

THE CHARACTERIZATION, CLASSIFICATION, AND EVALUATION OF ACID SOILS ON UPPER COASTAL PLAINS OF LAGOS STATE, NIGERIA.

Temitope A. Okusami

*Department of Soil Science
Obafemi Awolowo University
Ile-Ife, Osun, State, NIGERIA.*

Abstract

The global drive for the identification of criteria for sustainable land management evaluation has stemmed from the desire to manage appropriately and conserve the soil resources especially those of marginal lands. The objectives of the study were to characterize and classify the soils and to identify relevant land characteristics for sustainable land management evaluation for upland rice cultivation. The soils were classified at the series level using the existing local system of soil classification and these series include, Oteyyi, Alagba, Ibeshe, Asaba, Ugbolu, Owode, Agege, Iju, Ipaja, Atan and Mesan. Physiography and elevation have strong relationships to soil types of the Tertiary sediments. Crestal positions are almost level and possibly indicative of past erosional surfaces and/or static groundwater positions. Soils are mostly sandy clay/sandy clay loam, very strongly acid (pH 5-5.0) with low cation exchange capacity. Exchangeable Al constitute >50% of the exchangeable cations in most subsoil horizons. Surface soils on upper slope positions are considered droughty (sandy) but the subsoils are medium/fine textured. Typic Kandiusults and Typic Kanhaplusts dominate the upperslope and middleslope positions of the landscapes. Those of the lower slope positions mostly belong to the Tropic Fluvaquents and Humaqueptic Psammaquents. Selected criteria for land evaluation for sustainable upland rice management include soil texture, soil solum (as determined either by depth to compacted subsoil horizons (including concretionary/petroplinthites) or gravelly soil materials), slope and its length. Land suitability classes identified range from S1 (one series) through S2 (five series) to S3 (four series), and one in N1 class.

INTRODUCTION

Soil degradational processes are the most limiting factors to sustainable land use in the humid/subhumid tropics. These have become issues of scientific meetings at both local and international levels (e.g. IBSRAM, 1991). Sustainable land management requires basic understanding of the resources to be managed. Detailed basic/base line data on soils of

the humid tropics and their properties are mostly still lacking for adaptable package of land management technologies. It has also been stated that there is an urgent need to develop minimum data set towards the definition of soil quality in the context of sustainable land management (IBSRAM, 1991, p.14). This will involve the identification of relevant land/soil factors towards sustainable land use, initially at qualitative level and later to be verified quantitatively.

The Atlantic coastal land of Nigeria consists of an upper and lower plain land systems. The landforms encompassed in the coastal plain, as observed in Lagos State of Nigeria, typify the possible physiographic situations along the southern coast of Nigeria (Lekwa and Whiteside, 1986; Okusami, 1988, 1989). The parent material of both plains basically belong to different ages. Equally different are the lithology of their respective parent materials. Some of the soils of the upper coastal plain have been found to be very variable (Lekwa and Whiteside, 1986; Moss, 1957; Ojanuga *et al.* 1981 and Okusami *et al.*, 1985) and belong mostly to the Cretaceous and Tertiary (Moss, 1957). Lekwa and Whiteside (1986) showed that soils of coastal plain land of southeastern Nigeria are mostly Tertiary, loamy (mostly) and sandy with very strong to strong acidity and a dominating kaolinitic clay mineralogy. Okusami *et al.* (1985) worked on an identical landform located in southwest Nigeria and found an equally strongly acid soil but with contrasting mineralogy between adjacent soils formed in different parent materials, viz. shale and sandstone. Soils formed in shale have mixed clay mineralogy of kaolinite and smectite whereas those formed in sandstone are kaolinitic. All soils except that formed in shale have very low cation exchange capacity.

Barker and Herdt (1979) defined upland rice culture as unbunded rice that is grown on flat land or terraces and slopes without impounding standing water in the field. Although upland rice cultivation is popular mostly within the rural populace of some areas of southwest and southeast Nigeria, evaluating upland rice is evaluating or deducing relevant sustainable land management evaluation parameters for other upland crops that typically feature in the cropping systems which normally offer fragile and degradable micro-environment to the terrain on which they are cultivated. Such land utilization types include maize (*Zea mays*), yam (*Dioscorea sp.*) and cassava (*Manihot esculenta*) amongst other crops that have similar soil requirements as upland rice except that the latter would tolerate a fine-textured soil (ILACO, 1981).

A review of land requirements for upland rice cultivation in West Africa by Moormann (1979) indicates some minimum requirements for upland rice cultivation/management viz: (1) that a total rainfall of less than 1300 mm in a bimodal regime is too low and therefore that dry cultivation of rice will be suitable only for areas with more than 1500mm rainfall (Collonna, 1967) which should be well distributed with a minimum of 600mm rainfall during its growing cycle spread out at an average of 5mm/day (Cocheme, 1971); this contention has also been supported by an observation made at Ibadan in Nigeria (Abifarin *et al.* 1972) where a regular strong depressive effect on yield by drought spells was observed under a bimodal rainfall regime with an average annual rainfall of 1200mm; (2) that soil water availability which is a function of the position on the landscape and water retention characteristics of the soils should not be limiting. Soils on lower slope positions will be at an

advantage because they will receive interflow and surface flow water in addition to the rainfall water; but most upland tropical soils are kaolinitic and therefore will have low water retention characteristics. Moormann also concluded in his review that textural profile (Higgins, 1964) and structure (Seguy *et al.* 1970; Charreau and Nicou, 1970) directly or indirectly do influence available soil water to rice plant. A poorly developed subsurface structure is desirable for moisture retention while improved surface tilth as characterized by a lower bulk density will in addition to favourable water retention cause better development of rice roots (Seguy *et al.*, 1970).

Some other works have also given illuminating practices on soil management requirements for upland rice cultivation. Kang and Juo (1984) found a no-effect on upland rice yield when lime was applied at the rate of 1 ton of CaCO₃ equivalent per hectare but instead observed an increased N leaching. These authors also observed significant changes in soil properties (at 0-15cm) of kaolinitic Alfisol after 4 years of continuous upland rice cultivation - the soil became acid (or more acid) with consequent drop in exchangeable bases and increases in exchange acidity. A significant drop in effective cation exchange capacity and an increase in bulk density were equally observed. West African Rice Development Authority (WARDA, 1984) reported a reduction of 0.5-0.8% organic carbon content in surface soils after 1-2 years cultivation of cleared bush fallowlands.

Forest and Kalms (1984) considered the level of organic matter, soil texture at 60cm depth, and the presence or absence of gravel as the judging factors for the suitability of well-drained soils for upland rice production. These are similar to given land requirements by Sys (1985, see Table 1 of this paper). All these have shown that upland rice cultivation would be an exerting cropping system on most upland soils of the humid tropics.

The objectives of this paper therefore were to characterise and classify the soils formed in upper coastal plain landforms of Nigeria as represented in Lagos State. And to evaluate the soils and deduce soil/land criteria for sustainable upland rice management evaluation.

STUDY AREA

The study area is located on the upper coastal plain lands of southwest Nigeria and its southern boundary is about 1/4 km north of the Lagos Lagoon (Fig. 1). The upper coastal plains are those sedimentary deposits that have been described by Moss (1957) as belonging to various ages of the Cretaceous, Eocene and Post-Eocene. They are bounded in the southern part by the lower coastal plain sand separated in some instances by the Lagoon/Creeks and in the north by those landforms developed on the basement complex materials.

Climate is humid tropical with a bimodal rainfall pattern (Nigeria Meteorological Services, 1976) with peaks in June and September. The study area has an average annual rainfall of about 1800mm and an annual average air temperature of 27°C. Parent rock is basically sandstone with bands of slightly ferruginised clay outcropping occasionally (Table 2).

The landscape has a moderate relief and is moderately rolling. It consists of the crest, shoulder, middleslope, valley-fringe and valleybottom physiographic units. There are three surfaces that constitute the crest. These are at 45m, 30m and 15m elevations. They are plateau-like with that at 15m dominating. The shoulder is sloping but short (Figure 2 shows the variabilities in landscape geometry in the area of study). The valleybottoms contain

original rainforest vegetation possibly preserved because of its swampy nature. Most of the valleybottoms contain mangroves and those of the uplands contain a mixture of mature secondary forest and cultivated crops.

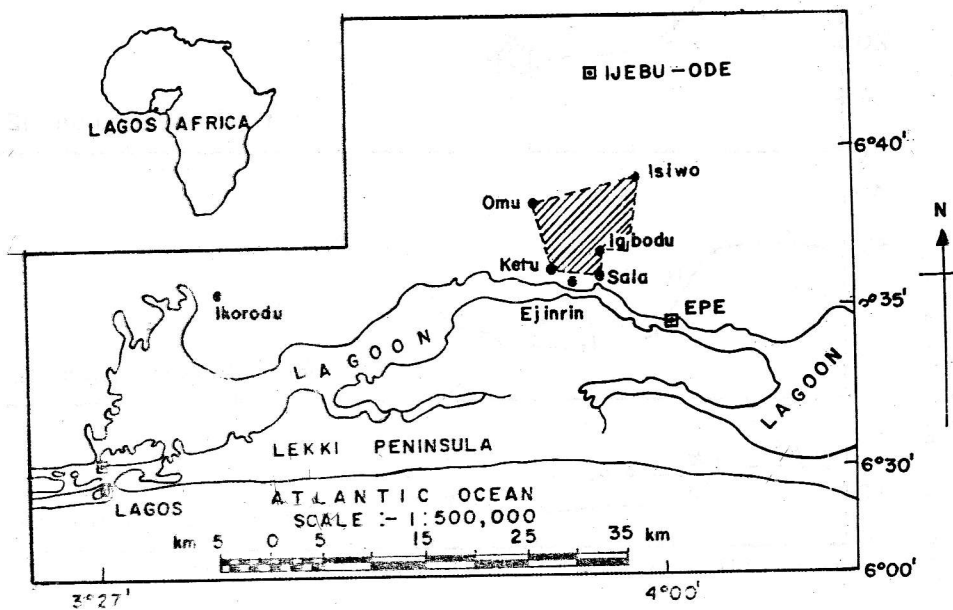


Fig. 1: LOCATION OF STUDY SITE

MATERIALS AND METHODS

Soil samples collected during a detailed soil survey investigation (Okusami *et al.*, 1988) were air-dried, pulverized and passed through 2mm sieve utilising those that are less than 2mm for laboratory analysis. Soil-landscape spatial relationships were established on the field through transecting and measurement of pedon positions. Particle size analysis was according to Day's (1953) method. Soil pH determination was at a ratio of 1:1 in distilled water. Exchangeable cations (i.e. Ca, Mg, Na and K) were extracted in 1M NH_4OAc at pH 7. Sodium and K were determined with a flame photometer while Ca and Mg were analysed on the atomic absorption spectrophotometer (Perkin Elmer 403). Exchange acidity was determined in 1M KCl (Mclean, 1965) and effective cation exchange capacity (ECEC) is

a summation of exchangeable bases (Ca, Mg, K and Na) and exchangeable acidity. Organic carbon was determined by Walkley-Black Method and available P by Bray P₁ method (Bray and Kurtz, 1945). Bulk density of whole soil was by the core method (Blake, 1965). The soils identified were classified according to Moss (1957) at the series level and to FAO-Unesco legend (1988) and Soil Taxonomy (Soil Survey Staff, 1992) at the higher categories level. Soils were evaluated for upland rice cultivation using Okusami (1991, as in Table 1 adapted from Sys 1985). Suffices or the land classes do indicate the most limiting factor(s) (maximum of two) as is designated in the FAO (1983) system.

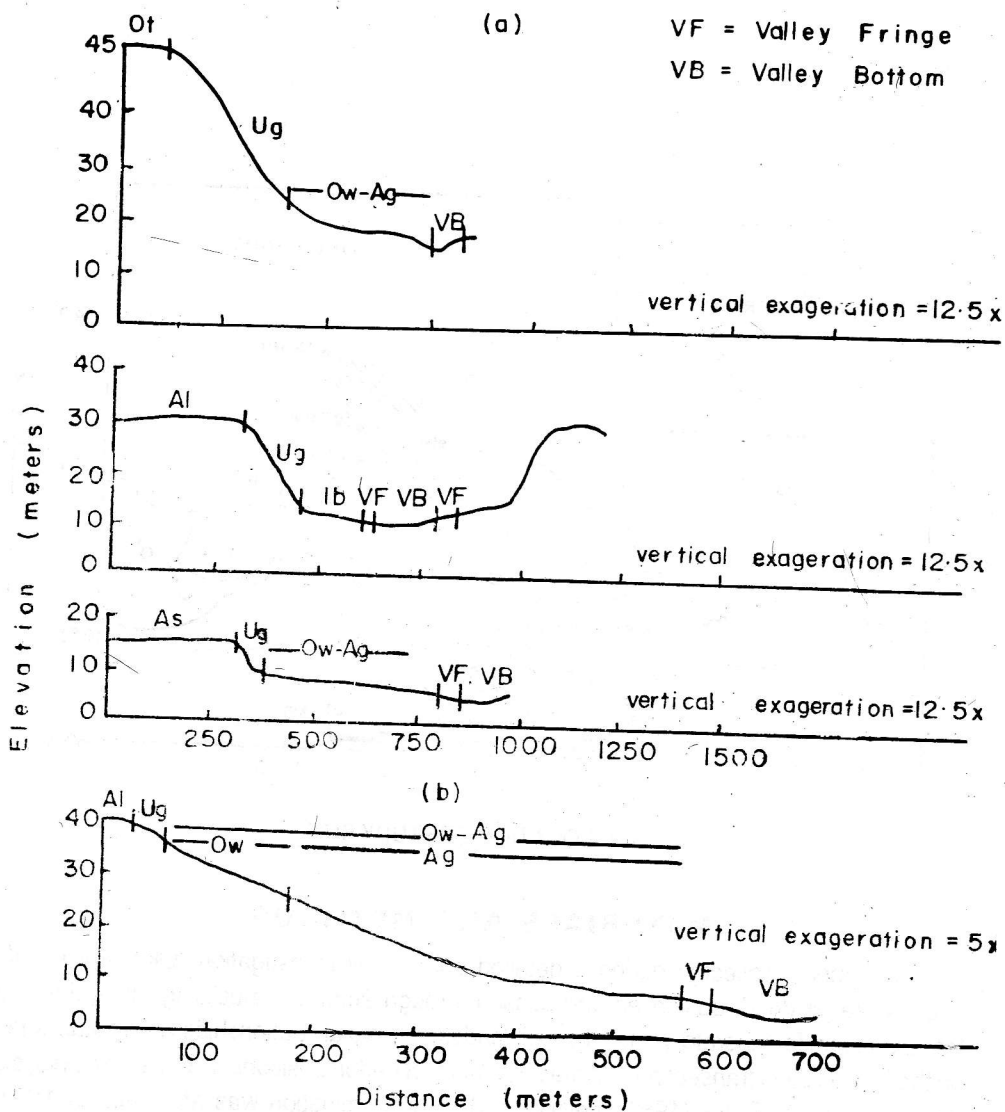


Fig. 2: Cross sections; (a) showing landscapes drawn from toposheets, and (b) shows a measured (approximate) transect with associated mapping units.

TABLE 1: Land requirements/classes for rainfed upland rice.

Land Characteristics	Land classes**				
	S1	S2	S3	N1	N2
TOPOGRAPHY (t)					
% Slope	<8	<16	<30	<30	<30
WETNESS (w)					
W/1 Flooding	no	no	no to slight	no to slight	no to slight
W/2 Drainage	good	moderate or better	imperfect or better	poor or better	poor or better
a. Fine Loamy or clayey families	imperfect	imperfect or moderate	good, moderate	poor or better	poor or better
b. Coarse Loamy or sandy families					
PHYSICAL SOIL CHARACTERISTICS (s)					
S/1 Surface					
a. Texture/Structure*	/ank; l/gr	fc/ank fls/gr	fc/ank; s/sg	fc/ank; s/sg	corcs./m
b. Coarse fragments (vol %)	<15	<35	<55	<55	<55
S/2 Subsurface					
a. texture/structure*	fc/ank: fls/gr	cor sc/ank	cor sc/ank	c, or sc/ank	c/m; s/sg
b. coarse fragments (vol. %)	<35	<55	<55	<55	<55
S/3 Solum depth or depth to impermeable layers (cm)	>90	>50	>20	>20	>20
FERTILITY LIMITATION (f)					
f/1 ECEC meq/100g clay***	>12	>6	>1.5		
f/2 Base saturation (%; 0 - 15cm)	>90	>80	>70		
f/3 organic carbon (%; 0 - 15cm)	>1.5	>0.8	<>0.8		

* c = clay, s = sand, l = loam; ank = angular blocky, gr = granular, sg = single grain, m = massive; f = fine

** S1, S2 and S3 = highly, moderately and marginally suitable respectively.

N1 = actually unsuitable but potentially suitable.

N2 = actually and potentially unsuitable

*** based on limits used in soil classifications

Table 2: Site information on described and sampled Pedons on the Upper Coastal plains in Lagos State.

Pedon Soil Type	Physiography	Drainage	Vegetation/Land Use	Parent Material
1. Oleyyi Series (O1)	Crest, (Plateau-like summit) 2%	Well-drained	Cassava/Bush regrowth	Sandstone
2. Alagba Series (Al)	Crest (Plateau-like), 2%	Well-drained	Mature Forest / Cassava farm	Sandstone
3. Asaba Series (As)	Crest (Plateau-like summit) 3.5%	Well-drained	Bush regrowth, Eupatorium sp.	Ferruginised sand stone
4. Ugbolu Series (Ug)	Shoulder, Lower Crestal, 2-3.5%	Well-drained	Secondary Forest, Bamboo stands	Loose sandstone
5. Owode Series (Ow)	Upper middle slope, 7%	Well-drained	Cassava and chromolaena sp	Colluvial/in situ from sandstone.
6. Agege Series (Ag)	Upper middle slope, 7%	Well-drained	Bush regrowth	Sandstone
7. Ibeshe Series (Ib)	Lower middle slope, 7%	Well-drained	Secondary Forest/Followed tree crop farm	Loose sandstone
8. Iju Series (Ij)	Valley fringe, 7%	Moderately Well-drained	Mature Secondary forest	Sandstone
9. Ipaja Series (Ip)	(Lower) middle slope/fringe, 7-9%	Moderately Well-drained	Bush regrowth/maize plot.	Sandstone.
10. Atan Series (At)	Valley bottom (upper), 9-10.5%	Somewhat poorly drained, water-table at 100 cm	Mature Secondary Forest	Colluvial/in-situ sandstone derived
11. Mesan Series (Me)	Valley bottom (terrace), 2%	Poorly drained, water table at 90cm	Woodland Forested	Colluvial/alluvial, sandstone derived.
12. Idesan series (Id)	Valley bottom	Poorly drained/swampy water table at 60 cm	Mature Secondary forest	Mostly colluvial
13. Oji Series (Oj)	Valley bottom	Poorly drained / swampy, water table at 30cm.	Mangrove	Colluvial/in situ.

RESULTS AND DISCUSSION

Soil Characterization

Soil-Physiography relationships:

There is a strong relationship between physiography, elevation and soil types (Fig. 2). Table 3 summarises profile description of the different pedons. The three crestal positions earlier identified contain Oteyyi, Alagba and Asaba series respectively. The shoulder positions have Ugbolu series and Alagba series, sloping phase (Als). Oyero series is an inclusion of Ugbolu series. Alagba series, sloping phase has identical soil morphology as Alagba series, (Table 3) but with a shallow colluvial surface soil horizons and may be below soil with ironpan (sometimes outcropping). With the exception of Alagba series and its sloping phase, all the above soils have ironstone concretions and/or ironpan rubbles in their soil profiles and are mottled (Table 3). This is particularly noticeable on lands occupied by Asaba series. Asaba series may be representative of an African erosional surface with its plain/ferruginised surface. Other soils on other crestal positions (see Fig. 2) may also be representing other (earlier) erosional surfaces and even previous groundwater tables of recent ages.

Owode, Agege and/or Ibeshe always occupy the middle-slope positions irrespective of the soils that occupy the summit of the landscape. Owode and Agege series will normally occur as a complex (Ow-Ag) because even at detailed/semi-detailed mapping level it was impossible to cartographically delineate Owode series from Agege series (Okusami *et al.* 1988). Both have mottled and concretionary subsoil horizons (Table 3) but the depth of the mottled subsoil horizons distinguish one from the other (Moss. 1957). The mottled horizons occur at greater depth in Owode series than observed in Agege series. In addition, Owode series occupied the narrow topmost section of the middleslope (Fig. 2). Ibeshe series uniquely has no mottled soil horizon to inspected depth of 2m but occurs on a shorter middleslope (Fig. 2). Usually, the middleslope constitutes the longest physiographic unit of the landscape and contain the greatest percentage of the well-drained and cultivatable soils (Okusami *et al.*, 1988).

Table 3:- Soil Morphology of some Pedons on the Upper Coastal Plain in Lagos State.

Horizon	Depth (cm)	Colour (moist)		Mottle	Texture	Structure	Consistence	Inclusions	Roots	Boundary Others	
		Matrix	Colour (moist)							Others	Others
Oyeji Series											
A ₀	0-10	10YR 3/2		-	sligr-ls	ma	wrs	Fe-g	cm vif	cs	vfe cn
B ₁	10-34	10YR 4/4		-	gr-sl	ma	wsls	Fe-g	fe f, cm m	gs	cm m pores, vfe cn
B ₂	34-50	10YR 3/6		-	gr-sc	ma	wsls	Fe-g	fe m	gs	cm m pores
B ₃	50-78	5YR 4/6		-	cm d 5YR 5/8	sc	ma	wsls	-	fe m	ds cm m pores
C ₁	78-105	10YR 6/8		-	2.5YR 4/8	ma	wsls	Fe-g	vfe f	csllw	fe fe-min cn
C _{2c}	105-140+	-		-	2.5YR 4/8	ma	wsls	Fe-g	-	-	f re Fe-g (5YR 3/3)
					10YR 6/8						rounded
					5YR 5/8						
Alagba Series											
A	0-5	10YR 3/4		-	sl	2 fm g	m vfr	-	fre f m fe co cs	cs	-
A ₂	5-14	5YR 3/4		-	sl	1 f sbk	m vfr	-	cm f m co ds	ds	-
B ₁	14-30	5YR 3/4		-	scl	2 f sbk	m vfr	-	fe m co gw	gw	cm pores
B ₂	30-50	2.5YR 4/4		-	sc	2 fm sbk	mfi	-	fe f m	cl	-
B ₁	50-101	2.5YR 4/8		-	sc	3 fm sbk	mfi	-	fe f	ds	pores
B ₂	101-135	2.5YR 4/8		-	c	3 co sbk	mfi	-	vfe fm	ds	some pores
B ₃	135-180	2.5YR 4/8		-	c	3 co sbk	m vfi	-	vfe f	-	pores
Asaba Series											
A _c	0-7	10YR 3/3		-	vgr-sl	ma	ml	Fe-g	vfe, vf	cs	angular cn
B _{1c}	7-21	10YR 4/4		-	vgr-scl	ma	ml	Fe-g	cm m, fe f	ds	angular cn
B _{2c}	21-55	5YR 3/4		-	gr-sc	ma	ml	Fe-g	cm m f	gs	fe angular cn
B _{3c}	55-95	5YR 5/8		-	gr-sc	ma	mfr	Fe-g	fe m f	as	fre angular cn
C _c	95+	10YR 6/8		-	-	ma	cem	Fe-g	-	-	cr-2.5YR 3/2, 2.5YR 3/6
Ugbolu Series											
A ₁	0-10	10YR 3/3		-	sl	3 m g	m vfr	-	ab f m	as	-
A ₂	10-21	10YR 3/6		-	scl	2 m sbk	m vfr	-	vfe f co	ds	-
A ₃	21-31	10YR 3/6		-	scl	2 f m sbk	m fi	-	fre f m, fe co gs	ds	f, m pores; occa cn
B ₁	31-60	7.5YR 4/4		-	scl	2 m sbk	m fi	-	cm m co	ds	hor co roots; f m pores; occa
B ₂	60-91	7.5YR 4/6		-	scl	3 f sbk	m vfi	-	fe f co	cv	hor co roots
C ₁	91-144	7.5YR 5/8		-	cm 2d 2.5YR 3/6						
					2.5YR 3/6						
					2.5YR 4/8						
					10YR 6/8						
C ₂	144-180	-		-	sl	ma	m vfi	-	vfe f	ds	-
					sl	ma	m vfi	-	vfe f	-	-

Horizon	Depth (cm)	Colour (moist) Matrix	Mottle	Texture	Structure	Consistence	Inclusions	Roots	Boundary Others
Owode Series									
Ap	0-7	10YR 3/3	-	sl	2 m co g	m vfr	-	ab f, fe m co cs	-
Bt1	7-30	10YR 4/6	-	sc	2 m co g	m vfr	-	cm f, fe m co	ds cm pores
Bt2	30-46	7.5YR 5/6	-	sc	3 m co sbk	m fi	Fe-g	fe f, m co	cm pores; clay skins in pores/roots; vfe ang.
Bt3	46-87	5YR 5/8	-	sc	2 m co sbk	m fi	Fe-g	vfe f	cm pores, patchy clay skins
ZBc	87-115	5YR 5/8	-	gr-sc	ma	m	Fe-g	vfe f	vfe ang. cn.
ZC	115-130	5YR 5/6	2.5YR 5/8 10YR 6/8	sl	ma	m vfi	-	vfe f	fre ang. cn.
Agege Series									
Ap	0-4	10YR 4/3	-	sl	2mg	m vfr	-	cm f	-
A2	4-18	10YR 3/3	-	sl	2 msbk	m vfr	-	cm f m co	many pores
Bt1	18-38	10YR 3/6	-	sc	3 co sbk	m vfr	Fe-g	cm m	cm pores, vfe ang. cn.
Bt2	38-63	10YR 4/6	-	sc	3 m co sbk	m fi	Fe-g	fe m	cm pores, vfe ang. cn.
Bt	63-79	7.5YR 5/6	cmfp 10R 4/8	sc	3 m co sbk	m fi	Fe-g	fe m	vfe ang. cn.
Bc	79-97	7.5YR 5/6	m2p 10R 4/8 m2b 10YR 6/8	sc	ma	m fi	Fe-g	fe f	vfe ang. cn.
C1	97-132	7.5YR 5/6	m3p 10R 4/8	slig-sc	ma	mvfr	Fe-g	fe f	vfe ang. cn.
C2	132-160	10YR 5/6	m3p 10YR 7/8 10R 4/8 10YR 8/4	slig-sc	ma	mvfi	-	vfe f	-
Ibeshe Series									
A1	0-5	10YR 3/3	-	sl	3fg	mfr	wd-c	abf	fre earthworm casts on surface
A2	5-21	10YR 3/4	-	sl	2 mg	mfr	wd-c	vfe f m co	cm m pores
Bt1	21-58	7.5YR 4/6	-	sc	2 fm sbk	mvfr	wd-c	cm fm co	cm m pores
Bt2	58-81	7.5YR 4/6	-	sc	2 fm sbk	m fi	wd-c	fe f m co	cm m pores
Bt3	81-126	7.5YR 5.6	-	sc	1 fm sbk	mfr	-	fe f m	thin cutans, cm m pores
C	126-180	5YR 5/8	-	sc	2 m agb	mfr	-	fe f m	cm f pores.

Hori- zon	Depth (cm)	Colour (moist)		Mottle	Texture	Structure	Consistence	Inclusions	Roots	Boundary	Others
		Matrix	Moist								
Ipaia Series											
A	0-5	10YR 3/3	-	-	l	2 fg	m vfr	-	ab v f, cm mas	-	-
A2	5-13	10YR 3/3	-	-	sl	1 f sbk	m vfr	-	cm f m co cs	-	-
BA1	13-27	10YR 3/3	-	-	scl	1 f sbk	m vfr	-	cm f m co gs	-	-
BA2	27-49	10YR 5/3	-	-	scl	2 m sbk	m vfr	-	cm f m cs	-	-
B1	49-68	10YR 5/4	-	-	sc	3 m co sbk	m fr	-	fe m ds	-	-
B2	68-135	2.5YR 6/4	-	-	sc	3 m co sbk	m fr	-	vfe f m ds	-	-
B3	135-148	2.5Y 6/4	-	-	sc	3 m co	m vfi	-	vfe m ds	-	-
C1	148-159	2.5Y 6/4	cm 3 d 10YR 5/8	-	c	c	ma	m vfi	vfe f	as	-
C2	159-180	2.5Y 7/2	cm 3 d 10YR 5/6	-	c	c	ma	m vfi	vfe f	-	-
Ipaia Series											
Ap	0-21	10YR 3/2	-	-	sl	1 m co cr	m vfr	-	fre f m cs	-	fre f m pores
B1	21-48	10YR 5/4	-	-	sc	2 m co agb	mfi	Wd-c	nd d sli w	-	frequent charcoal
B2	48-74	10YR 5/4	-	-	sc	1 co agb	mfi	-	cm f	cs	cutans (clay + organic matter) on ped (10YR 4/3).
28C											
	74-120	7.5YR 5/6	-	-	sc	1 m co agb	mfi	fe m pores	vfe f	ds	Patchy cutans, cm m pores.
2C1											
	120-170	5YR 5/8	-	-	cosc	1 co agb	mfr, wsls	-	vfe vf	gs	cm m Pores, organic-
2C2											
	170-200	5YR 5/8	faint	-	cosc	nd	wsls	-	vfe f	-	-
Atam Series											
A1	0-5	10YR 3/2	-	-	sl	1 f m g	mfr	-	ab vf	cs	-
A2	5-18	10YR 5/3	-	-	sl	1 m sbk	mfi	-	fre mco	ds	-
B1	18-32	10YR 6/4	-	-	scl	2 m co sbk	mfi	-	cm m	gs	-
B2g	32-45	10YR 6/2	cm 1 d 10YR 5/8	-	sc	ls	ma	wsls	-	fe f m	-
2C	45-64	10YR 6/2	fe 1 d 10YR 5/6	-	c	ma	ws	-	fe m	ds	-
2C2	64-80	10YR 6/1	faint	-	c	ma	ws	-	vfe f	cw	-
3Ac	80-100	10YR 3/2	-	-	sl	ma	wsls	-	vfe f	cw	decayed roots
3C	100+	5YR 7/1	fe 2 d 10YR 7/4	ls	sl	ma	wsls	-	vfe f	cw	-

Horizon	Depth (cm)	Colour (moist)		Mottles	Texture	Structure	Consistence	Inclusions	Roots	Boundary	Others
		Matrix	Mottles								
Meson Series											
A1	0-6	10YR 3/3	-		k/s	sg	ml	-	-	-	ds
A2	6-12	10YR 3/3	-		k/s	sg	ml	-	-	-	ds
A3	12-35	10YR 4/3	-		s/s	sg	ml	-	-	-	ds
A4	35-65	10YR 4/3	-		k	sg	ml	-	-	-	nd
C1	65-90	10YR 6/4	-		s	sg	ml	-	-	-	nd
C2	90+	10YR 7/1	cm3d	10YR 6/8	lls	nd	nd	nd	nd	-	nd

Abbreviation used are as follows:

(Not mutually exclusive to individual soil property)

Mottles: cm= common, m= many, fe= few, l= fine, 2= medium, 3 = coarse d=distinct, p=prominent,
Texture: co=coarse, v=very: gt = gravelly, sli = slightly, s - sandy, c = clay, l = loam;
Structure: 1 = weak, 2 = moderate, 3 = strong, f = fine, m = medium, g = granular, cr = crumb, agb = angular blocky,
 ma = massive, sg = single grain; sbk = subangular blocky;
Consistence: m = moist, d = dry, w = wet, fri = friable, fi = firm, l = loose, so = soft, s = sticky, ns = non-sticky;
Inclusion: Fe = iron, g = gravel; Wd-c = wood charcoal'
Roots: fre = frequent, ab = abundant;
Boundary: g = gradual, c = clear, d = diffuse, a = abrupt, s = smooth, i = irregular, w = wavy;
Others: cn = concretion, occa = occasional, ang = angular, nd = not determined; - = absent

Alagba series and its sloping phase and Ibeshe series, although occupy different physiographic positions (Table 2, Fig. 2), yet they are not mottled. Alagba series is red (Rhodic) and ustic whereas Ibeshe series (in some instances) was observed to have remained moister for longer period during the dry season and will therefore come under udic soil moisture regime. It is therefore probable that lack of mottles at inspected depth is an indication that these soils did not develop under a fluctuating (or shallower) groundwater table compared to Owode, Agege and even Oteyyi series. Asaba series possibly represent the last upper limit of the groundwater table before it dropped to its present level (present position of the lagoon).

Soils that occupy the valley fringe position are represented by Iju and Ipaja series (Tables 2, 3 and fig. 2). They have different soil textures but are commonly moderately well-drained with mottles at lower depths of their pedons. They have no concretions or nodules. The presence of charcoal fragments at greater depth suggest colluvial origin. Soils that occupy the valley bottom position are characterised by relatively high groundwater table at all seasons. They become flooded or saturated to the surface during the rainy season. This physiographic position is occupied by Atan, Mesan, Idesan and Oji series (Table 2) and they constitute almost fifty percent of soil types found on the watershed (4000ha land area) (Okusami, et al. 1988). Typically, these soils have deep humic surface horizons and subsoils with low chromas and high values (see Table 3). At shallower depth, mottling is readily observed in those soils that occupy the periphery of the valley bottom (e.g. Atan series) in contrast to those on the valley fringe (Iju and Ipaja series) because the latter lack groundwater at a minimum depth of 2m whereas water table was readily observed at about 100cm depth in Atan series (Table 2). Water table could also be shallower as observed in Idesan and Oji series (Table 2). High groundwater therefore prevented detailed morphology descriptions of Idesan and Oji series considered to be typical valley bottom soils. However, deeper horizons were sampled with augers.

Physical and chemical properties

Table 4 contains data for sampled pedons. There is no specific pattern in soil texture along landscapes. Profiles are dominantly loamy irrespective of physiographic position. The bulk density increases with depth. This can possibly be attributed to higher organic carbon content of the surface horizons. Organic carbon distribution follows the typical pattern observed in upland soils of Nigeria. There is a decrease with depth except in profiles with strong textural changes with depth (as is convincingly shown in Asaba and Atan series). Soil horizons are mostly very strongly acid (pH5.1-pH5.5). Exchangeable Al occupies almost fifty percent of the exchange sites especially in the subsoil horizons of most of the pedons. Pedons demonstrate a very low ECEC with an equally low base status (see Juo et al., (1976) for equivalence in methodologies).

Table 4: Physical and chemical properties of pedons on the upper coastal plain in Lagos State.

Horizon Depth (cm)	Sand	Silt	Clay	Textural Class (USDA)	pH _{H₂O}	Ca	Mg	Na	K	Al	H	ECEC meq/100g soil	ECEC meq/100g Clay	Base Satn. %	Org. C %	Avail. P ppm
Oteyvi Series																
Ap 0-10	53	29	18	sl*	1.00	3.90	2.20	0.16	0.32	0.35	0.00	6.93	38.50	95.0	3.55	42.00
BA 10-34	57	2	4	sc	1.48	4.80	2.10	0.27	0.19	0.90	0.70	5.16	12.59	69.0	1.52	10.50
Bt 34-50	49	2	49	sc	1.60	4.75	0.36	0.11	0.13	1.35	0.80	2.80	5.71	23.2	1.09	9.00
BC 50-78	53	3	44	sc	1.62	4.80	0.20	0.05	0.14	0.70	0.00	1.21	2.75	42.1	1.67	8.25
Cl 78-105	55	2	43	sc	1.56	4.70	0.20	0.05	0.13	1.00	0.70	2.18	5.07	22.0	1.21	16.50
C2c 105-140+53	53	2	45	sc	nd*	4.75	0.30	0.06	0.23	0.80	0.50	2.02	4.49	35.6	1.25	15.75
Alagba Series																
A 0-5	80	2	18	sl	1.08	4.50	1.50	0.78	0.25	1.50	0.40	4.65	25.83	59.1	3.01	31.50
A2 5-14	76	4	20	scd	1.58	4.40	0.30	0.20	0.21	1.50	0.50	2.87	14.35	30.3	1.76	20.25
BA1 14-30	70	4	26	scd	1.55	4.50	0.20	0.17	0.23	1.70	0.70	3.14	12.08	23.6	1.44	18.00
BA2 30-50	66	4	30	scd	1.49	4.60	0.17	0.11	0.27	1.80	0.70	3.18	10.60	21.4	0.90	19.50
Bt1 50-101	66	2	32	scd	1.43	4.90	0.13	0.07	0.21	1.40	0.70	2.65	8.28	20.8	0.56	27.00
Bt2 101-135	64	2	34	scd	1.50	5.00	0.30	0.12	0.43	1.00	0.40	2.41	7.09	41.9	1.91	14.25
Bt3 135-180	64	3	33	scd	nd	4.80	0.20	0.08	0.23	0.9	0.30	1.84	5.57	34.8	0.39	12.00
nd 180-200	64	4	32	scd	nd	5.20	nd	nd	nd	0.8	0.20	nd	nd	nd	0.35	12.00
Asaba Series																
Ac 0-7	57	12	31	scd	nd	5.50	0.40	0.20	0.17	0.03	0.10	1.40	4.52	57.1	1.05	24.00
BAc 7-21	54	3	43	sc	nd	5.10	0.13	0.46	0.19	1.00	0.90	2.78	6.47	31.7	0.39	15.75
Bc1 21-55	47	1	52	sc	nd	5.00	0.27	0.50	0.32	1.30	1.10	3.66	7.04	33.9	0.16	18.00
Bc2 55-95	53	1	46	sc	nd	5.15	0.63	0.43	0.24	1.20	0.90	3.55	7.72	40.8	3.86	44.25
Cc 95+	71	1	27	scd	nd	5.25	0.56	0.35	0.22	1.10	0.80	3.67	13.59	48.2	1.95	24.00
Ugbolu Series																
A1 0-10	55	10	35	scd	1.01	4.50	2.23	1.63	0.30	0.25	0.20	4.91	14.03	90.8	3.04	23.9
A2 10-21	62	2	36	sc	1.24	4.35	0.39	0.30	0.23	0.16	0.40	2.13	5.92	50.7	1.50	27.1
A3 21-31	59	2	39	sc	1.56	4.30	0.19	0.13	0.20	0.13	0.35	1.75	4.49	37.1	1.07	20.3

Horizon Depth (cm)	Sand %	Silt %	Clay %	Textural Bb Class (USDA)	P ₂ O ₅ gm/c	Ca	Mg	Na	K	AI	H	ECEC meq/100g Clay	Base Satn. %	Org. C %	Avail. P ppm
B1 31-60	50	2	48	sc	nd	0.22	0.08	0.23	0.14	0.90	0.20	1.77	37.9	0.47	15.5
B2 60-91	56	0	44	sc	4.35	0.40	0.12	0.33	0.19	0.60	0.40	2.04	51.0	0.35	11.6
C1 91-144	51	1	48	sc	4.40	0.24	0.07	0.23	0.13	0.50	0.30	1.47	45.6	0.12	10.8
C2 144-180	48	2	50	sc	4.40	0.23	0.07	0.33	0.13	0.40	0.30	1.46	29.2	0.12	79.7
Owode Series															
Ap 0-7	74	5	21	sd	5.60	2.70	1.40	0.33	0.25	0.70	0.20	5.58	83.9	3.39	13.50
B1 7-30	65	4	31	sd	4.80	0.30	0.24	0.11	0.16	1.50	0.30	2.61	31.0	1.28	1.28
B1 30-46	63	3	34	sd	5.00	0.15	0.17	0.11	0.13	0.70	0.10	1.36	41.2	0.86	0.86
B2 46-87	63	2	35	sd	4.30	0.18	0.17	0.43	0.37	1.60	0.70	3.45	33.3	0.47	0.47
2B03 87-115	62	2	36	sc	4.65	0.14	0.09	0.63	0.25	1.90	0.70	3.71	29.9	0.98	0.98
2C 115-130	65	1	34	sd	5.00	0.12	0.05	0.19	0.05	1.80	0.70	2.91	14.1	0.16	0.16
Agege Series															
Ap 0-4	56	7	37	sd	4.40	1.08	0.59	0.11	0.13	0.60	0.20	2.71	70.5	1.87	30.3
A2 4-18	56	7	37	sd	4.30	0.33	0.13	0.09	0.07	0.90	0.20	1.72	46.5	1.85	23.9
BA1 18-38	51	4	45	sc	4.10	0.25	0.13	0.22	0.05	1.00	0.30	1.95	33.3	0.86	22.3
BA2 38-63	47	3	50	sc	4.10	0.18	0.10	0.19	0.05	1.00	0.30	1.82	28.6	0.55	15.9
Bt 63-79	45	2	53	sc/c	4.30	0.18	0.09	0.17	0.05	0.80	0.20	1.49	32.9	0.51	13.5
BC 79-97	42	3	55	c	4.25	0.15	0.09	0.16	0.05	0.70	0.30	1.45	26.4	0.20	27.9
C1 97-132	46	2	52	sc	4.30	0.18	0.10	0.12	0.07	0.60	0.30	1.37	34.3	0.14	15.5
C2 132-160	41	1	58	c	4.40	1.14	0.63	0.11	0.13	0.60	0.20	2.81	48.4	0.10	11.6
Ibeshe Series															
A1 0-5	64	4	32	sd	5.60	2.79	2.71	0.42	0.18	0.20	0.00	5.30	96.2	3.40	6.00
A2 5-21	56	4	40	sc	5.80	0.77	0.64	0.12	0.07	0.50	0.40	2.50	62.5	1.37	4.50
B1 21-58	69	7	24	sd	4.90	0.19	0.18	0.11	0.05	0.55	0.30	1.39	38.1	0.39	22.50
B2 58-81	65	8	27	sd	5.00	0.20	0.16	0.33	0.05	0.30	0.10	1.59	42.2	0.55	0.75
B3 81-126	66	8	26	sd	4.80	0.22	0.09	0.22	0.05	0.40	0.20	1.18	45.4	0.08	10.50

Horizon Depth (cm)	Sand %	Silt %	Clay %	Textural Class (USDA)	Bb gm/cc	P _{H2O}	Ca	Mg meq/100 soil	Na	K	AI	H	ECEC meq/100g Clay	Base Satn. %	Org. C %	Avail. P ppm
C 126-180	80	8	12	sl	1.82	4.60	0.23	0.15	0.43	0.05	1.00	0.90	276	31.2	0.55	1.50
Iju Series																
A 0-5	80	2	18	sl	0.75	41.10	0.34	0.31	0.09	0.11	1.20	0.20	225	37.8	3.82	13.5
BA 5-13	76	4	20	sl	1.05	4.15	0.14	0.12	0.38	0.23	1.10	0.40	237	36.7	1.95	19.5
BA1 13-27	73	7	19	sl	1.85	4.55	0.15	0.10	0.10	0.07	1.00	0.30	172	24.4	1.28	22.5
BA2 27-49	76	5	19	sl	1.26	4.65	0.18	0.06	0.33	0.05	0.90	0.20	172	36.0	1.28	44.25
B1 49-68	74	7	19	sl	1.72	4.80	0.10	0.04	0.06	0.03	0.90	0.30	143	16.10	0.86	17.25
B2 68-135	76	5	19	sl	1.76	5.00	0.13	0.05	0.08	0.06	2.70	0.90	392	8.2	0.08	1.64
B3 135-148	76	5	19	sl	1.79	4.72	0.18	0.07	0.13	0.13	1.20	0.50	221	23.1	0.27	4.28
C1 148-159	76	6	18	sl	1.64	4.68	0.12	0.04	0.06	0.04	0.90	0.50	166	15.7	0.16	5.28
C2 159-180	78	3	19	sl	1.72	4.80	0.01	0.08	0.11	0.05	0.90	0.30	145	17.2	0.04	22.5
Ipaia Series																
Ap 0-21	68	9	23	scl	nd	4.65	0.77	0.47	0.10	0.13	0.75	0.55	277	53.1	2.73	33.0
B1 21-48	60	2	38	sc	nd	4.20	0.23	0.10	0.06	0.07	1.00	0.90	236	19.5	2.77	23.25
B2 48-74	56	6	38	sc	nd	4.35	0.23	0.10	0.21	0.10	0.85	0.60	209	30.6	0.59	10.50
2B1 74-120	65	2	33	scl	nd	4.30	0.45	0.20	0.11	0.06	0.70	0.40	192	42.7	0.39	22.50
2C1 120-170	64	4	32	scl	nd	4.55	0.23	0.09	0.11	0.07	0.70	0.50	170	29.4	0.23	11.25
2C2 170-200	67	4	29	scl	nd	4.55	0.22	0.08	0.09	0.05	0.80	0.60	184	23.9	1.09	43.50
Atran Series																
A1 0-5	74	10	16	sl	nc	5.15	0.58	0.50	0.14	0.06	0.75	0.70	273	47.3	3.43	6.00
A2 5-18	63	9	28	scl	nd	4.60	0.12	0.06	0.10	0.03	0.70	0.40	141	5.04	0.86	6.00
B1 18-32	71	3	26	scl	nd	4.60	0.44	0.20	0.13	0.19	0.35	0.30	161	59.6	0.82	1.50
B2g 32-45	69	5	26	scl	nd	5.80	0.10	0.04	0.05	0.07	1.00	0.70	196	13.3	0.51	9.75
2C1 45-64	71	5	24	scl	nd	4.80	0.35	0.17	0.10	0.07	0.70	0.40	179	38.5	0.66	8.25
2C2 64-80	76	7	17	sl	nd	5.30	0.19	0.09	0.10	0.06	0.80	0.60	184	10.82	0.86	13.50
3AcB 80-100	81	9	10	b	nd	4.90	0.18	0.07	0.06	0.05	0.35	0.00	0.71	50.7	2.97	4.50

Horizon	Depth (cm)	Sand %	Silt %	Clay %	Textural Class (USDA)	Bb	pH	Ca	Mg	Na	K	AI	H	EC/EC	EC/EC	Base Satn.	Org. C	Avail. P
meq/100 soil																		
Alam Series																		
3C	100+	61	8	31	scl	nd	4.65	nd	nd	nd	nd	0.60	0.40	nd	nd	nd	0.62	5.25
Mesam Series																		
A1	0-6	82	6	12	sl	nd	4.40	0.88	0.59	0.09	0.08	0.65	0.50	2.79	23.25	58.8	3.94	38.0
A2	6-12	82	5	13	sl	nd	4.00	0.34	0.19	0.42	0.06	0.65	0.50	2.16	16.62	46.8	0.51	6.75
A3	12-35	82	6	12	sl	nd	4.65	0.12	0.06	0.08	0.03	0.65	0.30	1.24	10.33	23.4	2.15	13.50
A4	35-65	81	9	10	ls	nd	5.00	0.12	0.05	0.10	0.10	0.65	0.30	1.32	13.20	28.0	0.94	6.75
C1	65-90	85	2	13	ls	nd	5.15	0.10	0.05	0.08	0.07	0.35	0.20	0.85	6.54	35.3	0.20	43.50
C2	90+	79	2	19	sl	nd	4.75	0.17	0.14	0.09	0.05	0.50	0.20	1.15	6.05	39.1	0.04	10.50
Idesam series																		
A1	0-15	62	11	27	scl	nd	3.75	0.42	0.35	0.19	0.13	2.00	1.00	4.09	15.15	26.7	5.85	6.00
A2	15-45	60	9	31	scl	nd	4.35	0.17	0.10	0.09	0.07	1.00	0.70	2.13	6.87	20.2	0.53	6.00
AC	45-70	59	9	32	scl	nd	4.45	0.13	0.07	0.06	0.05	0.35	0.30	0.96	3.00	32.3	0.74	18.00
Cg	70+	56	7	37	sc	nd	4.40	0.14	0.06	0.11	0.03	1.00	0.90	2.24	6.05	15.2	1.56	3.00
Oji Series																		
A1	0-5	64	11	25	scl	nd	4.20	0.32	0.29	0.25	0.25	2.70	0.90	4.71	18.84	23.6	6.40	29.5
A2	5-16	80	5	15	sl	nd	4.35	0.17	0.09	0.22	0.13	1.20	0.50	2.31	15.40	26.41	3.24	21.0
2CA	16-25	86	5	9	ls	nd	4.22	0.58	0.43	0.21	0.38	0.90	0.50	3.00	33.33	53.33	0.62	31.5
2C	25+	88	10	2	s	nd	4.90	0.12	0.09	0.63	0.13	0.50	0.30	1.77	88.50	54.80	0.08	30.0

* s = sand, c = clay, l = loam, nd = not determined.

SOIL CLASSIFICATION

Soil Taxonomy: Most of the upland soils (i.e., the well-drained to moderately well-drained pedons, Table 2) have evidence of clay/colloid movement and/or accumulation. The only exception here is Iju series, the pedon that occupies the valley fringe and is predominantly formed in a unilayered colluvial parent materials. All the pedons therefore have argillic or kandic horizons. However, the latter is dominant because of the presence of a relatively coarser-textured surface soil horizons over vertically (mostly morphological) continuous subsurface soil horizons; the low apparent ECECS ($<12\text{cmol}(+) \text{kg}^{-1}$ clay) within the B horizons; and fulfilment of the requirement of clay content increase with depth (soil survey staff, 1992) (see Tables 3 and 4). The requirement of a regular decrease in organic carbon content with increasing depth is only satisfied by Ugbolu, Agege and Ipaja series. Irregular decrease in organic-carbon content with increasing depth seems to be a characteristic of soils formed in coastal Cretaceous sediments as also shown in Okusami et al. (1997). However, the low ECEC and the assumed kaolinite clay mineralogy (Okusami et al., 1985, 1997) of soils formed in sandstone derived parent materials conclusively confirm the presence of kandic horizons in all subsoil horizons of all the upland pedons. All these pedons are Ultisols because of their low base saturation (Juo et al., 1976). They belong to the Ustults because of their dryness (droughtiness) during the dry season of 3-4 months which is made possible by the shallow (20-60cm) soil moisture control sections. Oteyyi, Alagba, Owode and Ipaja series belong to the great group Kandiustults because of the absence of lithic, paralithic or petroferric contact within 150cm of the mineral soil surface, the presence of a low ECEC that is less than $12 \text{cmol}(+) \text{kg}^{-1}$ clay in all the kandic horizons and absence of a clay decrease with increasing depth of $\geq 20\%$ from the maximum clay content.

Asaba, Ugbolu, Agege and Ibeshe series are all classified as Kanhaplustults principally because of the possibility of a petroferric contact within the subsoil horizons (as evident in Asaba series) and/or lack of peak of clay content within the pedons (as observed in Ugbolu and Agege series) and/or presence of a $>20\%$ decrease in clay content with depth (for instance in Ibeshe series). All the above pedons belong to the Typic subgroup (Table 5). Ibeshe may also be classified as Udults when it occurs on the lower middle slope position.

Table 5: Soil Classification and suitability ratings for studied pedons on upper coastal plains in Lagos State.

Soil Series	Soil Classification		Suitability Ratings for Upland Rice	
	Soil Taxonomy	FAO-UNESCO	Class	Sub-Class
Oteyyi	Typic Kandiuults	Haplic Ferralsols	S3	S3 s/3
Alagba	Typic Kandiuults	Rhodic Ferralsols	S1	
Asaba	Typic Kanhaplustults	Haplic Ferralsols	S3	S3 s/3
Ugbolu	Typic Kanhaplustults	Xanthic Ferralsols	S3	S3 ts/3
Owode	Typic Kandiuults	Xanthic Ferralsols	S2	S2 t
Agege	Typic Kanhaplustults	Xanthic Ferralsols	S2	S2 ts/3
Ibeshe	Typic Kanhaplustults	Xanthic Ferralsols	S2	S2 t
Ipaja	Typic Kandiuults	Xanthic Ferralsols	S2	S2 t
Iju	Typic Hapludox	Xanthic Ferralsols	S2	S2 t
Atan	Tropic Fluvaquents	Gleyic-Dystric Fluvisols	S3	S3 w/2
Mesan	Humaqueptic Psammaquents	Dystric Gleysols	N1	N1 w/1

Iju series fulfils most of the oxic horizon requirements. The oxic horizon is greater than 30cm with a particle size of sandy clay loam to sandy clay; Iju series has less than 4% (absolute) increase in clay content between the A horizon and A2 (or next) surface horizon. The subsoil horizons have ECEC that are predominantly <12 cmol(+) per kg clay. It is very possible that there will be no weatherable minerals in the sand size fraction in this soil formed in colluvial-derived parent materials (that are possibly multi-weathered, and multi-cycled). Its location on the landscape ensures that it has a udic soil moisture regime and so it is Udox at the sub-order level and Hapludox at the great group level for the lack of any peculiar morphological characteristic. It is a Typic Hapludox.

Atan and Mesan series are Entisols because of their location and continual addition of soil materials through surface and subsoil flows. Atan and Mesan series are both Aquepts. Atan series has a chroma of 2 with redox concentrations (10YR 5/6, Table 3) within the 32-45cm and 45-64cm horizons (Soil Survey Staff, 1994, page 131). Mesan series qualifies to be an Aquept because of the dominant colour of the uncoated sand grains. It is Psammaquents because it has a sandy particle size between 25cm and (presumably) the depth of 100cm. It is Humaqueptic Psammaquents due to the presence of a value, moist of 3 and a base saturation that is less than 50% (actually <98% by the ECEC method (see Juo *et al.*, 1976). Atan series is Fluvaquents because it has >0.2% organic carbon and an irregular decrease of organic carbon content between 25cm and a depth of 125cm. It is Tropic Fluvaquents because of the very low amplitude (<5°C) between mean rainy and dry seasons soil temperature.

FAO-Unesco Soil Map Legend: Previous work with soils of a similar environment (Okusami *et al.* 1997) has shown that all the upland soils with clay accumulation/movement

evidence would classify as Ferralsols because of the presence of ferralic B horizons instead of an argic horizon (an equivalent of argillic/kandic horizon) of the FAO/UN (1988). This is because an argic B horizon lacks the set of properties that characterize the ferralic B horizon. Ferralic B properties (i.e., low ECEC ($<12 \text{ cmol}(+) \text{ kg}^{-1} \text{ clay}$); a low silt-clay ratio, ≤ 0.2 ; less than 5% by volume showing rock structure) are all evident in these pedons. There is a strong possibility of $<10\%$ water-dispersible clay as already shown in Alagba series (Okusami, et al. 1997). Oteyyi and Asaba series are Haplic Ferralsols because the ferralic B horizons are neither redder than 5YR nor with a 7.5YR or yellower. Alagba series is Rhodic Ferralsols because of its ferralic B horizon with 2.5YR hues. Other upland soils and Iju series are Xanthic Ferralsols because of a ferralic B horizon with hues of 7.5YR or greater. They all, in addition, lack geric properties (i.e., they have $\text{ECEC}_{\text{clay}} > 1.5 \text{ cmol}(+) \text{ kg}^{-1} \text{ clay}$). Atan series is Dystric Fluvisols. It has fluvic properties because of the irregular decrease of organic carbon with depth and dystric because of the generally less than 50% base saturation within 20cm and 50cm depth from the surface. It is Gleyic-Dystric Fluvisols because of the influence of high groundwater table. Mesan series is Gleysols because of the greater influence of high groundwater table. It is Dystric Gleysols because of a less than 50% base saturation. Idesan and Oji series would classify similarly as Atan and Mesan respectively.

Land Suitability Evaluation

General Consideration

Water is the most limiting factor under rainfed rice culture. The study area has sufficient annual rainfall that is far higher than the required minimum of 1000mm recommended by Yoshida (1977). The rainfall is also moderately well distributed (Nigeria Meteorological Services, 1976) and fulfils the water requirements of upland rice culture in terms of amount and spread (Collonna, 1967 and Cocheme, 1971 in Moormann, 1979) during the <180 days (Sys, 1985 p.82) life-span of rice which will be between March/April and August/September in Nigeria. In sloping topography and on land without levees or similar soil conservation device, there will be greater loss of rainfall water from surface runoff. This will be a typical problem for upland rice culture on this moderately undulating land. Those soil physical properties that control the adequacy of soil moisture include soil texture, profile lithology and bulk density. During a normal rainy season period, without a dry spell, these upland soils should be able to sustain upland rice crop with regard to soil moisture requirements. Subsoil texture are sandy clay/sandy clay loam and will enhance soil moisture storage that could sustain crop growth if a dry spell were to occur during the rainy season.

Indirectly, topography (i.e. sloping land) will influence water percolation and retention in the soils. All the pedons (except Oteyyi, Alagba and Asaba series) occur on sloping surfaces sufficient to cause erosion when put into row crops production such as upland rice. Owode and Agege series occupy the longest physiographic unit of the landscape and will therefore be the most susceptible to erosion.

Upland rice roots normally grow deeper than the conventional 0-15cm or 0-30cm that is typically examined to evaluate soil fertility for arable crop production. The profile description

(Tables 2 and 3) suggest a moderate effective soil depth for most of the soils that are cultivatable. Most of these pedons do apparently carry large trees with deep anchoring roots even though root distribution (Table 3) still show that the surface A horizons remain the major feeding zone. Except for Asaba and Ugbolu series (and their kinds) that have gravelly surface and shallow gravelly subsoil horizon, the soils have good soil texture and blocky structure for adequate root penetration. The bulk density values are generally moderate but never so high as to constitute a problem to root penetration. The horizons with bulk density greater than 1.5gm/cc mostly belong to those soil types with concretionary/gravelly and compact (dense) subsoil horizons (e.g. Oteyyi and Ugbolu series).

Using the fertility-capacity classification (FCC) system of Buol *et al.* (1975) it can be concluded that most soil units when actively cultivated will suffer from nutrient deficiency. An example is the exchangeable K values that are generally below the 0.2meq/100g soil critical limit of FCC. The different pedons have moderate to low organic carbon content with some concretionary gravel content (a diluent factor). The extreme acidity of the soils under discussion is of no consequence towards the healthy growth of rice because the latter is well adapted to a wide latitude of soil pH., i.e. pH4.0-7.5 (ILACO, 1981, p.569). However, caution has to be taken in the soil fertility management so that the soil acidity does not deteriorate beyond the limit tolerable to conducive upland rice growth. An overall outlook of the pedons (well drained/moderately well drained) indicate that soil fertility is inadequate for sustainable upland rice production.

Soil Units Evaluation:

The limiting factors identified are therefore mostly edaphic/physical since it has been established that rainfall pattern is adequate and profile lithology will mostly enhance soil moisture retention for sustained upland rice crop production. The following therefore is an evaluation of the individual soil series (see Table 5).

Oteyyi Series: Pedon has a mottled and concretionary subsoil (Plinthite) horizon at 30cm. Generally, the subsoil is gravelly sandy loam to gravelly sandy clay. The solum depth (S/3) has therefore placed a limitation on the roots proliferation, and the depth to the plinthite/concretionary layer determines its quality. And because of this limitation, exposure of pedon to cultivation practices that may induce a profile wet/dry situation will eventually lead to irreversible hardening of subsoil (petroplinthization) materials. It is therefore better to preserve the status of pedon with permanent tree cover. It belongs to Class S3 and Subclass S3s/3.

Alagba Series: pedon has a sandy loam topsoil over friable to firm blocky sandy clay/clay subsoil. Texture and structure and solum depth are ideal for upland rice cultivation. Soil permeability makes it to be potentially susceptible to moisture stress (m). There is a possibility of slight soil erosion if continuously cultivated. It is in S1 class.

Asaba Series: pedon has variable depth to broken or consolidated mottled petroplinthites. A forest cover is recommended to prevent subsoil ironpan from being exposed by erosion. This in addition will help to sustain subsoil movement of soil water towards recharging those soils at lower elevation. Variable shallow solum controls the soil quality. It belongs to Class S3; and Subclass S3s/3.

Ugbolu Series: pedon has mottles at 70-90cm depth. It also has gravelly (concretionary)

sandy loam topsoil over gravelly sandy clay subsoil. It therefore has shallow effective soil depth because of the plinthites/concretionary materials (S/3). It is also susceptible to erosion because of its location and slope (t) (see Table 2 and Fig. 2). Pedon is recommended as a groundwater recharge zone. It is in Class S3; and Subclass S3 ts/3.

Owode Series: pedon's physiographic position and slope predispose it to erosion hazard (t) when not properly managed. It belongs to Class S2; and Subclass S2 t.

Agege Series: Soil will also be highly erodible (t) under upland rice (arable) because of the slope and its length. Mottling (plinthite) occurs at 70-90cm depth (S/3). These two determine the soil quality. Soil moisture should not be a problem because of sustained subsurface flow of soil water. Erosion when allowed to occur will expose the plithitic subsoil horizons. A productive land for rice if sustainable soil management practices are introduced. It belongs to Class S2; and Subclass S2 ts/3.

Ibeshe Series: Soil has similar characteristics as Alagba series. It is erodible (t) because of its slope and can be droughty during unexpected prolonged dry spell. It belongs to Class S2; and Subclass S2t.

Iju and Ipaja Series: These are inclusions within Agege series. They will both remain moister for a longer period than Agege because of subsurface soil water movement. It belongs to Class S2; and Subclass S2t.

Valley bottom Series: Atan and Mesan series dominantly occupy valley-bottom positions with Idesan and Oji as inclusions to Atan series. They are all wetland soils and will therefore just be marginally suitable to upland rice cultivation. Mesan floods every year. It therefore belongs to subclass N1 w/1. Others belong to S3 w/2.

SUMMARY AND CONCLUSION

All the well-drained and moderately well-drained pedons except typic Oteyyi, Alagba and Asaba series are potentially erodible because they are all located on greater than 2% slope. Erosion was observed to be very serious on soils of middleslope, viz: Owode and Ibeshe series, that were cultivated to maize although it was very minimal on farmer's fields that were cultivated to cassava. Physical degradation (erosion) has been identified (Lal, 1976) to have significant effect on yield even on a land with a minimum of 2% slope. Land use practices would have to be adopted that will mitigate the deleterious physical effects of soil erosion. The next notable physical characteristics is the soil solum or effective soil depth as determined by the gravel layer or concretionary/petroplinthite subsoil horizons. Soil texture seem to be ideal for upland rice cultivation. There is a lighter surface horizon underlain by clayey subsoil horizons that will assist with water retention. Flooding hazard and high regional water table separate soils of the valley bottom from those of the upland and therefore distinctly distinguish those soils that are not suitable for upland crops.

Chemical degradation is manifest through low soil pH, low soil exchangeable bases (or high exchangeable Al) with concomitant low base saturation. The pedons' surface horizons are adequate in soil organic carbon but this is because at the time of investigation, the land had been under a long term fallow or permanent tree crops. Therefore, a cropping practice or land management practice that will sustain the organic matter content of the soils are

desirable.

Soil morphological properties that distinguish the soils from each other are also paramount for evaluating lands for sustainability. The taxonomic units give an impression of groups of soils with identical soils properties and may therefore be easy to manage because of possible identical management practices requirements.

References

- Abifarin, A. O., Chabrolin, M. Jacquot, R. Marie, and J. C. Moomaw. (1972) "Upland rice improvement in West Africa". *IRRI Symposium on rice breeding*. p. 625-635.
- Barker, R. and R. W. Herdt. (1979) "Rainfed lowland rice as a research priority - an economist's view". p. 3-50. In: *IRRI Rainfed Lowland Rice*. (Selected papers from the 1978 International Rice Research Conference). Los Bannos, Laguna, Phillipines.
- Blake, G. R. (1965). "Bulk Density". p.374-390 in C.A. Black (ed). *Methods of soil Analysis*. Part 1. Agronomy No.9, ASA. Madison.
- Bray, R.H., and L.T. Kurtz. (1945) "Determination of total organic and available forms of P in soil." *Soil Sci.* 59:39-45.
- Buol, S.W., P.A. Sanchez, R.R.Cate Jr., and M. A. Granger. (1975) "Soil Fertility. Capability Classification". p. 126-140. In: E. Bornemisza and A. Alvarado (Eds.) *Soil Management in Tropical America*. North Carolina State University, Raleigh.
- Cocheme, J. (1971) "Notes on the ecology of rice in East Africa" In: *Notes on the ecology of rice and soil suitability for rice cultivation in West Africa*. FAO document p.1-5.
- Collonna, J. P. (1967) "Le riz et sa culture en Republique centre-africaine". *Agr. Trop.* XXII(1): 11-30.
- Day, P. R. (1953) "Experimental confirmation by Hydrometer theory". *Soil Sci.* 75:181-186.
- FAO. (1983) *Guidelines: land evaluation for rainfed agriculture*. (Soils Bulletin 52) FAO, Rome, 237p.
- Food and Agriculture Organization of the United Nations (1988) *FAO/Unesco Soil Map of the World, Revised Legend*. (World Soil Resources Report 60) FAO, Rome.
- Forest, F. and J. M. Kalms. (1984). "Influence of rainfall regime on upland rice production: Water demand simulation". p.143-160 In: *IRRI: An overview of Upland Rice Research*. (Proceedings of the 1982 Bouake, Ivory Coast Upland Rice Workshop), Laguna, Phillipines.
- Higgins, G. M. (1964). "Soils of some rice growing areas in N. Nigeria" *African Soils* 9(2) : 247-265.
- IBSRAM. 1991. *Evaluation for sustainable land management in the developing world. Volume 1. Towards the development of an International framework*. Bangkok, Thailand. IBSRAM Proceeding No. 12.
- ILACO. (1981) *Agricultural Compendium for Rural Development in the Tropics and Subtropics*. Elsevier. Amsterdam.
- Juo A.S.R., S. A. Ayanlaja, and J. A. Ogunwale. (1976) "An evaluation of cation exchange

- capacity measurements for soils in the tropics". *Comm. Soil Sci. Plant Anal.*, 7:751-761.
- Kang, B. T. and A. S. R. Juo (1984). "Review of soil fertility management and cropping systems for wetland rice production in West Africa". p.493-501. In *IRRI: An Overview of Upland Rice Research* (Proceedings of the 1982 Bouake, Ivory Coast Upland Rice Workshop) Laguma, Phillipines.
- Lal, R. (1976). "Soil erosion on Alfisols in Western Nigeria. I. Effects of slope, crop rotation and residue management". *Geoderma* 16:363-375.
- Lekwa, G., and E. P. Whiteside. (1986) "Coastal plain soils of Southeastern Nigeria; I. Morphology, Classification and genetic relationship". *Soil Sci. Soc. Am. J.* 50: 154-160.
- McLean, E. O. (1965). "Aluminium". p.978-997. In C.A. Black (Ed.) *Methods of Soil Analysis*. Part 2. ASA Monograph No. 9. Madison.
- Moormann, F. R. (1973) "General Assessment of land on which rice is grown in West Africa". p.248-282. In: *WARDA. Soil fertility and Fertilizer Use*. Seminar Proceedings 2. Jan. 22 - Jan. 27, Moronvia, Liberia.
- Moss, R. P. (1957). *Report on the classification of the soils found over sedimentary rocks in Western Nigeria*. MANR, Ibadan.
- Nigerian Meteorological Services, (1976). *Agrometeorological Bulletin*. Lagos.
- Ojanuga, A. G., G. Lekwa and F. R. O. Akamigbo. (1981) "Survey, classification and genesis of acid sands". p.1-17. In: E. J. Udo and R. A. Sobulo (eds.). *Acid Sands of Southern Nigeria*. Proceedings of Symposium. 9th Annual Conference of Soil Science Society of Nigeria. SSSN Monograph No. 1.
- Okusami, T. A. (1989). *Detailed Soil Survey and Qualitative Land Evaluation of Folawiyo Farms in Ibeju/Lekki Local Government Area of Lagos State, Nigeria*. UNIFECS. Obafemi Awolowo University, Ile-Ife, IV+ 76p and 2 Figures.
- Okusami, T. A. (1991). "Quartzitic Sloping Landscapes of Humid Tropics: soils and land evaluation studies of an upland rice-based cropping system in upper Osun River Basin of South-West Nigeria". *African Soils* 24:49-84.
- Okusami, T.A., E.A. Aduayi and A. A. Jayeola. (1988). *Soil Survey, Soil Fertility and Land Suitability Evaluation for Upland Rice Production at Igbodu-Ketu in Epe Local Government Area of Lagos State*. UNIFECS, Obafemi Awolowo University, Ile-Ife, Nigeria V+75p and 4 Figures.
- Okusami, T. A., R. H. Rust and A. O. Alao (1997). "Red soil of different origins from southwest Nigeria: Characteristics, classification, and management considerations". *Can. J. of Soil Sci.* 77:295-307.
- Okusami, T. A., R. H. Rust and A. S. R. Juo. (1985) "Characteristics and classification of some soils formed on post-cretaceous sediments in southern Nigeria". *Soil Sci.* 140(2): 110-119.
- Seguy, L., R. Nicou et, G. Haddad. (1970) *Comparison de l'enracinement de quatre varietes de riz pluvial en presence ou absence de travail du sol*. FF/IRAT/IITA Seminar on rice. (Mimogr. Document).

- Soil Survey Staff. (1994) *Keys to Soil Taxonomy*, Sixth edition,
- Sys. C. (1985) *Land Evaluation*. State University of Ghent Part II.
- WARDA, (1984) "Upland rice in West Africa" p.21-43. In: *IRRI: An overview of Upland Rice Research*. (Proceedings of the 1982 Bouake, Ivory Coast Upland Rice Workshop), Laguna. Philipines.
- Yoshida, S. (1977). "Rice". p.57-83. In: *Paulo de T. Alvim and T. T. Kozłowski (Eds.) Ecophysiology of Tropical Crops*. Academic Press - New York.