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Updated Classification of Some Soil Series in Southwestern Nigeria

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Abstract: Studies were carried out on six preclassified soils in Southwestern Nigeria based on the need to update their classification in consonance with modern knowledge of soil science. Samples were collected from the genetic horizons of the profiles and then subjected to routine physical and chemical analysis. The required data thus generated were used to classify the soils according to the USDA Soil Taxonomy and the FAO-UNESCO systems. In soil taxonomy, three of the soils namely, Itagunmodi, Alagba and Ondo Series were classified as Oxic Haplustults; Apomu soil series were classified as Oxic Ustropepts; Odeyinka series as Typic Ustropepts; and Iwo series as Oxic Haplustults. Under the FAO system, Itagunmodi, Iwo and Ondo series were classified as Ferric Acrisols; Alagba as Dystric Nitosols and Apomu as Cambic Arenosols. However, Odeyinka series could not fit into a single category due to its peculiar horizonation. The 0-60 cm layer was classified as Cambic Arenosols, the 60-92 cm layer as Orthic Ferrasols and the 92-160 cm horizon as Udic Cambisols.

Key words: Updated, classification, soils, Southwestern, Nigeria

INTRODUCTION

As Singer and Munns (1999) have aptly noted, it is easy to imagine the existence of an almost infinite variety of soils. The five soil-forming factors can combine in almost endless ways to give rise to almost countless kinds of soil individuals. It is clearly impossible to remember their names, let alone their properties, hence the need to organize soils information by classification systems.

In classifying Nigerian soils, some workers had used only Effective Cation Exchange Capacity (ECEC) to group some soils of southwestern Nigeria under Alfisols (Moorman *et al*., 1974; Harpstead, 1974). But it is commonly known in literature that it is only when considering fertility assessment purpose alone that ECEC is preferred to other methods of CEC measurements. However, soils are classified as natural bodies, on the basis of their profile characteristics and not merely on the basis of their suitability for a particular use (Brady and Weil, 1999). Murdoch *et al*. (1976) classified many common soil series in the area excluding the sedimentary zone in the southwest. They followed the sequence given by Dudal (1970) in keying out the soils for allocation to World Soil Map units, but however noted that further investigations may invalidate some of these classifications, as morphological and analytical data were scanty for some of the series that they classified.

Corroborating this opinion, Molindo (2006, Personal Communication) stressed the need to reclassify some of the soils under more than one leading classification system by using the appropriate criteria. Although the local classification contains the great advantage of being as precise as possible, given the local data, it has serious difficulty of comparing with other areas. Butler (1980) had argued the case for this bottom-up classification quite persuasively. But systematic classification offers compelling advantages which recommend it for a wider acceptability. Not only does systematic classification allow comparison of different areas, it also removes much of the burden of legend-making from the local survey thereby speeding up the survey.

It is the objective of this study therefore to update the classification of six of the most common soil series in southwestern Nigeria in consonance with the knowledge of modern soil science. In addition to ECEC method, several other methods will be used to evaluate the CEC of these soils. In all, four methods will be used to measure the CEC, namely sum of cations, neutral acetate, Soil-Test and effective CEC methods.

Samples will be collected from the genetic horizons of Itagunmodi, Alagba, Apomu, Odeyinka, Iwo and Ondo soil series and then subjected to routine physical and chemical analyses. The physico-chemical and morphological data obtained from there will be used to characterize the soils for classification in the USDA Soil Taxonomy and the FAO-UNESCO Soil Map of the World.

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MATERIALS AND METHODS

The study was carried out at pre-classified sites in Apomu, Iwo, Ife, Ondo and Ijebu-Ode towns, within latitudes 6° 5′ and 7° 6′ North and longitudes 4° 1′ and 4° 8′ East, in Southwestern Nigeria. Soil samples were collected from the genetic horizons of six soil series, namely Itagunmodi, Alagba, Apomu, Odeyinka, Iwo and Ondo. Itagunmodi series is located in the derived Savannah vegetation zone with an annual rainfall of 1400 mm and developed from Amphibolite. Alagba series is located in the rain forest with annual rainfall of 1900 mm on sedimentary rock. Ondo series is situated in the rain forest also, with annual rainfall of 1600 mm and developed from medium-grained granite/gneiss.

Apomu, Odeyinka and Iwo series are all in the Derived Savannah. Apomu and Iwo series have a common parent material, coarse grained granite/gneiss, with annual rainfall of 1400 and 1100 mm, respectively. Odeyinka series is located in the Derived savannah on Diorite gneiss, with annual precipitation of 1200 mm. All the locations support rain-fed agriculture. Collected samples were subjected to laboratory analysis.

Representative profile pits were dug and described for each of the soil series. Samples were collected from the various horizons and then subjected to laboratory analyses. The physical, chemical and biological properties of the soils were then used as criteria for classification. Some of the properties used included colour, texture, structure of the soil, contents of organic matter, clay, pH, the percentage base saturation and soil depth.

Laboratory analysis: The hydrometer method (Day, 1965) was used to determine the percentages of the primary separates: sand, silt and clay. Twenty milliliter of 4% NaOH was used as a dispersing agent. The textural classes were designated according to the Soil Taxonomy (Soil Survey Staff, 1998).

The Chromic acid digestion method (Jackson, 1958) was used to determine the organic carbon of the soils.

The soil pH was determined in 1:1 soil-water ratio and 1:1 soil-1 N KCl suspensions (Schofield and Taylor, 1955). 1 N NH_4OAC, pH 7 was used to extract the exchangeable bases.

Magnesium was determined by EDTA titration. The $BaCl_2$-TEA Extractable Acidity (EA) was determined using the Soil Survey Staff (1972) procedure. Soil-Testing (Soil-Test) EA was determined by the Jackson (1958) method. The amounts of exchangeable H and Al in the extracts were determined by the Fluoride titration procedure outlined in No. 6 G1d, Soil Survey Staff (1972). The CEC of the soils was carried out by four different methods namely, sum of cations, soil-test, ammonium acetate displacement and effective CEC.

The soils were then classified according to Soil Survey Staff (1999) and FAO (1990) classification systems, on the basis of their profile characteristics. This work lasted between 2003 and 2006.

RESULTS AND DISCUSSION

The physical and chemical properties of the six soil series are shown in Table 1-6. Using the Keys to Soil Survey Staff (1998) it is easy to classify Itagunmodi, Alagba and Ondo series as Oxic Paleustults; Apomu series as Oxic Ustropepts; Odeyinka as Typic Ustropepts and Iwo series as Oxic Haplustults. In the FAO-UNESCO system, Itagunmodi, Iwo and Ondo series can be classified as Ferric Acrisols; Alagba series as Dystric Nitosols, while Apomu soil series can be classified as Cambic Arenosols.

These results have shown that the former classification of many of the soils of South Western Nigeria was incorrect. The earlier workers had grouped the soils under Alfisols (Moorman *et al*., 1974; Harpstead, 1974). However, what the results of this present work have shown is that none of the soils studied hare are Alfisols. They are rather either Ultisols or Entisols. Clearly, this can have a very significant implication in the way that these soils could sustainably be used and managed.

It is not possible to classify Odeyinka series in a single FAO-UNESCO category. This is because of its peculiar horizonation. There is evidence of repeated lithological discontinuity, or buried soils here. Three distinct layers are clearly distinguished. The first 0-60 horizon classifies as Cambic Arenosol; the next, 60-92 cm horizon is best classified as Orthic Ferisol and the third, 92-160 cm horizon classifies as Udic Cambisol. This may suggest the necessity for a new category to be created within the FAO-UNESCO classification system to accommodate this soil type.

Clay mineralogy tests have revealed the dominance of kaolinite in most cocoa belt or rain forest series, as noted by Ojanuga (1973). The results (Table 1-6) show that the six soil series exhibit low cation exchange capacity. Smyth and Montgomery (1962) earlier observed that soils of the central western Nigeria have low CEC due to the predominance of kaolinitic clay. This contrasts with quite high smectite/montmorillonite proportions in

Table 1: Physical and chemical properties of Itagummodi series

	Soil depth (cm)				
Properties	0-20	20-56	56-100	100-140	140-180
pH (H_2O)	5.78	5.60	5.61	6.00	5.95
pH (KCl)	4.45	4.80	5.45	5.55	5.60
ΔH	-1.33	-0.80	-0.16	-0.45	-0.35
Organic carbon (g kg^{-1})	0.77	0.41	0.20	0.12	0.12
Extract Al cmol kg^{-1}	Traces	Traces	Traces	Traces	Traces
Ex. H^+	0.14	0.10	0.10	0.10	0.10
Extractable bases (cmol kg^{-1})					
Ca	0.75	0.75	0.80	0.85	0.70
Mg	0.95	0.55	0.44	0.23	0.78
Na	0.05	0.05	0.06	0.06	0.05
K	0.02	0.01	0.01	0.01	0.01
Extractable acidity (coml kg^{-1})					
$BaCl_2$-TEA, pH 8	5.88	8.35	6.87	6.37	3.40
Soil-test	4.05	8.45	4.05	4.05	2.05
Mg $(OAc)_2$, pH 7	5.73	8.89	7.69	6.85	9.46
KCl	0.14	0.10	0.10	0.10	0.10
CEC (cmol kg^{-1})					
$BaCl_2$-TEA, pH 8	7.65	9.71	8.18	7.52	4.94
Soil-test	5.82	9.81	5.36	5.40	3.59
Mg $(OAc)_2$ pH 7	7.50	10.25	9.00	8.00	11.00
Effective (KCl)	1.91	1.46	1.41	1.25	1.64
Base saturation (g kg^{-1})					
Sum of cations	23.00	14.00	16.00	15.00	31.00
Soil-test	30.00	14.00	24.00	21.00	43.00
Neutral acetate	24.00	13.00	15.00	14.00	14.00
Effective	93.00	93.00	93.00	92.00	94.00
Gravel (%)	4.00	6.00	14.00	6.00	21.00
Sand (%)	30.00	48.00	46.00	46.00	48.00
Silt (%)	46.00	2.00	4.00	2.00	4.00
Clay (%)	24.00	50.00	50.00	52.00	48.00
Textural class	Loam	Sandy clay	Sandy clay	Sandy clay	Sandy clay

Table 2: Physical and chemical properties of Alagba series

	Soil depth (cm)					
Properties	0-5	5-22	22-50	50-80	80-110	110-130
pH (H_2O)	5.10	5.10	5.00	5.00	5.05	5.08
pH (KCl)	3.75	4.10	4.05	4.00	4.00	4.05
ΔH	-1.35	-0.90	-0.95	-1.00	-1.05	-1.03
Organic carbon (g kg^{-1})	2.15	0.73	0.29	0.20	0.08	0.04
Extract Al (mol kg^{-1})	Traces	0.46	0.78	0.78	1.11	1.15
Ex. H^+	0.10	0.07	0.13	0.17	0.04	0.04
Extractable bases (cmol kg^{-1})						
Ca	1.50	0.65	0.55	0.30	0.30	0.20
Mg	1.27	0.87	0.56	0.25	0.40	0.30
Na	0.09	0.09	0.12	0.01	0.01	0.09
K	0.03	0.03	0.06	0.01	0.03	0.04
Extractable acidity (coml kg^{-1})						
$BaCl_2$-TEA, pH 8	10.33	10.83	10.33	7.86	8.35	9.84
Soil-test	5.65	5.89	6.29	6.53	6.45	7.25
Mg $(OAc)_2$, pH 7	7.86	6.09	8.71	7.58	8.76	10.62
KCl	0.10	0.53	0.91	0.95	1.15	1.19
CEC (cmol kg^{-1})						
$BaCl_2$-TEA, pH 8	13.22	12.49	11.62	8.53	9.09	10.47
Soil-test	8.54	7.55	7.58	7.20	7.19	7.88
Mg $(OAc)_2$, pH 7	10.75	7.75	10.00	8.25	9.50	11.25
Effective, KCl	2.99	2.19	2.20	1.62	1.89	1.82
Base saturation (g kg^{-1})						
Sum of cations	22.00	13.00	11.00	8.00	8.00	6.00
Soil-test	34.00	22.00	17.00	9.00	10.00	8.00
Neutral acetate	27.00	21.00	13.00	8.00	8.00	6.00
Effective	97.00	76.00	59.00	41.00	39.00	35.00
Gravel (%)	5.00	10.00	8.00	4.00	8.00	57.00
Sand (%)	38.00	42.00	40.00	36.00	36.00	32.00
Silt (%)	13.00	2.00	1.00	1.00	1.00	1.00
Clay (%)	49.00	56.00	59.00	63.00	63.00	67.00
Textural class	Clay	Clay	Clay	Clay	Clay	Clay

Table 3: Physical and chemical properties of Apomu series

	Soil depth (cm)						
Properties	0-6	6-24	24-46	46-70	70-120	120-167	167-195
pH (H_2O)	6.80	7.65	7.12	6.50	6.40	6.00	6.60
pH (KCl)	6.05	5.70	5.80	5.55	5.25	4.70	4.90
ΔH	-0.75	-1.95	-1.32	-0.95	-1.15	-1.30	-1.70
Organic carbon (g kg^{-1})	2.93	0.20	0.12	0.04	0.04	0.08	0.08
Extract Al (mol kg^{-1})	Traces	Traces	Traces	Traces	Traces	Traces	Traces
Ex. H^+	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Extractable bases (cmol kg^{-1})							
Ca	2.80	0.80	0.50	0.50	0.85	1.35	0.90
Mg	2.40	0.93	0.40	0.31	0.50	0.59	0.43
Na	0.09	0.03	0.03	0.01	0.03	0.05	0.03
K	0.05	0.02	0.02	0.01	0.02	0.04	0.03
Extractable acidity (coml kg^{-1})							
$BaCl_2$-TEA, pH 8	4.89	1.91	1.92	0.93	0.93	1.92	2.41
Soil-test	2.45	1.09	1.09	1.00	2.05	3.65	2.61
Mg $(OAc)_2$, pH 7	7.16	0.47	0.30	1.17	3.35	4.22	4.11
KCl	0.10	0.10	0.10	0.10	0.10	0.10	0.10
CEC (cmol kg^{-1})							
$BaCl_2$-TEA, pH 8	10.23	4.69	2.87	1.76	1.83	3.95	3.80
Soil-test	7.79	2.87	2.04	1.92	2.95	5.68	4.00
Mg $(OAc)_2$, pH 7	12.50	2.25	1.25	2.00	4.25	6.25	5.50
Effective (KCl)	5.44	1.88	1.05	0.93	1.00	2.13	1.49
Base saturation (g kg^{-1})							
Sum of cations	52.00	38.00	33.00	47.00	49.00	52.00	37.00
Soil-test	69.00	62.00	47.00	43.00	31.00	36.00	35.00
Neutral acetate	43.00	79.00	76.00	42.00	21.00	33.00	25.00
Effective	98.00	95.00	91.00	89.00	90.00	95.00	93.00
Gravel (%)	6.00	12.00	29.00	45.00	71.00	70.00	69.00
Sand (%)	58.00	86.00	84.00	86.00	76.00	64.00	72.00
Silt (%)	25.00	6.00	8.00	5.00	8.00	1.00	4.00
Clay (%)	17.00	8.00	8.00	9.00	16.00	35.00	24.00
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Table 4: Physical and chemical properties of Odeyinka series

	Soil depth (cm)					
Properties	0-6	6-35	35-60	60-92	92-108	108-160
pH (H_2O)	7.10	7.00	6.55	6.85	6.35	6.40
pH (KCl)	5.40	5.40	5.15	5.20	4.80	4.45
ΔH	-1.70	-1.60	-1.40	-1.65	-1.55	-1.95
Organic carbon (g kg^{-1})	2.27	0.20	0.16	0.16	0.04	0.04
Extract Al (mol kg^{-1})	Traces	Traces	Traces	Traces	Traces	Traces
Ex. H^+	0.14	0.10	0.10	0.10	0.14	0.14
Extractable bases (cmol kg^{-1})						
Ca	2.00	1.10	1.25	2.25	3.25	3.50
Mg	1.71	1.32	0.93	1.82	2.95	4.35
Na	0.06	0.01	0.17	0.04	0.10	0.13
K	0.03	0.02	0.02	0.02	0.02	0.02
Extractable acidity (coml kg^{-1})						
$BaCl_2$-TEA, pH 8	5.88	2.91	4.89	5.30	5.38	11.82
Soil-test	3.09	2.45	2.21	4.05	4.77	4.05
Mg $(OAc)_2$, pH 7	4.20	4.05	3.13	5.12	7.68	10.02
KCl	0.40	0.10	0.10	0.10	0.14	0.14
CEC (cmol kg^{-1})						
$BaCl_2$-TEA, pH 8	9.68	5.36	7.26	9.51	11.95	19.80
Soil-test	6.89	4.90	4.58	8.18	11.34	12.03
Mg $(OAc)_2$, pH 7	8.00	6.50	5.50	9.25	14.25	18.00
Effective (KCl)	3.94	2.55	2.47	4.23	6.71	8.12
Base saturation (g kg^{-1})						
Sum of cations	39.00	46.00	33.00	43.00	55.00	40.00
Soil-test	55.00	50.00	52.00	51.00	58.00	66.00
Neutral acetate	48.00	38.00	43.00	45.00	46.00	44.00
Effective	97.00	96.00	96.00	98.00	98.00	98.00
Gravel (%)	1.00	4.00	20.00	80.00	43.00	1.00
Sand (%)	78.00	80.00	80.00	64.00	52.00	56.00
Silt (%)	10.00	8.00	8.00	8.00	24.00	16.00
Clay (%)	12.00	12.00	12.00	28.00	24.00	28.00
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Table 5: Physical and chemical properties of Iwo series

	Soil depth (cm)					
Properties	0-20	20-33	33-58	58-82	82-103	103-132
pH (H_2O)	6.40	6.30	6.40	4.50	5.00	4.50
pH (KCl)	5.50	5.60	5.30	3.80	3.70	3.80
ΔH	-0.90	-0.70	-1.10	-0.70	-1.30	-0.70
Organic carbon (g kg^{-1})	1.34	0.33	0.20	0.16	0.04	0.04
Extract Al (mol kg^{-1})	Traces	Traces	Traces	0.11	0.14	0.23
Ex. H^+	0.10	0.24	0.19	0.08	0.10	0.10
Extractable bases (cmol kg^{-1})						
Ca	1.90	1.25	0.85	0.75	0.35	0.30
Mg	1.33	0.98	0.97	1.20	0.70	0.41
Na	0.06	0.07	0.09	0.07	0.06	0.05
K	0.06	0.05	0.04	0.04	0.04	0.03
Extractable acidity (coml kg^{-1})						
$BaCl_2$-TEA, pH 8	4.39	9.36	10.33	3.40	5.88	12.31
Soil-test	2.37	3.17	4.77	4.85	5.25	4.85
Mg $(OAc)_2$, pH 7	4.90	4.65	8.30	5.44	4.85	3.96
KCl	0.10	0.24	0.19	0.19	0.24	0.33
CEC (cmol kg^{-1})						
$BaCl_2$-TEA, pH 8	7.74	11.71	12.28	5.46	7.03	13.10
Soil-test	5.72	5.52	6.72	6.91	6.40	5.64
Mg $(OAc)_2$, pH 7	8.25	7.00	10.25	7.50	6.00	4.75
Effective (KCl)	3.45	2.59	2.14	2.25	1.39	1.12
Base saturation (g kg^{-1})						
Sum of cations	43.00	20.00	16.00	38.00	16.00	6.00
Soil-test	59.00	43.00	29.00	30.00	18.00	14.00
Neutral acetate	41.00	34.00	19.00	28.00	19.00	17.00
Effective	97.00	91.00	91.00	92.00	83.00	71.00
Gravel (%)	31.00	62.00	62.00	62.00	32.00	42.00
Sand (%)	70.00	50.00	22.00	22.00	54.00	54.00
Silt (%)	13.00	9.00	5.00	3.00	9.00	5.00
Clay (%)	17.00	41.00	73.00	75.00	37.00	41.00
Textural class	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam	Sandy loam

Table 6: Physical and chemical properties of Ondo series

	Soil depth (cm)					
Properties	0-8	8-24	24-54	54-88	88-122	122-152
pH (H_2O)	5.00	5.00	5.00	5.15	5.30	5.35
pH (KCl)	4.45	4.00	4.00	4.10	4.10	4.05
ΔH	-0.55	-1.00	-1.00	-1.05	-1.20	-1.30
Organic carbon (g kg^{-1})	2.04	0.20	0.16	0.16	0.12	0.08
Extract Al (mol kg^{-1})	Traces	0.55	0.88	0.69	0.88	0.88
Ex. H^+	0.14	0.17	0.07	0.07	0.07	0.07
Extractable bases (cmol kg^{-1})						
Ca	1.10	0.25	0.25	0.25	0.35	0.40
Mg	1.66	0.66	0.64	1.26	0.78	1.07
Na	0.05	0.05	0.06	0.05	0.07	0.12
K	0.03	0.01	0.02	0.01	0.02	0.02
Extractable acidity (coml kg^{-1})						
$BaCl_2$-TEA, pH 8	7.36	10.33	8.35	9.34	14.29	7.36
Soil-test	4.45	3.49	4.13	5.41	5.57	5.57
Mg $(OAc)_2$, pH 7	5.40	9.28	9.55	2.68	2.53	1.39
KCl	0.14	0.72	0.95	0.76	0.95	0.95
CEC (cmol kg^{-1})						
$BaCl_2$-TEA, pH 8	10.21	11.30	9.32	10.91	15.51	8.97
Soil-test	7.30	4.46	5.10	6.98	6.29	7.18
Mg $(OAc)_2$, pH 7	8.25	10.25	10.50	4.25	3.75	3.00
Effective (KCl)	2.99	1.69	9.92	2.33	2.17	2.56
Base saturation (g kg^{-1})						
Sum of cations	28.00	9.00	10.00	14.00	8.00	18.00
Soil-test	39.00	22.00	19.00	23.00	18.00	23.00
Neutral acetate	35.00	10.00	9.00	37.00	33.00	54.00
Effective	95.00	57.00	51.00	67.00	56.00	63.00
Gravel (%)	16.00	34.00	40.00	28.00	13.00	7.00
Sand (%)	66.00	66.00	54.00	22.00	22.00	18.00
Silt (%)	13.00	9.00	9.00	9.00	9.00	13.00
Clay (%)	21.00	25.00	37.00	69.00	69.00	69.00
Textural class	Sandy clay loam	Sandy clay loam	Sandy clay	Clay	Clay	Clay

typical savannah profiles. The finding of appreciable quantities of 2:1 lattice clay minerals corroborates results obtained by Ashaye (1972).

However, the results (Table 2, 6) show that Alagba and Ondo profiles have relatively higher cation exchange capacity than their Itagunmodi and Apomu Soil Series of the savannah vegetation. This suggests that the latter may not indeed be said to be strictly typical savannah profiles.

CONCLUSION

The results showed that the former classification of southwestern Nigeria soils needs to be updated by using appropriate criteria. Under Soil Taxonomy, Itagunmodi, Alagba and Ondo series are classified as Oxic Paleustults; Apomu as Oxic ustropepts, Odeyinka as Typic ustropepts and Iwo series as Oxic Haplustults. That is, the soils are now classified under Entisols and Ultisols. They were earlier classified as Alfisols. Clearly, this reclassification by using the appropriate criteria in consonance with knowledge of modern soil science will help to use these soils in a more profitable and sustainable manner.

In the FAO classification system, Itagunmodi, Iwo and Ondo series are classified as Ferric Acrisols; Alagba series is classified as Dystric Nitosols and Apomu series is classified as Cambic Arenosols. Odeyinka series can not fit into a single category: the 0-60 cm horizon is classified as Cambic Arenosols; the 60-92 cm horizon is classified as Orthic Ferralsols, while the 92-160 cm horizon is classified as Udic cambisols. This may strongly suggest that a new category be created within the FAO hierarchical taxonomy to accommodate this unique soil series.

REFERENCES

Ashaye, T.I., 1972. Vertisolic pedogenesis on drioritic material under humid tropical conditions. Nig. Agric. J., 9: 5-16.

Brady, N.C. and R.R. Weil, 1999. The Nature and Properties of Soils. Prentice-Hall, Inc. Pearson Education, Upper Saddle River, New Jersey 07458.

Butler, B.E., 1980. Soil Classification for Soil Survey. Monographs on Soil Survey, Beckett, P.H.T. (Ed.). Oxf. Sci. Publ., B98 Mann., pp: 516-592.

Day, P.R., 1965. Particle Fractionation and Particle Size Analysis. In: Methods of Soil Analysis. Part 1: ASA Monograph No. 9. American Society of Agronomy. Madison, Wisconson, USA., pp: 545-567.

Dudal, R., 1970. Key to Soil Units for the Soil Map of the World. Docum. FAO Rome. AGL/SM/70/2.

FAO., 1990. Soil map of the world: Revised legend. World Soil Resources Report 60, Rome: FAO S591. F68 No. 60 Mann. Food and Agriculture Organization of the United Nations, pp: 119.

Harpstead, M.I., 1974. The classification of some Nigerian soils. Soil Sci., 116: 437-447.

Jackson, M.L., 1958. Soil Chemical Analysis. Englewood Cliffs, N.J. Prentice-Hall, pp: 57-67.

Moorman, F.R., R. Lal and A.S.R. Juo, 1974. The Soils of IITA. IITA Tech. Bull. No. 3 Int. Inst. Trop. Agric. Ibadan, Nigeria.

Murdoch, G. *et al.*, 1976. Soils of the Western State Savanna in Nigeria. Vol. 1. The Environment. Land Resources Division, Ministry of Overseas Development. Tolworth Tower, Surbiton, England KT6 7DY.

Ojanuga, A.G., 1973. Weathering of biotite in soils of the humid tropical climate. Proc. Soil Sci. Soc. Am., 37: 644-646.

Schofield, R.K. and W. Taylor, 1955. The measurement of soil pH. Soil Sci. Soc. Am. Pro., 10: 164-167.

Singer, M.J. and D.N. Munns, 1999. Soils an Introduction. Prentice-Hall, Inc. Simon and Schuster/A Viacom Company Upper Saddle River, New Jersey 07458, pp: 12-13.

Smyth and Montgomery, 1962. Soils and Land Use of Central Western Nigeria. Government Western Nigerian Press, Ibadan, Nigeria.

Soil Survey Staff, 1972. Soils and Land Use of Central Western Nigeria. Government Western Nigerian Press. Ibadan, Nigeria.

Soil Survey Staff, 1998. Keys to Soil Taxonomy (USDA Natural Resources Conservation Service. Washington, DC.).

Soil Survey Staff, 1999. Soil Taxonomy: A Basic System of Soil Classification for Making and Interpreting Soil Surveys. 2nd Edn. (USDA Natural Resources Conservation Service. Washington, DC.).