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Variations in morphological and physico-chemical properties as influenced by topography in southern guinea savannah zone of Nigeria

[1] OJ Ogbu, [2] J Usman, [3] ES Iji, [4] SO Oyetola

[1, 3, 4] Department of Agricultural Education, College of education, Oju, Oju L.G.A

[2] Department of Soil Science, University of Agriculture, Makurdi, Nigeria

Abstract

Four topograghic positions and eight profiles pits identified at Andibilla plateau of Oju Local Government Area, Benue State were studied to evaluate the variation in morphological and physico-chemical properties of the soils as influenced by the topographic features (crest, upperslope, middleslope and the toeslope). The investigation reviewed that the soils were shallow to very deep ranging in depth from 6cm to 150cm. They had sandy loam surface textures underlain by sandy clay loam and clay, and were drained to poorly drained. Their chemical soil reaction were moderately to slightly acidic (5.20-6.26) with moderate to high base saturation (54-76%) and low to moderate % organic carbon content (0.04-2.44%) based on these features, the soils of the crest, (profiles 1 and 2) were classified as Lithic Ustorthents/Lithic Leptosols those of the upper slope as Aeric Umbric Kandiaqulfs/ Eutric Gleysols. Soils of the middle slopes (profiles 5 and 6) were classified as Kandic Paleustalfs/Eutric Nitosols while those of the toeslope (profiles 7 and 8) were grouped as Typic Plinthaqualfs/Plinthic Gleysols. Perennial crops were recommended for the soils of the crest and upper slope while the best land use for these of middle and toeslope are arable crops and water loving crops respectively.

Keywords: variation, morphology, physico-chemical properties, topography, southern guinea savannah

Introduction

Morphological and physical properties of soils and topographic features of landscapes are important factors that aid the understanding of soil forming processes. Buoul *et al*. (1973) [6] outlined various inferences that can be obtained from the study of soil morphological and physical properties. Forth (1978) [18] has shown various processes through which topography modifies soil profile development. Consequently, understanding the role these properties play should aid in assessing productive value of soils and in developing strategies for its conservation (Owonubi *et al*, 2007)

The predominant morphological and physical features of soils horizons are their colour and tint, consistency, structure, texture, neofermation, depth, inclusion, drainage, surface characteristics, relief, soil temperature, organism, porosity, particle density and bulk density (Akamigbo and Asade 1986, Maya 1986) [2, 30]. Some of these properties especially structure, texture, bulk density and porosity are very important soil characteristics that exerts strong influence on plant growth through their influence on soil infiltration, erodibility, aeration, water retention and root growth and distribution (Glinski and Stepnieski, 1986) [19].

Soil colour affects the mineral and humus composition. It is an index used for naming soils (Maya 1986, Brady 1999, Areola *et al*, 2009) [30, 7, 4]. Soil textures affect both water and nutrient retentive ability of soils and consequently soil productivity (Idoga *et al*, 2007) [23]. Soil structure influence soil erodibility, fertility, porosity, aeration and root growth and distribution. Soil temperature affect the formation of soil organic matter, rate of seed germination and root development and the activities of mcro-organisms. Neoformations indicate how soil was formed and which processes are being caused by atmospheric precipitation and ground water.

Soil chemical characteristics such as P^{H}, organic C, N, P, base saturation, ECE and others affect soil and crop productivity. The management of soil physical and morphological properties is usually of lower priority than that of chemical properties in traditional agricultural system. It is also highly soil specific (Sanchez, 1976, Fasina, 2004) [15]. These soil chemical properties can easily change with management (Ogbu 2011) [31]

Variation in soil properties have significant influence on soil mangagement and crop production (Fasina, 2003) [16]. Soil variability has been seen as a word wide problem. The non-uniformity in crop growth along the toposequence reduced farmers yield and also complicates the interpretation of agronomic experiment (Brouwer *et al*, 1993) [8].

In Nigeria apart from the highly elevated and more extensive plateau like Manbilla, Jos and Obudu which are extensively grazed and highly cultivated to tea, irrish potato, apple and vegetables (Ipinmoroti *et al*, 2009, Harault, 1998) [25, 20], very little is known about minor plateau such as Andibilla plateau, Owokwu and Umkar hill. The objective of the study were therefore to investigate the variations in some morphological and physico- chemical properties of the soils as influenced by topography and relate the variation to land use management for sustainable crop production.

Materials and Methods

- **Description of the study area.**

Andibilla plateau lies about 9.5km south east of Oju Local Government Headquarters in Benue State. The plateau covers an area of about 6,000 square kilometer and reaching a height of about 1700 feet above mean sea level. Andibilla plateau lies between latitudes 6^0 45’ and $6^0$50’ N and longitudes $8^0$20’ and $8^0$25’ E (fig1). The area experiences a tropical sub-humid climate with about 7-8 Months of rainfall and 4-5 Months of dryness. The rainy season spans from March to October and the dry season start from November to February (Ogbu 2011) [31]. The mean annual rainfall is at least 1177mn with maximum in July and September. The average daily air temperature ranges between 17. 8^0c and 28.9^0c.

Andibilla plateau is an expansive elevated level land with occasional inselbergs,, lateritic mesas, knolls and low ridges which alternate with shallow valleys and descending steeply to the surrounding low land. It is drained by River Ojiriga which flows northwest into River Oyongo. Akiraba River flows eastward to Ikachi dam. The dam is used for dry season farming of crops like okra, maize, garden eggs and vegetable crops and other domestic uses. Andibilla plateau is also drained by River Opa to the north towards Etugba, Ochochi and Embwu Ubegwu Springs are found at the foot of the hill. The geological features of the plateau include: older gianites, laterites, shale, cataclassic rocks, quartz, feldspar and mica, basalt, clay, shales graphites, marbles, sand stones muscovite, and quartzites (Ogbu 2011) [31]. Fig2 Geological Map Showing Part of Andibilla Plateau.

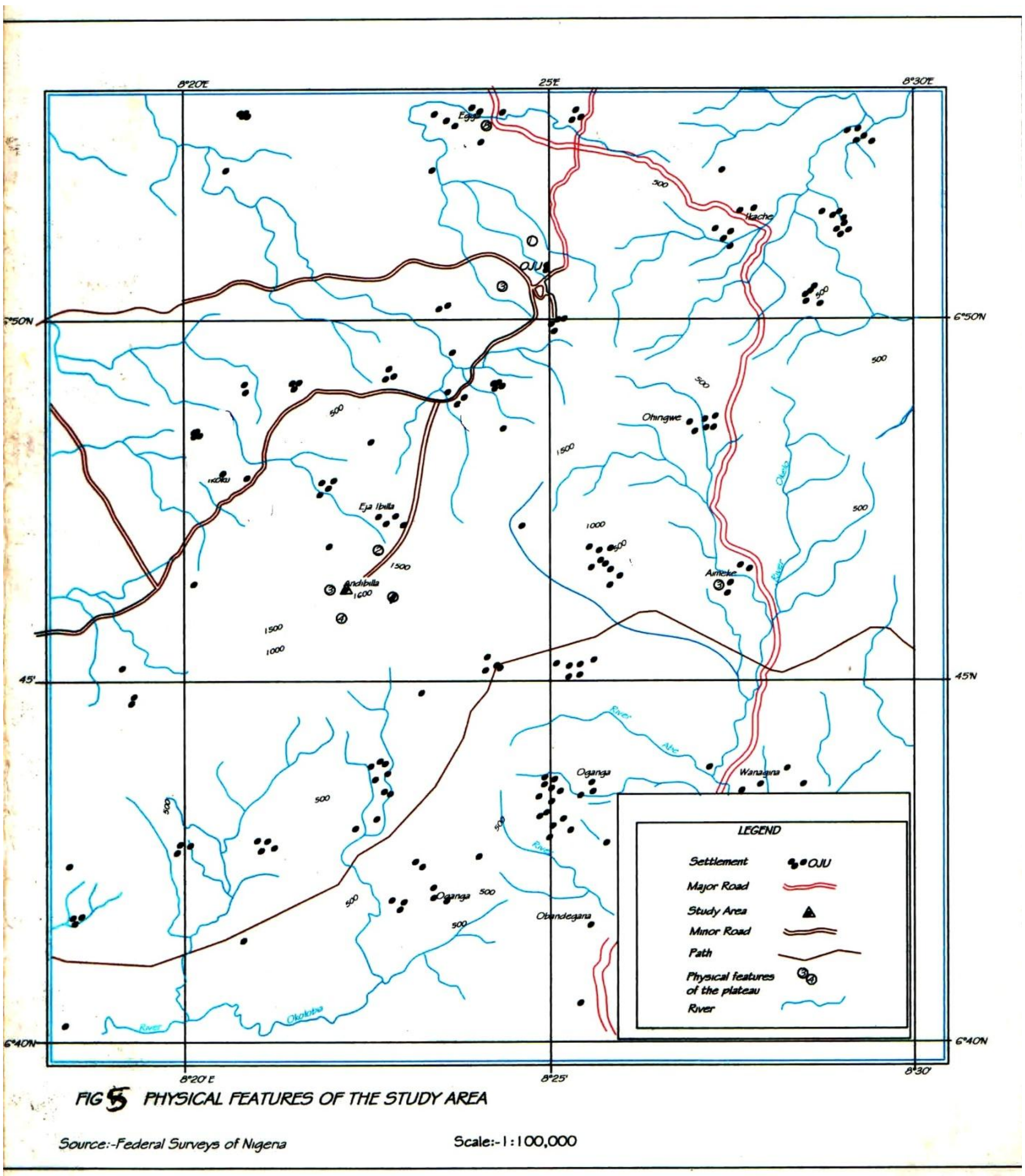

Fig 1: Topographical Map of study area

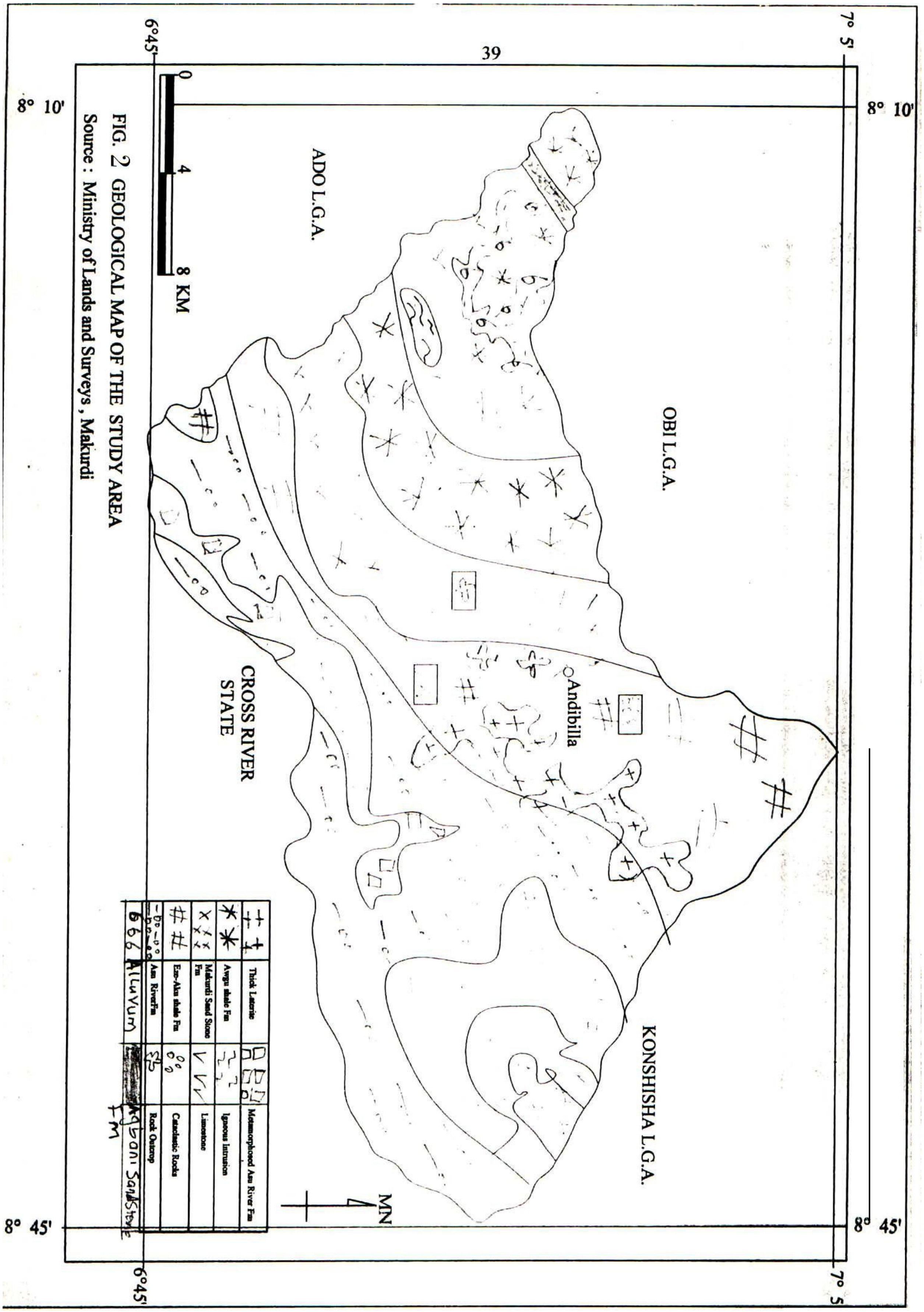

FIG. 2 GEOLOGICAL MAP OF THE STUDY AREA
Source : Ministry of Lands and Surveys , Makurdi

Fig 2

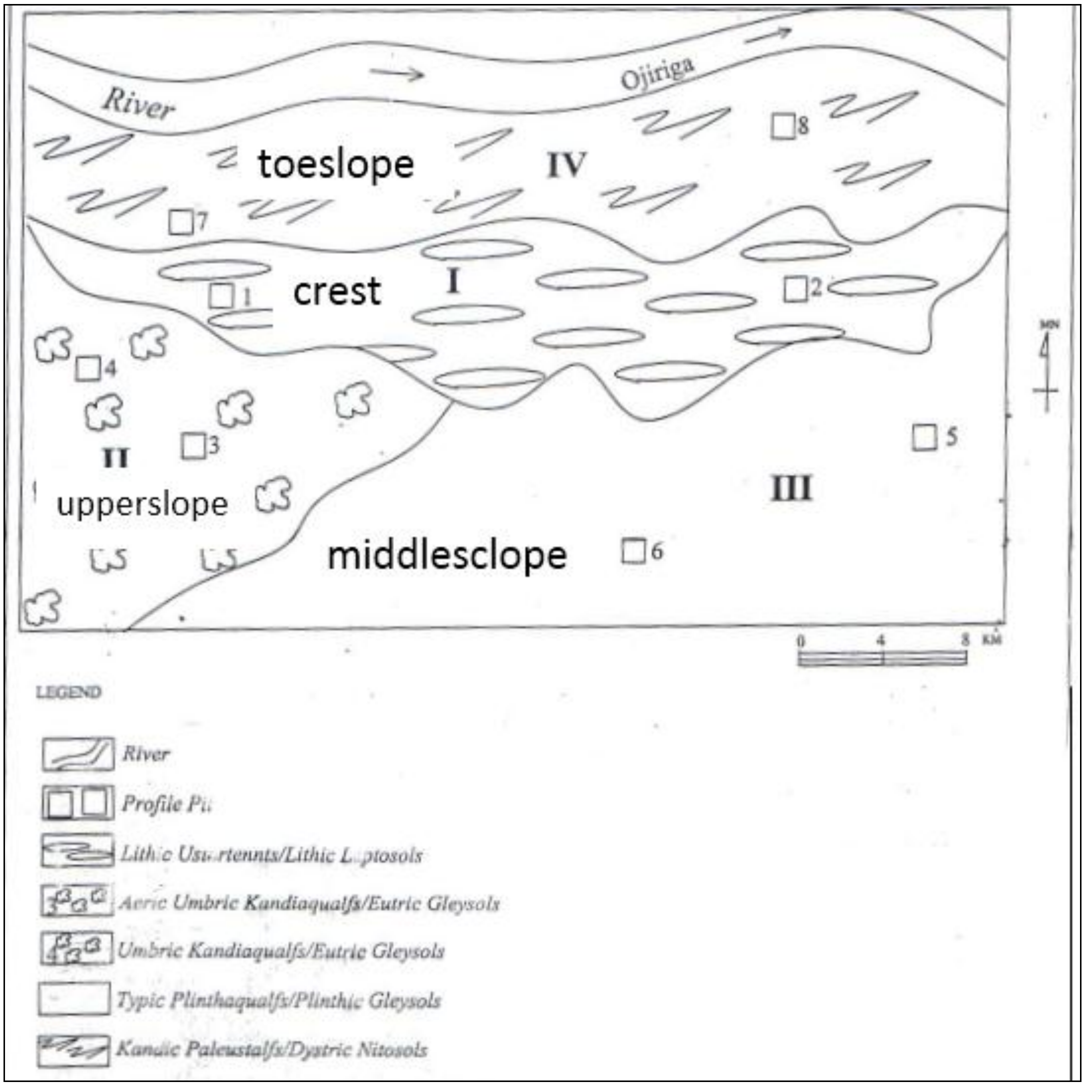

Fig 3: Soil Map of the Study Area

Vegetation

Andibilla Plateau is within the Southern Guinea Savannah Zone of Nigeria with its characteristic coarse grasses and numberous species of scattered trees. The common plant species include: Citrus spp (orange) Tectonia grandis (teak) Butyrosperum paradoxum (shear butter) Chloraphera excelsa (iroko) Ceiba pentandra (silk cotton), Triploctriton seleroxyton (obeche), Cola nitada (kola) Terminalia superb (afora), Khaya iyeriensis (mahogany), Elaesis guineansis (oil palm), Theobroma cacao (cocao), Psidium guajava (guava), Mangifera indica (mango) and Carica papay (pawpaw). The common grsses species found at Andibilla Plateau include; Pennisetum purpureum (elephant grass) Panicum maximum (guimea grass) Mucuna utilis (muccuna), Axonopus compressus (carpet grass) Tridex procumbens (tridax); Aspilia africana (wild mangold) and Imperata cylindrical (spear grass). The major occupation of the dwellers is Agriculture. They farm arable crops like yams, cassava, groundnut, maize, cotton, tobacco and rice at the foot of the plateau and hunt wild animals such as lion, tiger at the high crest which has very thick forest. The land is highly degraded through erosion hence under scoring the importance of this study.

Field study

Andibilla Plateau of Oju Local Government Area of Benue State, Nigeria was selected for the study. The area is characterized by a rolling topography. The plateau was soil surveyed using a rigid grid method. Auger point investigations were carried out at 100m intervals along transverses cut at 100m apart on the baseline. Four topographic positions were located namely hill crest, upperslope, middleslope and the toeslope base on some morphological features like soil colour, texture, depth, and surface characteristics. Two profile pits were dug in each of the four topographic positions given a total of eight (8) pits and were describes according to the guidelines of soil survey staff (1998) [36]. Soil samples were collected from each pit by genetic horizons and carefully labeled for laboratory analysis.

Laboratory analysis

Appropriate laboratory procedures were employed to determine some physical and chemical characteristics of the soils (Udo and Ogunwale, 1986, IITA, 1979, day 1965, Hesse 1971, Black 1965) [38, 24, 20, 9, 5]. The soil characteristic analyzed include; soil PH,particle size (sand, silt, and clay), organic matter (OM), organic carbon (OC), Available phosphorus, (AP), exchangeable acidity (EA), electrical conductivity (EC), exchangeable bases (basic cations like Ca, Mg, Na and K) effective cation exchange capacity (ECEC) and total nitrogen (N) (table 2.)

Soil Classification
From the results of the laboratory analyses and the field morphological characteristics, the pedons encountered at the four locations were classified according to the USDA Soil Taxonomy (Soil Survey Staff, 1999) [37], into order, sub order, great group and sub groups categorus, and were correlated with the FAO/UNESCO soil legend (FAO, 199O).

Results and Discussion
Soil morphological characteristics
The common soil morphological characteristics examined in the study area include; soil colour, texture, structure, depth and consistence (table 1). At the high crest (profile 1 and 2), the soil covered about 18% of the plateau and have very shallow depth (> 10cm) with abundant cataclassic rocks. They were well drained with dominant hue of 5YR, are formed on a nearly level to gently undulating slope (0-2%). Soil texture was sandy loam with moderate medium crumb structure and slightly sticky wet in consistence. Soil inclusion was many fine roots with diffuse smooth boundary. The upperslope account for about 22% of the study area. The boundary surface features were the most distinguishing characteristic of this topographic position. The soils were deep with sand clay loam surfaces underlain by clay subsoils with dark brown surface colour (7:5YR 4/2). Soil structures were moderate, medium strong subanguar blocky with several rills and high slope gradient (4-7%). The poor drainage observed by the presence of mottles right from the surface to the sub surface horizons and the glayish subsoil could be due to the heavy texture of the soils. They were presumed to have been formed from shale. The soil has many medium roots inclusion at the surface horizon, very sticky wet and clear smooth boundary.
The middleslopes were nearly level (2-4%) accounting for their relatively deep, well developed profiles with little evidence of soil erosion and dominant colour hue of 5YR. The surface characteristics are gravelly, abrut smooth boundary, predominantly sandy loam surface texture, moderate coarse crumb, moderate and strong coarse subangular block structures and account for about 26% of the area while the toeslope covered the largest portion (34%) of the study area. They were characterized with sandy loam surface textures while the structure is generally strong coarse subangular blocky with soft iron concentions. The rounded nature of the gravels indicates that they were transported from the upper slope through the process of attrition and abrasion. The soils were very poorly drained due to depressional position (Idoga *et al* 2005) [21]. The presence of mottles indicates that this portion is seasonally water logged. While the strong brown (7.5YR 5/6) surface soil colour may be due to the presence of organic matter. They were very sticky very plastic wet, gradual smooth boundary with few lines roots and iron stones in the sub soil.

Physical and Chemical Characteristics
Soils at the upper and toe slopes had finer textures than those of hill crest and middle slopes (Table 2). The clay content ranged from 18% -65%. Soils of the crest had only one profile showing evidence of shallowness while others showed an increasing clay content and decreasing sand fraction with depth (69% - 14%). This trend appears to be most prevalent in the sub-humid Savannah Zone of Nigeria (Akinyemi and Vivian, 2001, Malgwi *et al,* 2007) [3, 23]. The silt fraction did not show any definite pattern of distribution among the topographic positions. Similar findings were reported for soils of Nigeria Savannah (Brady, 1999, Ahn, 1970, Idoga *et al,* 2005) [7, 1, 21]
The Plateau were slightly to moderately acidic in reaction, lowest (5.96) in middle slope surface horizons and highest (6.26) in crest positions. The PH values decreased from surface to the sub soils in all the profiles as a result of nutrient biocycling (Ogunwale *et al*., 2002 and Ugwu *et al*., 2001) [33, 39]. The organic carbon (0.04% -2.55%) and total N (0.07%-0.22%) were low to moderate. These values decreased with profile depth in all the soils due to the concentration of plant and animal residues on the topsoils (Jenney, 2008, Endredy, 2008) [10]. The relatively high content of organic C (1.96% – 2.55%) and N(0.189%) among the upperslope soils may be due to their poor drainage condition, low temperature and low microbial activities, resulting to high accumulation of organic C and N (ESU 1982) [11]. Soil available P (1.12 – 6.40ppm) was low and decreased with depth like organic C and N. This shows that the P content of the surface horizons were mostly in organic form (Sanchez, 1976). Total exchangeable bases were slightly low (5.15 – 8.78cmol/kg) in all the soils due to high weathering intensity and low organic C which reduced their ability to hold cations in exchangeable form (Krasilinikoff *et al.*, 2002 and Kang, 1993) [27, 26]. Exchangeable acidity (2.8-4.8cmol/kg) and ECEC (8.76-15.78 cmol/kg) were low to moderate and decreased with depth due to soil organic matter (Idoga and Azagaku, 2005, Brady, 1999, FAO, 1983) [22, 7, 12] Base saturation (62-98%) were moderately high, mostly at the surface horizons due to high surface organic matter (Wood, 1981, Idoga and Azagaku 2005) [40, 22].

Table 1: Morphological Description of the Soils of Andibilla Plateau of Oju Local Government Area

Horizon	Depth (C m)	Munsell	Colour Mottling	Texture	Structure	Consistence	inclusions	Boundary
Crest:	Profile I			Sandy Loam	2MCR	SSW	Many fine roots	
A	0-8	5YR4/2						
Crest:	Profile 2			Sandy Loam	2MCR	SSW	Many coarse roots	
A	0-6	5YR4/6 `						
Upper slope:	Profile 3							
A	0-35	7.5YR4/2	5YR4/8	Sandy Clay loam	2MSBK	VSW	Many medium roots	ds
AB	35-50	7.5YR5/2	5YR4/6	Clay loam	3CSBK	VSSPW	Many line roots	cs
Btg	50- 100	2-5yr5/2	5YR4/6	Clay	3CF SBK	VSVPW	Common fine roots	
Upper slope:	Profile 4							
A	0-20	7.5YR4/4	5YR4/8	Sandy clay loam	2MSBK	SSPW	Many medium roots	cs
Bt,	20-48	7.5YR5/8	5YR5/8	Clay	3CMSBK	VSVPW	Common fine roots	ds
Big	48-101	2.5YR5/2		Clay	3CFSBK	VSPW	Few fine roots	-
Middle slope:	Profile 5							
Ap	0- I 8	5YR5/2		Sandy loam	2FCR	SSW	Many fine roots	as
AB	18-36	5YR4/6		Sandy loam	2MSBK -	SSW	Many fine roots	ds
B	36-54	l0YR4/4		Sandy Clay loam	3CSBK	VSW	Few fine root	cs
BC	54- 130	l0YR5/4		Sandy Clay loam	3CSBK	VSPW	Few fine roots	
Middle slope:	Profile 6							
Ap	0-20	5YR5/3		Sandy loam	2CR	SSW	Many medium roots	as
AB	20-39	5YR4/6		Sandy loam	2MSBK	SSW	Many medium roots	cs
Bt,	39-66	7.5YR4/4		Sandy clay loam	3MSBK	VSPW	Common fine roots	gs
BC	66- 150	l0YR5/4 -		Sandy clay loam	3MSBK	VSPW	Few line roots	
Lower slope:	Profile 7							
Ap	0-20	7.5YR5/6	5YR4/2	Sandy clay loam	2MSBK	VSW	Many coarse roots	cs
Bt	20-30	l0YR4/3		Sandy clay loam	2MSBK	VSPW	Common medium root	ds
BL	30-50	l0YR4/4		Clay	3C SBK	VSVPW	Common fine roots	gs
Bt;	50-70	2.5YR4/4		Clay	3CSBK	VSVPW	Few line roots	
Lower slopes	Profile 8						Few fine roots Ironstone at 70cm	
Ap	O-I9	7.5YR5/6	2.5YR3/2	Sandy loam	2MCR	SSW '		
B	19-34	l0YR5/6	7.5YR4/2	Sandy Clay loam	3CSBK	VSW	Many coarse roots	
Btg	34-65	2.5YR5/6		Clay	SCSBK	VSPW	Many medium roots	
Few line roots ironstone al 65cm								

Legend				
Texture	**Structure**	**Consistence**	**Inclusion**	**Boundary**
SL = Sandy loam	2ccr = moderate coarse crumb	ssw= slightly sticky wet	c2f = common medium faint	ds = diffuse smooth
SCL = Sandy Clay loam	2mcr = moderate medium crumb	vsw = very sticky wet	m2d = many medium distinct	gs – gradual smooth
C = Clay	2msbk = moderate medium sub angular blocky	vpw = very plastic wet	fif = few fine taint	cs = clear smooth
	Zfsbk = moderate line subangular blocky			
	3csbk i strong coarse subangular blocky	sw = sticky wet	c3d = common coarse distinct	as = abrupt smooth
	3msbk = strong medium subangular blocky	nsw = non sticky wet		
	Vsvpw = very sticky very plastic wet			

Table 2: Physical and chemical properties of soils of Andibilla plateau

Horizon depth		Particle size				Texture		pH	Org.	Org.	Total	Available		Exchangeable				TEC	Exchange	ECEC	CEC	B.S
	(cm)	analysis		class		H20 KCL	C	matter	N	P	Total	Cations						Acidity				
		Sand Silt Clay				1:1		1:1			ppm	Ca		Mg		K		Na		E.A	AI	H
→		%				←			→	%	←	→				Cmol kg^{-1}%				←		
Soil Unit I																						
Lithic UstorthentslLithic Leptosls																						
A	0-10	61.6	19.2	19.2	SL	6.26	5.15	2.09	3.62	0.168	5.40	4.82	2.82	0.29	0.45	8.38	6.8	3.6	3.2	12.8	9.48	88
Lithic Ustorthents/Lithic Leptosls																						
A	0-6	63.4	18.2	18.4	SL	5.95	4.93	2.23	3.98	0.154	6.40	4.56	2.40	0.60	0.92	8.48	6.8	2.4	4.4	13.8	9.52	89
Soil Unite II																						
Pedon 3 Aeric Umbric Kandiaqualfs/Eutric Gleysols																						
A	0-35	55,6	21.2	23.2	SCL	5,78	5.20	1.96	3.30	0.215	4.50	4.26	2.24	0.30	0.49	7.29	3.2	2.0	1.2	10.49	9.12	80
AB	35-50	41.6	22.2	36.2	CL	5.52	4.90	1.64	2.83	0.105	2.80	3.94	2.00	0.19	0.28	6.41	4.8	1.6	3.2	11.21	7.36	87
Bt	50.100	35.6	13.2	51.2	C	5.40	4.81	1.40	2.41	0.084	2.60	3.40	1.69	0.20	0.30	5.59	4.8	1.6	3.2	10.39	7.00	80
Pedon 4 Umbric Kandiaqualfslliutric Gleysols																						
A	0-20	52.8	20.0	27.2	SCL	5.98	5.65	2.55	4.40	0.182	2.70	4.80	2.64	0.50	0.77	8.71	6.8	3.6	3.2	15.51	11.78	74
B	20-48	16.7	20.1	63.2	C	5.70	4.96	1.54	2.66	0.133	2.40	4.28	2.06	0.49	0.58	7.41	5.6	1.6	4.0	13.01	9.20	81
Bt	48-101	14.8	20.2	65.2	C	5.40	4.65	0.90	1.66	0.091	1.25	3.85	1.81	0.20	0.28	6.14	6.0	3.2	2.8	12.14	6.36	96
Soil unit III																						
Pedon 5 Typic Plinthaqualfs/Plinthic Gleysols																						
A	0-20	57.6	15.2	27.2	SCL	5.87	4.35	2.44	4.37	0.175	3.60	4.58	2.42	0.50	0.63	8.13	7.6	2.4	5.2	15.75	10.32	79
AB	20-40	54.6	16.2	29.2	SCL	5.15	4.10	1.91	2.03	0.098	2.90	3.66	1.60	0.48	0.22	5.96	7.2	3.2	4.0	13.16	9.10	62
BC	40-55	16.8	20.0	63.2	C	4.60	4.00	0.92	1.59	0.084	2.10	3.41	1.55	0.44	0.47	5.87	6.4	2.0	4.4	12.27	8.28	71
C	55-70	15.6	20.0	64.4	C	4.45	3.90	0.68	1.17	0.077	1.85	3.21	1.50	0.36	0.50	5.48	7.4	2.4	4.8	12.88	8.00	69
Pedon 6 Typic Plinthaqualfs/Plinthic Glcysols																						
A	0-19	59.6	19.2	21.2	SL	5.90	5.09	2.00	3.41	0.133	5.40	4.33	2.13	0.46	0.66	7.58	7.6	3.2	4.4	15.18	8.44	90
AB	19-34	57.6	20.0	22.4	SCL	5.80	5.10	1.55	2.70	0.111	3.20	3.94	1.97	0.30	0.45	6.66	7.6	3.2	4.4	14.26	8.04	80
C	34-65	24.4	21.2	54.4	C	5.64	4.90	1.50	2.20	0.084	2.80	3.90	1.82	0.25	0.40	6.39	6.8	2.0	4.4	13.19	6.74	95
Pedon 7 Kandic Paleustafs/Dystric Nitosols																						
A	0-18	57.6	21.2	19.2	SL	5.65	5.10	1.87	3.28	0.126	2.80	4.28	2.34	0.40	0.69	7.70	2.8	2.0	0.8	10.50	9.44	82
AB	18-36	55.6	21.2	23.2	SL	5.43	4.88	1.80	3.10	0.112	2.60	4.10	2.08	0.32	0.30	6.80	6.0	3.8	2.2	12.80	8.70	78
B	36-54	54.4	21.2	24.4	SCL	5.25	4.70	1.30	2.07	0.091	2.45	4.08	1.92	0.28	0.28	6.56	7.2	2.8	4.4	13.76	8.32	79
Bt	54-130	54.4	20.2	25.4	SCL	5.20	4.62	0.80	1.38	0.084	2.40	3.90	1.12	0.25	0.19	5.96	2.8	1.2	1.6	8.76	7.10	84
Pedon 8 Kandic Palaustalfs/Dystric Nitosols																						
A	0-20	69.4	13.2	16.4	SL	5.70	4.92	1.84	3.17	0.133	3.60	4.16	1.96	0.52	0.50	7.14	4.0	1.2	2.8	11.14	8.48	84
AB	20-39	60.4	14.2	25.5	SCL	5.37	4.65	1.52	2.62	0.118	2.40	3.84	1.56	0.31	0.41	6.12	6.4	2.4	4.0	12.52	6.44	98
B	39-66	56.4	12.2	31.4	SCL	5.23	4.60	1.28	2.21	0.098	2.60	3.36	1.47	0.20	0.33	5.36	5.6	1.6	4.0	10.96	6.40	84
C	66-150	54.4	12.2	33.4	SCL	5.16	4.70	0.04	1.79	0.070	2.30	3.32	1.42	0.16	0.45	5.35	5.6	2.0	36	10.95	5.70	94

Soil classification

Hill crest soils were thin (< 10cm) and underlain by hard coherent rock. The absence of diagnostic horizon apart from ochric epipedon placed the soil in the order Entisol and sub order Orthent due to their gentle slope and dominant hue of 5YR. The Ustic soil moisture regime places the soils as great group Ustorthent while the presence of Lithic contact within 10cm of the soil surface qualitfes them as Lithic Ustor thents and Lithic Leptosol (FAO/UNESCO soil legend, 1994) [12].

Soils of upper, middle and toe slopes had high B.S (>50%) with argillic horizons and therefore belong to the order Alfisols. The upper and the toe slopes had aquic soil moisture regime and redox concentration of more than 50% of the matrix, hence belong to sub order Aqualfs. The low ECEC of the soils of upper slope despite the high clay content of the argillic (Bt) horizons indicates the presence of low activity clay. They were classified as Kandiaqualf and grouped as Umbric Kandiaqualfs due to the presence of umbric epipedon (thick surface horizons and high organic matter > 1.5%) overlying the argillic horizons. In the FAO/UNESCO soil legend, they were grouped as Eutric Gleysols due to high B.S and very poor drainage conditions.

The ustic soil moisture regime of middle slope soils placed them in the suborder Ustalf. Since the difference in the amount of clay between the argillic horizons and the overlying horizon did not exceed 20%, the soils were grouped as Paleustalfs while the low CEC (7.75-9.65cmol/kg) of the argillic horizons qualified them as Kandic Paleustalfs. In FAO/UNESCO legend, they were classified as Eutric Nitosols because of the high B.S and the clay distribution pattern. The toeslope soils were underlain by plinthite which occurred between 65cm and 70cm of the soil surface. The plinthite was believed to have been responsible for the gleyed matrix colour of the overlying Bt horizons. Hence the soils were classified as Plinthaqualfs and further sub grouped as Typic Plinthaqualfs. In FAO/UNESCO soil legend, they were classified as Plinthic Gleysols (Table 3).

Table 3: Soil Classes in the Study Area

Topographic positions	Profiles	USDA	FAO/UNESCO
Hill crest	1 and 2	Lithic Ustorthents	Lithic Leptosols
Upperslope	3	Aeric Umbric Kandiaqualfs	Eutric Gleysols
Upperslope	4	Umbric Kandiaqualfs	Eutric Gleysols
Middleslope	5 and 6	Kandic Paleustalfs	Eutric Gleysols
Toeslope	7 and 8	Typic Plinthaqualfs	Eutric Gleysols

Land Use

The limited depth (<10cm) of the hill crest soils implies that, they have low water and nutrient holding capacities, and low rooting zone. Ridging and mounds making are extremely difficult and practically impossible. They are to dry to support arable cropping especially in the face of erratic rainfall. Cultivation will expose the soils to more erosion with further decrease in solum thickness. Hence perennial crops like oil palm, kola, cashew, mango and cocoa are ideals for this soil. They have fibrous rooting system which permeate the rocks and disintegrate them physically. The canopy is capable of reducing rain drop impact while the fibrous roots can check runoff and erosion. The plants may take longer time to established, but once established, they stabilized the soils and consequently the environment. Upper slope soils are moderately to steeply sloping with numerous rills and gullies. Some places are disserted by deep narrow valleys and covered by large surface boulders which reduce plant population when cultivate to arable crops. Therefore perennial crops are also recommended because their wider spacing and plant population is better ensured. Middleslope soils can be cultivated to arable crops like yam, cassava, maize and millet because of their deep, well drained and developed profiles while toeslope soils can be cultivated to water loving crops like rice, sugarcane, plantain and banana because of their aquic soil moisture regime.

Conclusion

The study shown that, there were variations in morphological and physico- chemical characteristics as well as soil classes within the study area which are highly influenced by topography. The importance of topography in soil formation and distribution has been realized from inception of soil science (Young, 1976, Ogunkunle and Onasanya, 1992) [32 The observation also shown that the soil depth and structure improve downward. Soil texture becomes finee with undulating relief. Their stickness increased down slope with increase in clay content. These morphological and phyico-chemical relationship influence land use management such that the different facets of the toposequence are restricted to different crops and management practices. For sustainable productivity and optimum returns the above recommendation should be strictly adhered.

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