to infer the possible impact of the introduction of machine power in this region.

This paper reports the findings of the studies carried out in selected locations of two states in southeastern Nigeria to investigate the influence of two major land use types on the morphology, genesis, chemical and physical properties of their soils.

MATERIALS AND METHODS

Study area and site selection

A reconnaissance survey of the study area showed that undisturbed forest clusters are few hence the selection of sample sties was restricted to locations that have suitable environmental conditions. Two rainfall regime belts were therefore considered. For the lower rainfall regime, the locations are bounded by latitudes 6^0 3^0'N and 7^0N and longitudes $7^0$15'E and 7^0 30'E. The average annual rainfall here is approximately 1750mm. Ten locations were sampled. The higher rainfall regime area with average annual rainfall of about 2,500 mm is bounded by latitudes 5^0 3'N and 5^0 50'N and longitudes 7^0 15'E and 7^0 30'E. Ten locations were also studied (Fig. 1).

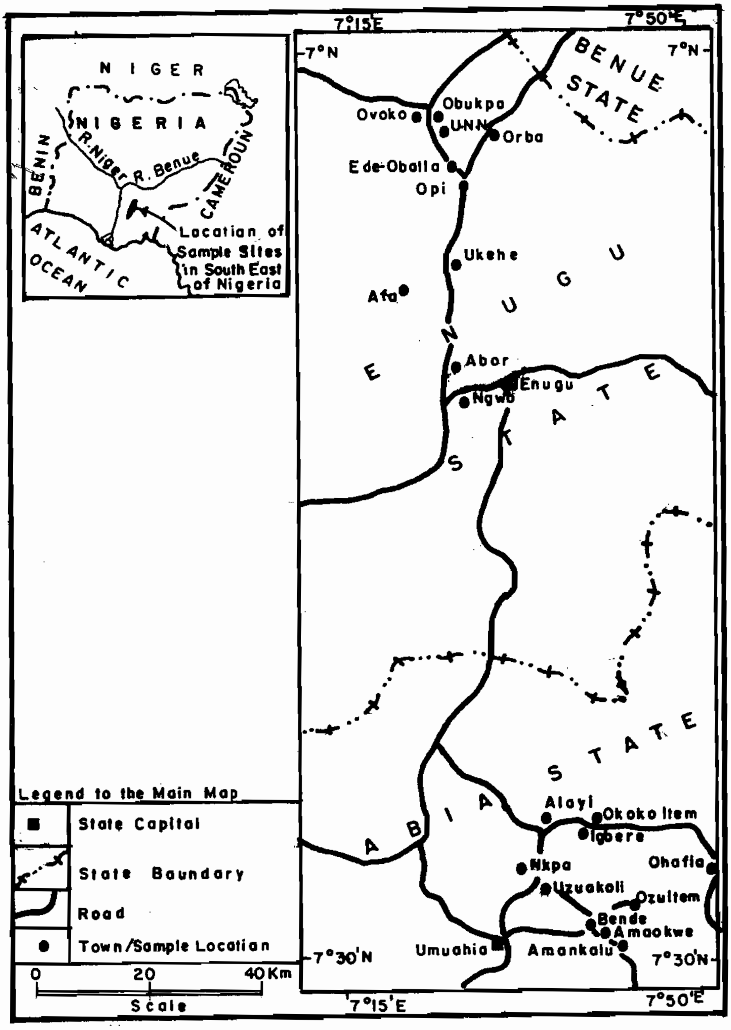

Fig 1: Location Map of Sample Sites

The forest land use type was selected from forest lands that are reservations which serve as shrines for deities. Oral evidence from deity priests and others in the society confirmed that the forests have not been felled or cultivated in the past 100 - 150 years. However, privileged indigens are allowed into the forest to collect leaf vegetable and mushroom. The cultivated land use type is an area in close proximity of the forest land that has been cultivated to the staple crops of the area by using the traditional method of land preparation and cultivation. These areas have been brought under cultivation in the past 30 -50 years. The traditional system involves slash and burn for land clearance and tilling of the upper layers of the soil with hand hoes to raise mounds or ridges on which the crop is sowed. Minimum tillage is practised by some farmers in some locations, especially, in the zone of higher rainfall regime.

Field Studies

Two profile pits were sited in contiguous sites for each location, one in forest land while the other was in cultivated land. The two profile pits were separated by distances between 100 -200m. This was so done in an attempt to achieve uniformity in the parent materials of the two adjacent profiles.The macroclimate was also assured to be uniform. A total of forty profiles were studied macro-morphologically and soil samples collected from delineated horizons for laboratory analysis. Undistributed soil samples were collected from the surface layers for bulk density determination.

For each profile, an area of 400 cm^2 was marked out in each of the delineated horizons. Root density counts were taken from this 400 cm^2. It should be remarked that the selection of this area of 400 cm^2 avoided portions that contained roots with diameters of one centimetre or more. Again macropores in similar area of 400 cm^2 were counted. Macropores are those pores visibile with a hand lens and having diameter of about one millimeter or more and capable of being stuck with one end of a stretched paper clip (normal paper clip No 3) without fracturing the pore.

Laboratory Methods

The bulk soil samples were air-dried and ground to pass through a 2 mm sieve. Particle size distribution was determined by the hydrometer method (Bouyoucos, 1936). Soil pH was measured in distilled water and 0.1M KCL at a soil-solution ratio of 1:2:5. Organic carbon was determined by acid dichromate digestion (Walkley and Black, 1934). Exchangeable bases were extracted with IM NH_4 OAC (pH 7.0) and the Ca and Mg in the extract were determined by EDTA titration.

Potassium and Na were determined by flame photometry. Exchangeable acidity (Al + H) was extracted with 1M KCL and determined by titration with NaOH. The Al component of the acidity was determined by titration with HCl after an addition of NaF. Effective cation exchange capacity (ECEC) was estimated as the sum of the exchangeable cations (Ca, Mg, K and Na) plus KCl exchangeable acidity. Dispersible clay was determined as was done for particle size distribution but without the addition of calgon as dispersant. Bulk density was measured using the clod method described by Blake (1965).

RESULTS

Morphological

The morphological characteristics of representative profiles are given in Table 1a and 1b. The moist colour of the topsoils was generally different for the two land use types. The forest soils have very dark reddish brown colours to brownish black colours (5 YR 2/3 - 5 YR 2/4; and 5 YR 3/1 - 2.5 YR 2/4), while the cultivated topsoils are dull reddish brown (5 YR 4/4) to dark reddish brown (5YR ¾). The thickness of the A - horizons also differed; the cultivated soils having thicker A - horizons (x = 13.8cm) than the forest soils with an average thickness of 10.8 cm. A higher dense root mat occured in the top soil (0 -30 cm) of the forest soil profiles than was the case in similar depth in the cultivated soil profiles. An average of 324 roots were counted in an area 400cm^2 in the forest soil profile as against 145 roots in a similar area in the cultivated soil (Table 1b). Macropores were also more in the forest soil profiles than were counted in similar area of the cultivated soil profiles. Average counts in the 0 - 30 cm of the epidedons of the forest soils were 141 as against 103 macropores in the cultivated soils.

Similar trends were exhibited for both root and macropore counts down the entire depth of the profiles. The forest soils have an average of 230 roots in their subsoils while the cultivated soils recorded 107 roots; and 221 and 161 macropores respectively. The moist consistence of the topsoils of the forest land use differed from that of the cultivated land use type. The forest soils showed loose consistence while the comparable cultivated soils were loose to friable.

Table 1a: Morphological characteristics of representative profiles

Parameters	Forest Soil	Cultivated Soil
	Odim Nsukka	Odim Nsukka
a) Colour of top-soil (moist) and	Very dark reddish brown (5 YR 2/3);	Reddish brown, (5 YR 4/4)
b) Consistence	Loose	Friable
	Obukpa	Obukpa
a)	Very dark reddish brown (5 YR 2/4);	Dark reddish brown (5 YR ¾);
b)	Loose	Very Friable
	Ede-Oballa	Ede-Oballa
a)	Brownish black (10 YR 3/2);	Dark reddish brown (2.5 YR 3/3;
b)	Loose	Loose
	Opi	Opi
a)	Very dark reddish brown (2.5 YR 2/2);	Dark reddish brown (5 YR 4/6);
b)	Loose	Loose very friable
	Ukehe	Ukehe
a)	Very dark reddish brown (2.5 YR 2/2);	Dark reddish brown (2.5 YR 3/2);
b)	Loose	Friable
	Alayi	Alayi
a)	Brownish black (5 YR 3/1);	Brownish black (2.5 YR 2/2);
b)	Loose	Friable
	Igbere	Igbere
a)	Very dark reddish brown (2.5 YR 2/2);	Dark reddish brown (2.5 YR 2/4); Loose to
b)	Loose	Very friable
	Uzuakoli	Uzuakoli
a)	Very dark reddish brown (2.5 YR 2/2);	Dark reddish brown (2.5 YR 3/3);
b)	Loose	Very friable
	Item	Item
a)	Brownish black (2 YR 2/2);	Dark reddish gr[illegible] (2.5 YR 3/1);
b)	Very friable	Friable
	Bende	Bende
a)	Brownish black (5 YR 2/1);	Brownish black (5 YR 2/2);
b)	Very friable	Friable

= Colour of topsoil (moist)

= Moist consistence of topsoil.

Table 1b: Morphological characteristics of representative profiles

Parameters	Forest Soil	Cultivated Soil
	Odim Nsukka	Odim Nsukka
a) Thickness of A-horizon	5 cm	6 cm
b) Root density in 400 cm^2	120	105
c) Macropore density in 400 cm^2.	120	30
	Obukpa	Obukpa
a) Thickness of A-horizon	10cm	25cm
b) Root density (400 cm^2)	270	160
c) Macrophore density (400 cm^2)	170	140
	Ede-Oballa	Ede-Oballa
a) Thickness of A-horizon	6cm	7cm
b) Root density (400 cm^2)	380	150
c) Macropore density (400 cm^2)	290	228
	Opi	Opi
a) Thickness of A-horizon	10cm	30cm
b) Root density (400 cm^2)	440	150
c) Macropore density (400 cm^2)	240	200
	Alayi	Alayi
a) Thickness of A-horizon	14cm	12cm
b) Root density (400cm^2)	315	235
c) Macropore density (400cm^2)	200	140
	Igbere	Igbere
a) Thickness of A-horizon	10cm	8cm
b) Root density in 400 cm^2	325	200
c) Macropore density in 400cm^2	180	142
	Uzuakoli	Uzuakoli
a) Thickness of A-horizon	13cm	14cm
b) Root density (400cm^2)	460	170
c) Macropore density (400 cm^2)	234	160
	Item	Item
a) Thickness of A-horizon	8cm	13cm
b) Root density (400cm^2)	450	40
c) Macropore density (400cm^2)	100	70
	Bende	Bende
a) Thickness of A -horizon	10cm	12cm
b) Root density (400 cm^2)	325	160
c) Macropore density (400 cm^2)	188	140

= Thickness of A-horizon

= Root density in 400 cm^2 within 0 - 30 cm.

= Macropore density in 400 cm^2 within 0 - 30 cm.

Xi for representative profiles = cultivated = 14.1 cm, Forest soil = 9.6cm.

Xii for representative profiles = 343 roots for Forest and 152 roots for Cultivate land.

Xiii for representative profiles = 191 macropores for Forest and 139 macropores for Cultivated land.

Physical and Chemical

The physical and chemical data (Tables 2a and 2b) show that soil texture was generally the same under the two land use types. However, the topsoils of the forest lands in most of the locations contained less amounts of clay fractions, but were richer in coarse sand fractions.

Table 2a: Some physical properties of representative profile (Topsoils)

Depth cm	Clay %	Silt %	F. Sand %	C. Sand %	Total Sand	Text Class	Disper sible clay %	BD Mgm^{-3}	T.Poro-sity %	Land use type
ODIM NS										
0 - 28	14	4	42	40	82	SL	3	1.52	43	Cultivated
0 -22	11	6	32	51	83	LS	2	1.42	46	Forest
Obukpa										
0 -25	6	2	22	70	92	S	Nil	1.57	41	Cultivated
0 - 10	4	4	22	70	92	S	Nil	1.52	43	Forest
Ede- Oballa										
0 - 7	16	4	21	59	80	SL	2	1.60	40	Cultivated
0 - 6	8	4	23	65	88	S	Nil	1.45	45	Forest
Opi										
0 - 30	4	4	24	68	92	S	Nil	1.67	37	Cultivated
0 - 10	4	4	21	71	92	S	Nil	1.52	43	Forest
Ukehe										
0 - 16	8	4	18	70	88	S	2	1.66	37	Cultivated
0 - 8	4	4	12	80	92	S	Nil	1.53	42	Forest
Alayi										
0 - 12	4	4	41	51	92	S	2	1.51	43	Cultivated
0 - 14	2	4	47	47	94	S	Nil	1.30	51	Forest
Igbere										
0 - 10	4	4	26	66	92	S	2	1.51	43	Cultivated
0 - 8	2	4	13	81	94	S	Nil	1.45	45	Forest
Uzuakoli										
0 - 14	6	4	30	60	90	S	Nil	1.51	43	Cultivated
0 - 13	4	2	22	72	94	S	Nil	1.42	46	Forest
Item										
0 - 13	6	4	56	34	90	S	4	1.53	42	Cultivated
0 - 8	4	4	57	35	92	S	Nil	1.32	50	Forest
Bende										
0 - 12	6	6	83	5	88	S	Nil	1.45	45	Cultivated
0 - 10	4	2	87	7	94	S	Nil	1.36	49	Forest

SL = Sandy Loam, Ls - Loamy Sand and S = Sand

Table 2b: Some chemical properties of representative profiles

Depth:cm	HpH₂0	KCL	Organic carbon %	Exch. Acidity	TEB	ECEC	Land use type
ODIM NS							
0 -28	4.6	3.9	0.72	1.8	1.28	2.88	Cultivated
0 -22	4.2	3.8	1.74	2.8	1.10	3.90	Forest
OBUKPA							
0 - 25	5.8	4.2	0.51	1.0	0.69	1.69	Cultivated
0 - 10	4.4	3.8	1.59	1.6	1.13	2.73	Forest
EDE-OBALLA							
0 - 7	4.7	4.2	0.54	2.0	0.68	2.68	Cultivated
0 6	4.2	3.8	2.25	3.6	0.96	4.56	Forest
OPI							
0 - 30	4.7	4.1	0.30	1.2	0.96	2.16	Cultivated
0 - 10	4.6	4.4	1.62	0.8	5.14	5.94	Forest
UKEHE							
0 - 16	4.6	4.0	0.78	1.6	1.16	2.76	Cultivated
0 - 8	4.1	3.7	0.93	0.8	1.62	2.42	Forest
Alayi							
0 - 12	5.1	4.3	0.64	0.4	3.11	3.51	Cultivated
0 -14	5.0	4.6	1.95	0.4	10.92	11.32	Forest
IGBERE							
0 - 10	5.4	4.6	1.17	0.4	2.81	3.21	Cultivated
0 - 8	4.3	3.7	1.35	1.6	2.31	3.91	Forest
UZUAKOLI							
0 -14	4.1	3.3	1.77	2.0	1.02	3.02	Cultivated
0 - 13	3.5	3.0	0.96	2.0	1.41	3.41	Forest
ITEM							
0 -13	4.5	3.4	1.29	2.0	1.01	3.01	Cultivated
0 - 8	4.1	3.1	2.43	2.4	1.22	3.62	Forest
BENDE							
0 -12	5.4	4.5	1.14	0.8	3.86	4.66	Cultivated
0 - 10	5.2	4.4	0.75	0.4	4.35	4.75	Forest

Increase in clay content occurred with depth generally in all the locations but this was relatively more pronounced in the cultivated soil profiles (Table 3). The dispersible clay tended to be higher in the cultivated than forest soils although the trend was not consistent, and again clay fractions are sparse in the topsoil of the two land use types. The bulk density of the topsoil of the forest profiles was lower than that of the cultivated soils (x = 1.40 Mgm^{-3} versus 1.53 Mgm^{-3}), consequently the total porosity of the forest soils was relatively but consistently higher than that of the cultivated soil profiles (x = 47.21% versus 42.38%).

The soils are generally extremely too strongly acid especially in the A - horizons where soil reaction varied from pH values of 3.5 to 5.8. However, the forest soil A - horizons have generally the lower pH values. Organic carbon, organic matter and effective cation exchange capacity (ECEC) values were significantly higher for the topsoils of the forest land than for the cultivated land (t - test at 99% confidence level). The textural classes, clay contents, total Nitrogen, total exchangeable bases (TEB), and exchangeable acidity did not exhibit any significant difference by the t-test statistic. Comparison of the above soil parameters for the subsoils of both land use types did not differ significantly, although the X^2- distribution statistic showed that significant differences exist between the topsoils and subsoils of both land use types. However in pedological studies of this nature, statistical significance may not be most crucial to infer implication of the consequence of such a land use, rather a consistent trend of the changes may be an important indicator of future implication.

Table 3: Argillic horizons of representative profiles showing percent clay content and thickness of Bt-horizon

Location	Bt_2-Horizon	FOREST SOIL		CULTIVATED SOIL	
		Forest Soil % Clay in Bt_2	Thickness of Bt; cm	Cultivated soil, % clay in Bt_2	Thickness of Bt-horizon; cm
Odim NS.	Bt_2	20	135	24	142
Obukpa	Bt_2	18	155	22	165
Ede-Oballa	Bt_2	28	174	34	188
Opi	Bt_2	20	116	24	135
Ukehe	Bt_2	18	141	26	158
Alayi	Bt_2	16	113	26	132
Igbere	Bt_2	14	164	18	172
Uzuakoli	Bt_2	14	138	16	166
Item	Bt_2	12	114	16	116
Bende	Bt_2	18	84	20	100
Mean (x)		17.8	133.4	22.6	147.4

Twenty adjacent pedons were taxonomically classified to the sub-group level according to the nomenclatures of the USDA Soil Taxonomy (1975 as amended in 1992) and correlated with the FAO/UNESCO (1988) revised legend, and similar classifications were achieved for a greater number of adjacent pedons with a small number of dissimilar classifications especially for the forest soils. The application of the nomenclatures of the Soil Taxonomy achieved better discrimination taxonomically than that of the FAO/UNESCO revised legend (Table 4), hence a classification of soil at the family level employing the nomenclature of the Soil Taxonomy will probably facilitate technology transfer at the farm level.

Table 4: Classification of some pedons

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Location (Pedon)	Land use	Soil Taxonomy	FAO/UNESCO
Odim NS.	Cultivated	Typic Kanhaplustults	Haplic Acrisols
" "	Forest	- do -	- do -
Obukpa	Cultivated	- do -	- do -
" "	Forest	- do -	- do -
Ede - Oballa	Cultivated	- do -	- do -
" "	Forest	- do -	- do -
Opi	Cultivated	- do -	- do -
" "	Forest	- do -	- do -
Ukehe	Cultivated	- do -	- do -
"	Forest	Arenic Kanhaplustults	- do -
Alayi	Cultivated	Arenic Kanhapludults	Haplic Acrisols
"	Forest	Rhodic Kanhaplufults	- do -
Igbere	Cultivated	Arenic Kanhapludults	Luvic Arenosols
"	Forest		- do -
Uzuakoli	Cultivated	- do -	- do -
"	Forest	- do -	- do -
Item	Cultivated	- do -	- do -
"	Forest	- do -	- do -

DISCUSSION

The field outlay of this study was planned and executed in such a manner that differences between two adjacent pedons could reasonably be attributed to the land use types, especially, in the upper layers, the epidons of the pedons. The distances between adjacent pedons were narrow to ensure homogeneity in parent materials, climate, influence of relief and time of soil formation. Microclimate was different as the forest land use type provided a closed tree canopy over the soil and this could have several impacts with respect to radiation, rain splash andmicro- and macro-fauna that affect the soil.

The macro-morphological differences recorded in the investigated locations are attributable to the difference in land use. The colour differenceoftheA-horizonmighthave been due to the accumulation of leaf and twig litters, their gradual decomposition and incorporation of the humified materials in the surface layers of the forest land use as compared to the rapid decomposition and incorporation of less leaf and twig materials in the cultivated land use. The forest land use has a darker colour of the A-horizon while that of the cultivated land use which is constantly tilled and mixed by cultivation operations has lighter colour as a result of less organic deposition and the anthropogenic mixing of the surface layer with some subsoil material (Tables 1a and1b). The tillage operation is probably responsible for the greater thickness of the A-horizon of cultivated soils as the surficial homogenization is tending to the formaion of "anthropic epipedon" in cultivated soils. Such an anthropogenic activity could have caused the improvement of the texture of the A-horizons of the cultivated soils by the incorporation of the more clayey suboils in the cultivated layer (Table 2a). However, the soils are generally sandy in texture, but the smaller content of clay fractions in A-horizons of the greater proportion of the forest soils may be attributable to continuos but gradual sheet erosion, leaching and lessivage that seem to be contemporary in the location.

Table 3 indicates that the processes of clay migration and illuviation are active in these sites despite their sandy parent materials. The rates of these processes seem to be much faster in the cultivated lands where it is plausible to postulate that the cultivation operation may have accelerated the formation of the argillic horizon and the inception of the 'agric' horizon. The Bt_2 horizons of cultivated soils contain higher quantities of clay fractions and the thickness of clay enrichment is more for cultivated soils buttressing the proposition that cultivation activity promotes clay eluviation/ migration and illuviation. The higher content of disperable clay detected in the A-horizon of cultivated soils is a reflection of the rate of eluviation and illuviation of clay-sized particles in both the forest and cultivated soils sites.

The lower macropore counts in the subsoils of the cultivated soils is another indication that illuviation has been more rapid in this land use type than is the case in forest soils. The macropores are the pathways through which soil colloids migrate down the profile depths in the process of lesivage (Akamigbo and Darlymple, 1985). During the repeated cycles of wetting and drying, the colloidal particles in suspension probably clog the pores thereby forming clay coating, especially, in the argillic Bt-horizon. This pedogenic process which is enhanced by cultivation activity is capable of reducing the quantity of macropores in the cultivated soils over the years.

The bulk density of the topsoils of the forest soils which is lower in value may be attributable to the higher organic matter content (Table 2b) and the probable higher activity of fauna and the absence of activities that might compact the soil.

Consequently, their total porosities are generally higher in value than those of the cultivated soils which are exposed to compaction activities of farmers, even though, the technology of the farm implements is still on a traditional level. Similar trends could be inferred for the subsoils more especially as the subsoils of the cultivated soils have been shown to be more compact as a result of the formation of the 'agric' horizon.

Leaching is another contemporary process in these soils. It seems to be more severe in forest soils (Table 2b), as the soil reaction shows that forest soils are extremely acid while those of cultivated soils are very strongly acid. The influence of parent material can explain the general acidity observed in these soils (Akamigbo and Asadu, 1983), but the micro-climate of the forest soils, the abundant leaf and twig litters in the forest and the total humid environments which contribute the leaching fluid may explain the difference. 'Natural lime' which comes from the ash of the slash and burn practices of the traditional farmer may also very marginally reduce the acidity of the cultivated soils. All the investigated soils are generally low in fertility status although, the forest soils have slightly higher contents of nutrient elements and this is in agreement with the finding of Pushparajah (1983) that clearing of forest for agriculture leads to rapid deterioration in the nutrient elements.

The differences observed between the soil of the two land uses have not greatly influenced the classification of the soils but have pointed to the fact that certain land use types have the potential of accelerating certain pedogenetic processes which will eventually alter the diagnotic characteristics of the soils. For example, the subsoils of the cultivated soils are tending to develop an 'agric' horizon in addition to the already developed argillic horizon. The difference in the rainfall regimes does not seem to have markedly altered the trend of changes observed between the land use types, since the agroecology was within the same tropical very humid zone.

IMPLICATION AND CONCLUSION

The study has demonstrated that the use of simple traditional implementation in the traditional agricultural system is capable of influencing some properties of the soil. The properties so influenced include bulk density, total porosity, A-horizon thickness, organic carbon content and pedogenesis. These influences will tend to lead to the deterioration and degradation of the soil. The bulk density is increased and porosity decreased in the cultivated soil and this may impede root growth and lead to soil erosion. According to Veihmeyer and Hendrickson (1948) root growth is prevented at bulk density values of between 1.7 and 1.8 Mgm^{-3} in sandy soils and between 1.45 and 1.65 Mgm^{-3} in clay soils. Although a recent study by Ugbah and Babalola (1990) shows that higher bulk densities would enhance root development probably due to increase in water holding capacity for sandy soils, the general tendency is for higher bulk densities to impede root development and growth.

The implication of the results of this investigation is that the introduction of heavy machinery for routine farm operations will be capable of influencing the soils of the investigated areas adversely. There is therefore the need for more research with the purpose of evolving an indigenous and adaptable technology to remove most of the drudgery involved in cultivation operations which will not at the same time cause the deterioration of the soil, to promote the production of food and fibre in the country.

Again, detailed soils investigation and recommendation for soil conservation practices should always precede the introduction of heavy farm machinery for any farming system in order to avoid permanent damage to the soil and the environment.

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