Global Journal of Agricultural Sciences. Vol. 3, No. 1 & 2, 2004.: 25 - 34
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Characterization and Classification of the Inland Valley Soils of Central Cross River State, Nigeria.

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(Received 3 October 2003; Revision Accepted 28 February 2004)

Six profiles located in the inland valley soils of central Cross River State were studied. The surface horizon colour of the first four were either dark Grey or dark brown. The last two profiles were grey. All subsurface horizons were either greyish or brownish and highly mottled. The structure of all the profiles were either blocky or prismatic with the latter predominating for the subsurface horizons. The textures of the surface horizons ranged from sandy loam to clay while the subsoil soil horizons were predominantly clay. The pH of the soils ranged from acid (4.7). to neutral 7.4 The percent organic carbon content decreased slightly irregularly with increase in depth with the top soils concentration generally high. Similarly, percent total nitrogen was high with most values greater than 0.2%. However, concentration of available phosphorous was moderate. The exchangeable cations Ca. Mg and K were high. Exchange acidity of the soils decreased with increase in profile depth. Cation exchange capacity results were appreciable for four of the six profile with their base saturation values greater than 50% for the surface horizons. Using the criteria of the USDA Soil Taxonomy, profile APT – 1 was classified as Aeric Epiaqulfs, APT – 2 as Typic Epiaqualfs, ABN – 3 as Typic Umbraqualfs and ABN – 4 as Vertic Epiaqualfs. Profiles APP – 5 and APP – 6 were classified as Typic Epiaquults. Using the FAO – UNESCO soil map of the world legend, profiles APT – 1 APT – 2, ABN – 3 and ABN – 4 were classified as Gleyic Luvisols while APP – 5 and APP – 6 as Gleyic Alisols.

KEYWORDS: Characterization, classification, inland valley soil, surface horizon, subsoil horizon.

INTRODUCTION

Inland valleys (IVS) comprise valley bottons and minor floodplains which are seasonally submerged each year (Misari, 1996). Ahmad (1982) described inland valleys as areas o prime soils but remarked that throughout the tropics, they are far less efficiently utilized. Inland valley soils have characteristics associated with heterogeneity since they occur in areas of marked differences in soils, climate, relief, etc (Carsky, 1992). West Africa has about ten to twenty million hectares of inland valleys (Hekstra and Andriesse, 1983).

Of the various wetland cultivated to rice in Nigeria, the Inland valleys constitute about 10% (Ayotade and Fagade, 1986). However, of the total rice produced in Nigeria about 45% is from the inland valleys (Shiawoya et al, 1986). Apart from cultivation, inland valleys serve as grazing grounds and water supply for cattle (Tran et al 1995). In fact, it is reasoned that in tropical Africa today, intensifying the use of wetlands for food crop production by the small holder farmers might lead to a major breakthrough in food sufficiency (11TA, 1986).

One of the precarious constraints to the use of inland valley soils for agricultural production is the problem of iron toxicity. This problem has been identified in the inland valley soils of Vietnam, Philippines, Thailand, Malaysia, Sri Lanka, Columbia, etc (Li and Ponnamperuma, 1984). In West Africa, iron toxic inland valleys have been found in Liberia, Benin Rep.; Sierra Leone,, Cote D' Ivoire, Senegal, etc (Abitarin, 1989). Soil characterization studies of this nature had in the past unraveled the mystery of bronzing symptoms of rice cultivated in Sri Lanka and Sumatra (Jugsujinda and Parick; 1993). These similar problems have been reported in some inland valley soils of South Eastern Nigeria (Bende) and it is expected that, part of the task of pedologists is to identify soils with such problems (11TA, 1985).

Out of the total land area occupied by wetlands in the Cross River State of Nigeria, the inland valleys are ranked after the mangrove and floodplain soils in areal extent. However, despite the obvious importance of the soils and the fact that Cross River State has over 38,000 ha of inland valley soils, rice cultivation takes place in less than 50% of the area (CRADP, 1992). In addition to this, extensive pedological studies have not been specifically focussed on the soils to generate detail information for their classification and modern management. This study was, thereof, undertaken to determine the morphological, and physiochemical properties as well as classify the inland valley soils of central Cross River State using the criteria of the USDA soil Taxonomy (Soil Survey Staff 1975; 1996) and the FAO/UNESCO soil map of the world legend (FAO/UNESCO, 1985).

MATERIALS AND METHODS

STUDY AREA

The study area is located in the central part of Cross River State (latitudes 4°45'N and 6°45'N and longitudes 7°45' and 9°00'E) in Southeastern Nigeria. Three sample areas with extensive inland valleys located at Akpet 1, (APT - 1 and APT – 2), Abini (ABN – 3 and ABN – 4) and Apiapum (APP – 5 and APP – 6) where selected for the siting and detailed description of modal soil profiles (fig. 1). The study locations are underlain by cretaceous sand – stones and Shales of the Eze– Aku group of the southeastern Benue Trough (Petters, 1995).

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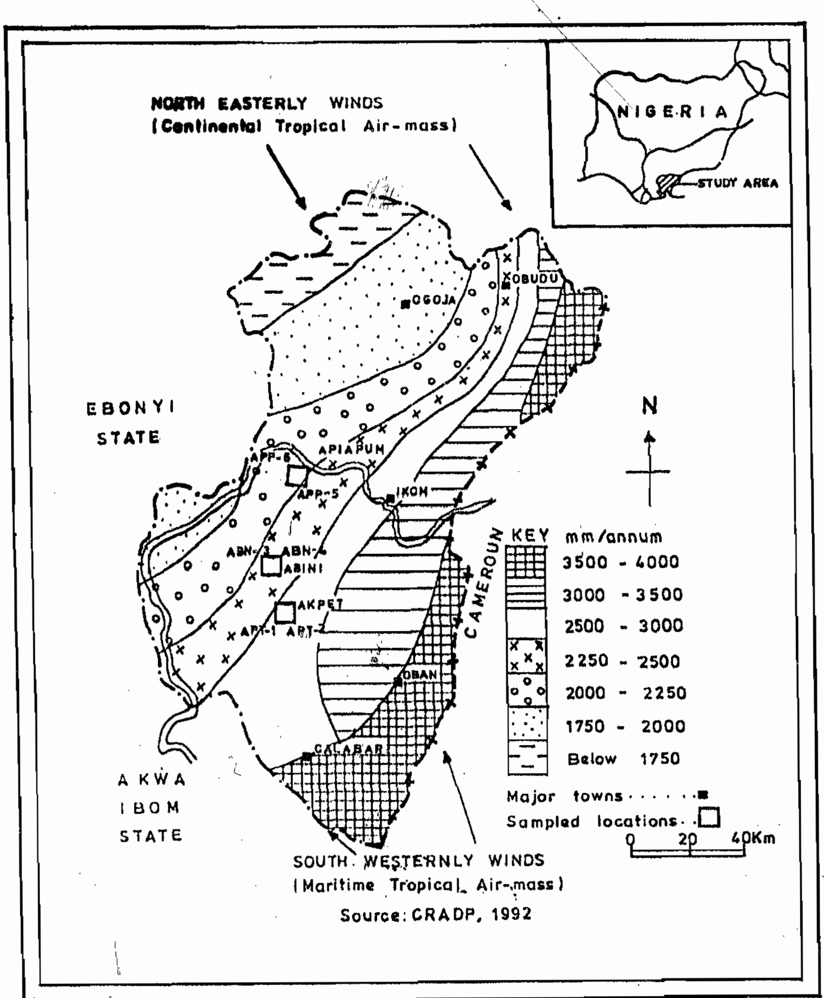

FIG.1: MAP OF CROSS RIVER STATE SHOWING MEAN ANNUAL RAINFALL DISTRIBUTION AND THE SAMPLED LOCATIONS.

FILED STUDIES

Preliminary studies were carried out through field visits and interviewing of local residents and actual siting of soil profiles pits was done. Each of the locations chosen represented the major rainfall zones within the study area. A total of six profile pits dug in three separate locations with each location having two. Each profile pit was dug at the centre of the nearly level extensive inland valleys. Soil colour and mottles were described using the Munsell colour chart, texture by feel in between fingers, consistence by applying pressure on soil peds between fingers while the occurrence of cutans, pores and boundaries were determined by visual observation. Upon description, soil samples from each horizon of the profiles, as well as undisturbed core samples were also collected for bulk density determination.

LABORATORY STUDIES

Soil samples brought from the field were air – dried under shade and sieved through a 2.00mm sieve for physical and chemical analyses. Particle size distribution was determined using the Bouyoucos hydrometer as described by Day (1965) using sodium hexametaphosphate as the dispersant. From these results, the textures were determined using the USDA soil textural triangle (NSSC, 1995). Determination of bulk density was carried out by using undisturbed core samples dried at 105°c and dividing the mass by the volume (Blake, 1965) while particle density was determined by the method described by Bowles, (1992). Total porosity was determine mathematically from the results of bulk and particle density (Vomocil, 1965).

Soil pH was determined potentiometrically using the glass electrode as described by 11TA (1979) in a 1:2.5 soil: water ratio while organic carbon was by Walkley and Black wet oxidation method (Allison, 1965). The percent total nitrogen was determine using the Micro Kjeldhal method outlined by Bremner and Mulvaney (1982). Available phosphorus determination was carried out by the Bray and Kurtz (1945)

No. 1 procedure and the exchangeable acidity by first extracting with KCl and latter by titration (Mclean, 1965). The exchangrable cations, Ca, Mg, K and Na were determined using IN NH_4OAC (pH7.0) method of Chapman (1965). The concentration of exchangeable AC and Mg was read off from an atomic absorption spectrophotometer (AAS) while the K and Na were determine using the flame photometer. The cation exchange capacity was determined using neutral NH_4 O A_c and the adsorbed NH_4^+ was displaced using the acid

TABLE 1: FIELD MORPHOLOGICAL DESCRIPTION AND CLASSIFICATION OF THE SAMPLED SOILS

Horizon	Depth (cm)	Munsell Colour	Mottling	Texture	Structure	Consistence (moist)	Boundary	Other features
APT-1 (Aeric Epiaqualfs/Gleyic Luvisols)								
Apg	0-28	10YR3/1 10YR3/2	10YR5/6	L*	Sbk*	v.fr*	Cw*	Many fine & medium pores few ant holes and live ants. Few very fine mica flakes, many Org. M stains in ped faces & root channels
BAg	28-45	10YR7/3	10YR5/8 2.5YR4/8	L	sbk	s&pl(wet)	Cs	Many Fe stains in pores many fine to medium pores, mica; few live ant and common ant holes.
2Btg1	45- 75	7.5 YR5/8	-	cl	sbk	s&p(wet)	Gs	Moderate to thick clay & Fe Oxide cutans on ped and pore faces:
2Btg2	75-134	10YR5/8	10YR7/8	C	P	s&vpl (wet)	Ds	Thick continues clay and Fe cutans on ped faces many medium pores; few medium and common fine roots: common fine meca; Fe and Mn nodules.
2Btg3	134-183	10YR5/8	10YR7/8	C	p	s&v.pl(wet)	-	Thick continuous clay cutans on ped faces:many very fine pores: common medium Mn andFe nodules: common thin mica flakes.
APT-2Typic Epiaqualfs/Gleyic Luvisols								
Apg	0-30	10YR2/1	10YR2/1	C	abk	s&pl(wet)	cw	Fine medium roots: very fine common mica: few termites
Btg1	30-62	10YR7/1	5YR6/8	C	p	s&pl(wet)	cs	Few thin clay and Fe cutans on ped and pore faces; very fine to fine roots
2Btg2	62-105	5YR7/8	2.5YR4/6	C	p	Firm s&v.pl(wet)	cs	Common continuos clay cutans on ped faces; fine few pores: V. fine to fine few roots; common fine mica
2Btg3	105-180	5YR7/1	2.5YR4/6	C	abk:p	fr s&v.pl(wet)	-	Moderately thick continuous clay and Fe cutans on ped faces and pores: common fine pores; few very fine roots: few fine mica
ABN – 3 Typic Umbraquals/Glegic Luvisols								
Apg	0-10	10YR3/4	5YR5/8	Sl	sbk	fr. s&pl	cw	Many medium pores: many fine to medium roots: few rounded Fe nodules: few mica.

Horizon	Depth	Munsell Colour	Mottling	Texture	Structure	Consistence	Boundary	Other Feature
BAg	10-40	10YR6/3	10YR5/8	Cl	sbk;p	firm s&pl	cs	Common thin clay cutans many medium pores: many fine roots; many medium Fe nodules: few fine mica.
2Btg1	40-70	10YR5/8 10YR6/4	Mottled	C	sbk	firm s&pl(wet)	gs	Moderate to thick continuous Fe and clay cutans on ped faces and pores common very fine roots; rounded Fe- Mn concretions few earth worms.
2Btg2	70-140	10YR6/8	mottled	C	p	v.fr. s&vpl (wet)	-	Thick continuous clay and Fe oxide cutans on ped faces and pores: few very fine roots: irregular shaped common medium and large Fe-Mn concretion, few very Fine mica
Horizon	**Depth**	**Munsell Colour**	**Mottling**	**Texture**	**Structure**	**Consistence**	**Boundary**	**Other Feature**
ABN-4 Vertic Epiaqualfs/Gleyic Luvisols								
Apg	0-15	10YR3/2	5YR4/6)	Sl	sbk	s&pl (wet)	cw	Very few thin Fe cutans in pores; many medium pores; many fine mica
BAtg	15-27	10YR6/1	2.5YR4/4	Sl	sbk	fr s& pl (wet)	cw	Few thin Fe cutans in ped faces; many medium pores many fine to medium roots:Mn nodules: few fine mica; few earthworms.
2Btgl	27-43	10YR5/1	2.5YR5/8	Scl	P	firm s&pl(wet)	gs	Common thin clay cutans on ped faces and iron oxide in pores. Mn nodules Fe-Mn concretions: common fine mica: few earthworms.
2Btg2	43-152	10YR6/1 7.5YR6/8	Mottled	Scl	abk;p	fr. s&pl(wet)	-	Common thin cutans on ped faces and pores. Few very fine to fine roots; few Fe-Mn concretions; few Fe nodules few small quartz grains; common fine mica; few earthworms.
Horizon	**Depth**	**Munsell Colour**	**Mottling**	**Texture**	**Structure**	**Consistence**	**Boundary**	**Other features**
App-5 Typic Epiaqualts/Gleyic Alisols								
Apg	0-20	7.5YR5/6 10YR6/2	Mottled	Scl	sbk	Fr	cw	Many fine to medium pores many fine to medium roots; few ant: common earthworm casts. Fe stains as mottles.

BAg	20-40	5YR4/6 7.5YR7/2	Mottled	Cl	sbk	fr S&pl (wet)	cw	Many fine and medium pores; fine common roots, few hard small Fe-Mn concretions and many soft Mn nodules.
2Btg1	40-115	7.5YR7/7 7.5YR4/4 7.5YR5/6	Mottled	Cl	p	v.firm v. hard (dry) s&pl(wet)	ds	Common thick clay cutans; many fine and medium pores; few fine roots; common soft Fe- Mn concretions; many soft Mn nodules
2Btg1	115-183	7.5YR7/2	7.5YR5/8	Scl	sbk	firm s&pl(wet)		Moderately thick continuous clay cutans; many fine to medium pores; many small rounded Fe-Mn concretions; many fine mica flakes.
Horizon	Depth (cm)	Munsell colour	Mottling	Texture	Structure	Consistence	Boundary	Other features
APP- 6 Typic Epiaquults/Gleyic Alisols								
Apg	0-25	10YR6/2	5YR5/7	Scl	sbk;p	s&pl	cs	Many Fe-stain in pores; many medium pores; many fine and medium roots; common fine mica; some ant holes; common earthworm
2Btg1	25-74	7.5YR6/2 10YR4/6	Mottled	Cl	p	firm s&pl	cw	Common moderately thick clay cutans on ped faces and pores; many fine roots; common small rounded Fe-Mn concretions.
2Btg2	74-112	10YR6/2	Mottled	C	Sbk;p	v. firm v.hard (dry) s&pl (wet)	cw	Common medium pores; few V. fine roots; many medium Mn nodules and few Fe-Mn concretion.
2Btg3	112-183	10YR6/2	2.5YR4/8	Cl	Sbk;p	firm v.s&pl (wet)	-	Moderately thick continuous clay and iron oxide cutans on ped faces and pores; many fine and medium pores; few V. fine roots; many small and large Fe nodules.

* L-Loam, Cl-Clay Loam, C-Clay, SL – Sandy Loam, SCL – Sandy Clay Loam;
Sbk – Subangular blocky, p – prismatic, abk – angular blocky;
V.fr – very friable, S & pl – Sticky and plastic, S & Vpl – Sticky and Very plastic
Fr – friable;
cw – clear and wavy; cs – clear and smooth, gs – gradual and smooth
ds – diffuse and smooth.

– NaCl method (Chapman, 1965) while the effective cation exchange capacity (ECEC) was calculated by summing the total exchangeable bases and exchangeable acidity. Determination of base saturation (both effective and neutral) was calculated by the division of total exchangeable bases (Ca, Mg, K and Na) by effective CEC; and CEC obtained by NH_4OAc procedure respectively and finding their percentages (NSSC, 1995).

RESULTS AND DISCUSSION

Morphological properties

A summary of the morphological properties of the sampled soils is shown in Table 1. For the surface horizons, pedon APT – 1 had two colours of very dark grey (10YR 3/1) and very dark greyish brown (10YR3/2). Pedon APT –2 had two colours also with grey (10YR6/1) as the dominant one separated by a thin band of black (10YR2/1) layer of about 4cm in the centre of the horizon. Pedon ABN – 3 had dark yellowish brown (10YR3/4) colour while ABN – 4 had dark greyish brown. Pedon APP-5 and APP – 6 had similar colours of light brownish grey (10YR6/2). However, because of greater degree of mottling pedon APP- 5 had an additional colour of strong brown (7.5YR5/6).

The subsurface horizons had various shades from very pale brown (10YR7/3) to strong brown (7.5YR5/8) for Apt -1 while APT – 2 had light grey (10YR7/1). The colours of pedon ABN-3 ranged from pale brown (10YR6/3) to yellowish brown (10YR5/8) colour while ABN-4 had a single colour of grey (10YR6/1). Pedon APP – 5 and APP – 6 colours were either pinkish grey (7.5YR6/2) or strong brown (10YR4/6).

PHYSICOCHEMICAL PROPERTIES

The total sand contents of the soils generally decreased with increase in soil depth except for profile ABN –4 and APP –5 which had 56% in the Apg and 58% in the 2 Btg2 respectively (table 2). The surface horizons had a total sand fraction ranging between 30% and 60% with an average of 47.4% while the subsurface horizons had values between 8% and 60% with an average of 37.3%. The percentage fine and coarse sand fractions fluctuated with depth. However, their surface soil horizons value were not widely varied for each location.

Silt fraction on the whole ranged between 12% and 46% with a mean of 27.4%. The topsoil horizons had values between 19% and 36% with an average of 26.9% while subsurface horizons had values from 12% to 38% with an average of 27.2%.

The clay fraction increased with increase in profile depth. The surface horizons had a clay fraction ranging between 14% and 68% with a mean of 25.9% while for the subsoil horizons, the values obtained ranged from 18% to 68% with a mean of 38.7%. The range of the total clay fraction is from 14% to 68% with a mean of 35.6%. Each pedon clearly showed a clay bulge.

Soil textures obtained in this work corroborate with that of Brinkman and Blockhuis (1986) who found that the textures of inland valley soils could range from sand to clay but the latter predominates.

The pH (H_2O) of all profiles are in the range of 4.5 and 7.4. The surface horizon values were between 4.5 and 7.4 with a mean of 5.2. Apart from APT–1 with pH 7.4, all the other five profiles had their surface soil pH ranging from 4.5 to 4.9 with a mean of 4.7. The pH of the subsurface horizons ranged from 4.9 to 7.4 with a mean of 5.8. While there were slight fluctuations in pH values obtained in some profiles, pedon ABN-3 and ABN-4 showed a peculiar trend whereby the pH increased with increase in profile depth. The mean pH values for both the surface and subsurface horizons were as expected since the pH of the air- dried paddy soils are usually around 5.0 to 5.5 (Kawaguchi and Kyuma 1997). Apart from APT-1, it could be concluded that the surface horizons of all the profiles are acidic, while the subsurface ones were slightly acidic (Zonn, 1986). The percent organic carbon results (tables 3) of the soils ranged from 0.88% to 3.34% with a mean of 2.38% while the subsurface horizons values were from 0.14% to 1.5% with a mean of 0. 7%. The inland valleys have good organic carbon content in their top soils. Out of six profiles, only two, APR-5 and APP-6 had organic carbon content in the surface soil that could be described as medium while the remaining four, APT-1, APT-2, ABN-3 and ABN-4, had values that could be rated as high (FMANR, 1990). The values obtained from the surface horizons for the first four profiles were similar to those obtained from similar soils by Kosaki and Juo (1986) and Tran et al (1995).

The total nitrogen contents showed a similar trend to that of organic carbon in that the nitrogen content decreased as soil depth increased except for profile APP- 5 where there was a slight variation. Total nitrogen generally ranged from 0.03% to 0.42%. All the surface horizon values were between 0.03-0. 18% giving a mean of 0. 25%. The subsurface horizon result ranged from 0.03-0. 18% with a mean of 0.07%. The results show that the surface horizons of all but profile APP- 5 contain nitrogen values greater than 0.15% described as moderate (FMANR, 1990). The surface horizon values of the soils are higher when compared with those obtained by Okusami (1986) and Tran *et al* (1995). However, the subsoil horizon values are similar.

Available phosphorus contents for all the horizons ranged from 1.00mg/kg to 19.45mg/kg. The range of values for all the surface horizons is from 2.35mg/kg to 19.45mg/kg with a mean of 9.35mg/kg while the subsurface horizon values ranged from 1.00mg/kg to 10.85mg/kg with a mean of 3.76mg/kg. Similar observations where the upper horizons had more concentration of phosphorous than the lower ones had been made by Bamjoko *et al* (1983). Using the rating by FMANR (1990) and Udo and Ogunwale (1986), it could be concluded that the soils are moderate to high in available phosphorus. This is because four (APT-1, APT-2 ABN-4 and APP-6) surface horizons possess moderate to high values (8.00-20.00mg/kg).

The concentration of sulphur ranged from traces to 106.25mg/kg. The range from surface horizons is from traces to 42.50mg/kg with a mean of 10.57mg/kg. The subsurface horizon values also fell between traces and 106.25mg/gk to give a mean of 17.75mg/kg. The concentration of sulphur in these soils especially in the surface horizons is very low because Jones (1987) reported an expected mean value of 106mg/kg for tropical soils. Also Suzuki (1987) stated that the critical level of extractable sulphur in soils (for rice) is around 7-11mg/kg.

A result of exchangeable bases is shown in Table 3. The content of exchangeable calcium obtained fluctuated in all the profiles. Generally the values in all the profiles ranged from 2.0 and 12.00cmol/kg. The values from surface horizons were within 5.2 and 12.00cmol/kg with a mean of 8.6cmol/kg. For the subsurface horizons the range was from 2.00-12.00cmol/kg to give a mean of 7.37cmol/kg. The exchangeable Mg for the surface horizons fell between 1.2 and 10.00cmol/kg with a mean of 6.15cmol/kg. The exchangeable K was mostly concentrated in the surface horizons except for profile APT-1. The surface horizon concentration ranged from 0.12- 0.30cmol/kg while the subsurface horizon values vary between 0. 07 and 0. 23cmol/kg with a mean of 0.11cmol/kg. The surface horizon values for sodium were in the range of 0.04 and 0.09cmol/kg with a mean of 0. 05cmol/kg while the subsurface horizon had a range of 0. 04 to 0. 13 cmol/kg with a mean of 0. 06cmol/kg.

All the profiles could be said to be high in calcium since soils with about 3.5 Ca could possibly not be limiting to plants (Periaswamy et at, 1983). With respect to Mg, these inland valley soils like others developed on cretaceous parents material have high Ca and Mg contents (Eshett, 1985). Mg deficiency is said to occur in wetland soils if the concentration falls below 3-4% of the CEC; more especially if the pH is below 5.5 (Jones, 1987). Going by this, all the surface horizons have values greater than 4% of the CEC. The low concentration of Mg in the subsoil horizons is as expected for many southern Nigerian soils (Adepetu *et al* (1979). The results of potassium obtained in these soils are similar to those obtained by other workers as the critical levels of potassium. This is because in India 0.26 is regarded as the critical level while in Japan it is 0.21cmol/kg (Jones, 1987).

The results of exchange acidity generally decrease with increase in profile depth. On the whole, the values vary between 1.20-9.00cmol/kg with a mean of 5.13cmol/kg. The surface horizons values ranged from 2.00 to 9.00cmol/kg with mean of 5.13cmol/kg while the subsoil horizons had a range of 1.2 and 5.0cmol/kg with a mean of 2.5cmol/kg. These values of exchange acidity appear high especially for the surface horizons. This is as a result of the high exchangeable aluminum values (Esu, et al; 1991).

The CEC of the soils ranged from 12.0 to 39.0cmol/kg. The surface horizons had values ranging from 22.0 to 38.0cmol/kg while the subsurface horizon had values ranging from 12.0 to 39.0cmol/kg with a mean of 22.63cmol/kg. The ECEC results for the surface horizons are in the range of 13.36cmol/kg and 28.72

TABLE 2: SELECTED PHYSICOCHEMICAL PROPERTIES OF THE SOILS

PROFILE	HORIZON	DEPTH (cm)	SAND (%)	SILT (%)	CLAY (%)	SOIL TEXTURE	pH (H_2O)	ORG. C (%)	% N	P mg/kg
APT - 1	Apg	0-28	39.80	36.00	24.20	Loam	7.4	3.34	0.17	11.00
	BAg	28-45	34.60	46.00	20.20	Loam	5.4	1.04	0.08	11.00
	2 Btg 1	45-75	29.80	36.00	34.20	Clay loam	4.9	1.16	0.06	2.00
	2 Btg 2	75-134	25.80	34.00	40.20	Clay	6.8	0.84	0.04	1.00
	2 Btg 3	134-183	27.80	30.00	42.20	Clay	7.4	0.72	0.04	1.00
APT - 2	Apg	0-30	30.40	19.40	50.20	Clay	4.7	3.24	0.42	19.00
	Btg 1	30-62	11.80	33.40	54.20	Clay	5.2	1.54	0.18	6.00
	2 Btg 2	62-105	8.40	27.40	64.20	Clay	5.1	0.82	0.06	2.00
	2 Btg 3	105-180	8.40	23.40	68.20	Clay	5.1	1.04	0.06	3.00
ABN - 3	Apg	0-10	59.80	26.00	14.20	Sandy loam	4.7	3.33	0.36	3.00
	BAg	10-40	39.80	24.00	36.20	Clay loam	6.9	1.46	0.15	7.00
	2 Btg 1	40-70	23.80	28.00	48.20	Clay	6.9	1.02	0.07	1.00
	2 Btg 2	70-140	29.80	22.00	48.20	Clay	7.4	1.00	0.03	1.00
ABN - 4	Apg	0-15	55.80	30.00	14.20	Sandy loam	4.9	2.12	0.21	7.00
	BAg	15-27	62.40	19.40	18.20	Sandy loam	5.3	0.96	0.10	9.00
	2 Btg 1	27-43	60.40	17.40	22.20	Sandy clay loam	6.0	1.12	0.10	8.00
	2 Btg 2	43-152	56.40	21.40	32.20	Sandy clay loam	7.2	0.72	0.04	2.00
APP - 5	Apg	0-20	49.80	28.00	22.20	Sandy clay	4.5	1.34	0.08	2.00
	BAg	20-40	44.60	24.00	32.20	Loam	5.1	0.59	0.03	3.00
	2 Btg 1	40-115	26.80	38.00	35.20	Clay loam	5.3	0.20	0.05	3.00
	2 Btg 2	115-183	57.80	18.00	24.20	Sandy clay loam	5.0	0.14	0.03	5.00
APP - 6	Apg	0-25	48.80	22.00	30.20	Sandy clay loam	4.7	0.88	0.24	13.00
	2 Btg 1	25-74	39.80	30.00	30.20	Clay loam	5.6	0.22	0.08	2.00
	2 Btg 2	74-112	39.80	12.00	48.20	Clay	5.3	0.26	0.07	2.00
	2 Btg 3	112-183	30.00	32.80	37.20	Clay loam	5.2	0.24	0.05	2.00

TABLE 3: Exchangeable bases and related properties of the sampled soils

PROFILE	HORIZON	DEPTH (cm)	Ca	Mg	K	Na	TEB	Exch. Al	EA	ECEC	CEC NH_4OAC	B. S (%) (NH_4OAC)
			<………				cmol/kg			………>	cmol/kg	(%)
APT – 1	Apg	0-28	11.20	7.20	0.20	0.04	18.64	1.20	2.20	35.00	35.00	53.00
	BAg	28-45	5.20	2.00	0.15	0.09	7.44	1.80	2.20	12.00	12.00	62.00
	2 Btg 1	45-75	5.60	1.00	0.23	0.09	7.52	1.60	2.40	15.00	15.00	50.00
	2 Btg 2	75-134	5.20	10.40	0.12	0.13	15.85	1.60	1.80	25.00	25.00	63.00
	2 Btg 3	134-183	8.40	8.00	0.10	0.13	16.63	0.80	1.80	18.00	18.00	92.00
APT - 2	Apg	0-30	9.20	3.60	0.30	0.04	13.14	8.20	8.20	23.00	23.00	57.00
	Btg 1	30-62	6.00	2.80	0.15	0.09	9.04	2.60	2.60	19.00	19.00	48.00
	2 Btg 2	62-105	8.40	4.40	0.17	0.04	13.01	2.00	2.00	23.00	23.00	57.00
	2 Btg 3	105-180	10.00	5.20	0.17	0.04	15.41	2.00	2.60	23.00	23.00	67.00
ABN – 3	Apg	0-10	8.40	10.00	0.23	0.04	18.67	2.20	3.00	38.00	38.00	49.00
	BAg	10-40	9.60	6.00	0.12	0.04	15.76	0.60	1.20	33.00	33.00	48.00
	2 Btg 1	40-70	4.80	4.80	0.07	0.04	20 51	0.60	1.60	39.00	39.00	53.00
	2 Btg 2	70-140	12.00	10.40	0.12	0.09	22.61	1.20	1.80	34.00	34.00	67.00
ABN – 4	Apg	0-15	12.00	4.80	0.23	0.09	17.15	1.40	2.00	24.00	24.00	71.00
	BAg	15-27	2.80	3.60	0.10	0.04	6.54	1.00	2.00	22.00	22.00	30.00
	2 Btg 1	27-43	3.20	4.40	0.12	0.04	7.76	0.60	1.80	15.00	15.00	52.00
	2 Btg 2	43-152	5.20	7.20	0.10	0.04	12.54	1.20	1.20	14.00	14.00	90.00
APP – 5	Apg	0-20	5.20	1.60	0.12	0.04	6.96	6.80	6.40	28.00	28.00	25.00
	BAg	20-40	4.80	1.60	0.10	0.04	6.54	2.60	3.00	17.00	17.00	38.00
	2 Btg 1	40-115	5.20	3.20	0.07	0.04	8.51	3.80	3.80	18.00	18.00	47.00
	2 Btg 2	115-183	6.40	4.40	0.07	0.04	10.91	3.80	3.80	21.00	21.00	52.00
APP – 6	Apg	0-25	5.60	1.20	0.12	0.09	7.01	7.00	9.00	22.00	22.00	32.00
	2 Btg 1	25-74	2.00	14.40	0.07	0.04	6.11	5.00	5.00	22.00	22.00	77.00
	2 Btg 2	74-112	3.20	8.00	0.10	0.04	11 34	3.40	3.60	30.00	30.00	38.00
	2 Btg 3	112-183	3.20	3.80	0.10	0.04	7.14	2.20	3.00	30.00	30.00	24.00

with a mean of 20.32cmol/kg. These results of CEC either by ammonium acetate saturation or by summation are described as high (Udo and Ogunwale, 1986).

The NH_4OAc base saturation values of the surface horizons ranged from 24.9% to 72% with a mean of 47.97%. The subsoil horizon values are between 23.3 and 92.4% with a mean of 55.4%. Apart from profile APP – 5 and APP – 6 all others had base saturation in the range described as either high or moderate (Udo and Ogunwale, 1986).

CLASSIFICATION ACCORDING USDA SOIL TAXONOMY

This classification undertaken using USDA Taxonomy (Soil Survey Staff, 1975, 1996) was up to the subgroup level. Profiles APT – 1, APT – 2,ABN-3 and ABN –4 possess argillic (Bt) horizon, medium to high content of basic cationic elements and base saturation percentage greater than 50% by NH_4 OAc in the Bt horizons. They were therefore classified as Alfisols.

Since they show redoximorphic conditions between AP and 40cm depth .they were, classified as Aqualfs at the sub order level. At the great grounp level APT-1, APT-2 and ABN-4 were classified as Epiaqualfs for possessing episaturation characteristics and a chroma of 2 or less on ped faces. Profile ABN-3 possessing a surface horizon with organic carbon greater than 1% with base saturation less than 50% was classified as an Umbraqualfs. At the subgroup level profile APT-1 was classified as Aeric Epiaqualfs and APT-2 as Typic Epiaqualfs. While profile ABN-3 was classified as Typic Umbraqualfs for possessing an umbric epipedon, ABN-4 was classified as Vertic Epiaqualfs, because of its characteristics wide and deep cracks.

Profiles APP-5 and APP-6 with base saturation less than 50% by NH_4OAc and having aquic moisture regime were classified as Aquults. Since they possess episaturation they were both classified as Typic Epiaquults.

CLASSIFICATION ACCORDING TO FAO-UNESCO SOIL MAP OF THE WORLD LEGEND (1985):

Profiles APT-1, APT-2, ABN-3 and ABN-4 possess clay polished ped faces with base saturation of 50% by NH_40AC in at least some part of the B-horizons and lacking a mollic A horizon were classified as Luvisols. At the lower category they were classified as Gleyic Luvisols. Profiles APP-5 and APP-6 with base saturation less than 50% by NH_4 OAc in some part of the B-horizon and lacking a mollic A- horizon were classified as Alisols. At the lower category since they show hydromorphic properties and lack plinthite within 125cm of the surface, they were classified as Gleyic Alisols.

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