Futo Journal Series (FUTOJNLS)
e-ISSN :2476-8456 p-ISSN : 2467-8325
Volume-2, Issue-1, pp- 41 - 47
www.futojnls.org

Research Paper July 2016

Characterization and Classification of Soils Of Egbema in Imo State, South-Eastern Nigeria

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Abstract

Classification of soils is very necessary in deepening our understanding about pedogenic properties of soils for making an informed decision to harnessing our soil resource. Detailed characterization of soils was carried out by collecting soil samples (using the FAO guideline) from one pedon in each of four locations namely; Iyiaba, Omampe, Orashi and Agbo in Egbema, Imo State and then analyzing the samples in the laboratory using standard methods. Soil data were subjected to simple statistical analysis using Statistical Analytical System. Drainage was poor in most of the locations although the soil profiles were deep (shallowest pedon was 140 cm). Soil texture of the locations varied ranging from sandy loam to clay. Bulk density of the soils decreased down the horizons (≥ 1.21 gcm^{-3} ≤ 1.33 gcm^{-3}) and varied moderately (CV ≥ 16 % ≤ 20 %) in most of the locations. The soil reaction were moderately acidic (pH = 4.75 – 5.09) from upper to the lower horizons in most of the pedons. The soils had low concentrations of exchangeable cations (Ca, Mg, Na and K $\geq 0.01 \leq 3.83$ Cmolkg^{-1}) in the horizons. From the results of the soil properties, the soils were classified- Iyiabapedon as ArenicPlinthicKandiudalfs, Omampe and Agbopedons as TypicFraglossudalfs and Orashipedon as TypicFragiudalfs. Because soil survey reports may not give a detailed and clear outlook of the important characteristics of our soils the research becomes very necessary in many localities of similar need.

Keywords: *Characterization, Classification, Pedogenesis, Pedon.*

1.0 Introduction

Soils in most landscapes form the foundation for many ecological processes such as biogeochemical cycling, distribution of plant communities and, ultimately, the location of human activities. In most of our soil studies, we often characterize the soil to garner about its inherent/dynamic properties. Soils are usually characterized using relevant physical, chemical and morphological properties inherent in them. It has been reported by Idoga *et al*., (2005) that soil as a natural resource cannot be properly managed without proper understanding of their characteristics. Soil classification systems organize soil variability into useful groupings that can be identified by field investigation and documented in soil survey activities to promote effective resource management and technology transfer. Many Classification systems have been developed for better understanding of the properties of our soils for the purpose of extrapolation of research results to localities of need. The most popular soil classification systems in the world are; USDA soil classification system and FAO/WRB (World Reference Base) classification system. In Africa, Ghanaian classification system has been developed.

According to Ahukaemere, (2015), some soil properties (Soil drainage, nutrient content of soils, soil colour, soil structure and soil reaction) are influenced by parent material. It is obvious that differences in soil properties are inherently due to differences in the pedogenetic origin (parent material) of the soil and dynamically due to differences in land use and or management practices. Significant relationship between parent material and soil texture, soil reaction, total exchangeable bases, total acidity, soil depth, colour, profile drainage and gravel content have earlier been reported (Akamigbo & ASsdu, 1983; Esu, 2010). Ojenuga *et al*., (1981) and Ofomata, (1981) emphasized that soils of south-eastern Nigeria formed on unconsolidated coastal plain sands are characterized by the dominance of sand-textured fragments comprising larger quantities of coarse over fine textured materials, have low fertility due to dominance of low activity clays and inherent low organic matter contents.

This paper investigated the characteristics and classification of four pedons within Imo state in Nigeria in order to illustrate the obvious need to increase our understanding of the soils. Soils of the area investigated for this study were developed from different parent materials and as such explain the need for detailed characterization of the soils. The objective of this study was therefore to characterize and then classify the soils of Imo state, Nigeria using the USDA Soil Taxonomy.

2.0 Materials and Methods

2.1. Description of the Study Area

The study was carried out in four locations namely; Orashi, Agbo, Omampe and Iyiaba in Egbema Local Government Area of Imo State. The study area lies between latitude 5˚ 33' and 5˚ 58' N and longitude 6˚ 50' and 6˚ 59' E within a humid tropical climate characterized by rainy season (February/March – November) and dry season (November – February/March). Annual rainfall of the area is about 2,500 mm along the Atlantic coast (NIMET, 2014). Soils of the four locations were derived from coastal plain sands and have been altered by anthropogenic activities. Some of the areas were characterized by wetland hydrology and hydrophytic vegetation.

2.2 Soil Sampling and Laboratory Analysis

Reconnaissance field trip was undertaken and routine materials and methods to be used in the field study were noted. Profile pits were dug (one each for the four different areas) in the four wetland soils, described and sampled according to genetic horizons for characterization and classification (FAO, 2006; Soil Survey Staff, 2006). Soil samples were collected from the bottom-most horizon to the topmost to avoid contamination of soils from the horizons. The soil samples were air dried, crushed and made to pass through 2.0 mm mesh sieve. Samples were also collected with core samplers for bulk density and moisture content analyses. The slope of each of the sampling sites was measured in the field with an abney level. Particle size analysis was performed using the Bouyoucous hydrometer method (Gee & Or, 2002). Bulk density was determined using the core method as described by (Gross and Reinsch 2002). Exchangeable base cations (Ca, Mg, K, and Na) were extracted with 1 N NH_4OAc (pH 7) (Thomas, 1982). Exchangeable calcium and magnesium were determined by EDTA complexio-metric titration while exchangeable potassium and sodium were determined by flame photometry. Effective Cation Exchange Capacity (ECEC) was calculated by the summation of the total exchangeable bases and total exchangeable acidity. Soil organic carbon was analyzed by Walkley and Black wet digestion method (Nelson & Sommers, 1982). Available phosphorous was determined by Bray II method (Olsen & Sommers 1982). Soil pH was measured potentiometrically in both water and 1 N KCl at the soil- liquid ratio of 1:2.5 (Thomas, 1996). Clay activity was calculated by ECEC/Clay x 100.

2.3 Statistical Analysis

Measured variables in the data set were analyzed using classical statistical methods to obtain the descriptive statistics, taking out only the mean and then coefficient of variation was determined to find out how variables vary in the study sites. The statistical analysis was carried out with the aid of SAS (SAS, 1999).

3.0. Results and Discussion

3.1. Morphological Characteristics

Table 1 shows the morphological characteristics of the studied pedons. The soil texture of the four areas was mainly sandy loam, sandy clay loam and clay. Although the sampled four pedons were made up of wetland soils, the soil profiles were deep as at the time of sampling with the shallowest profile having a depth of 140 cm. All the pedons were poorly drained which could be adduced to a high water table of the soils which could have further reduced infiltration, seepage and percolation. The soil colour was evident of soils of the sort where redoximorphic activities were ongoing as the hues ranged from 2.5 YR to 10 YR (moist). There was no root or water restrictive layer within the profile depth in all the pedons in the sites except the water table observed in the Agbo pedon. The soils had mainly weak to moderate blocky structure in the Iyiaba location, prismatic in the surface horizons, and weak to moderate crumb and blocky structure in the Omampe, Orashi, Agbo horizons. The soil consistence (wet) was mostly friable and firm in all the horizons of the four pedons. The Iyiaba and Agbo soils had only firm consistence which graduated to very firm in the lower horizons while the Omampe and Orashi soils had a friable consistence that graduated into firm consistence in the lower horizons. Water and air has been known to either increase or decrease in soils in equal proportion as redoximorphism takes place. Due to a reduced condition in the pedons, there were mainly few roots (having a depth to no root of at least 23 cm) in all the pedons except in Iyiaba soils. The minimum thickness of their surface horizon was 20 cm. A layer that looked like fragipan was observed in most horizons of the pedons which mostly had a coarse prismatic, columnar and or blocky structure. Morphological characterization of studied soils showed that the soil profiles were deep (> 200cm), the hues were 7.5 YR (moist) throughout the profile depth in all the pedons and there was no root or water restrictive layer within the profile depth in all the pedons.

Table 1: Morphological Properties of the Pedons in the Study Area

Horizons	Depth (cm)	Munsell colour (Moist)	Texture	Structure	Consistence (moist)	Drainage	Root abundance
Iyiaba Soil							
A	0-25	5 YR 2.5/1	SL	1crpl	Fi	Poorly drained	Very dark few roots
B	25-65	10 YR 6/2	SL	3cbk	Fi	Poorly drained	Mottles
Btg1	65-82	7.5 YR 5/3	SCL	2mbk	Vfi	Poorly drained	Abundant of roots
Btg2	82-120	10 YR 5/4	SL	2cbk	Vfi	Poorly drained	Mottles and highly un-nodulated
BC	120-170	2.5YR 5/6	SCL	2cbk	Vfi	Poorly drained	No roots
Omampe Soil							
A	0-20	7.5YR 5/8	LS	1mpr	Fr	Poorly drained	Many roots
AB	20-56	10 YR 5/4	LS	1mpr	Fr	Poorly drained	Few roots
Btg1	56-92	7.5YR 4/6	SCL	2mcr	Vfi	Poorly drained	No roots
Btg2	92-160	7.5YR 5/8	SL	1mcr	Fr	Poorly drained	No roots
BC	160-200	7.5YR 5/6	SCL	2cbk	Vfi	Poorly drained	No roots
Orashi Soil							
Ap	0-24	5YR 3/1	LC	1mpr	Fr	Poorly drained	Many roots
AB	24-43	2.5YR 5/3	C	1mpr	Fr	Poorly drained	Few roots
Btg1	43-73	10 YR 5/4	CL	2pl	Fi	Poorly drained	No roots
Btg2	73-140	10 YR 5/4	C	3bk	Fi	Poorly drained	No roots
BCg	140-170	10 YR 5/4	C	3bk	Fi	Poorly drained	No roots
Agbo Soil							
A	0-23	5YR 2.5/1	SL	1mpr	Fi	Poorly drained	Few roots
AB	23-55	5YR 5/1	SL	3bk	Fi	Poorly drained	No roots
C	55-140	5YR 3/1	SL	2mcr	Vfi	Poorly drained	No roots

Texture - LS = Loamy sand, SL = Sandy loam, SCL = Sandy clay loam, C = Clay, CL = Clay Loam, LC = Loamy clay.
Structure - 1 = weak, 2 = moderate, 3 = strong, f = fine, m = medium, c = coarse, g = granular,cr = crumb, bk = blocky, pr = prismatic, pl = platy, ma = massive. **Consistence** (moist) - fi = firm, vfi = very firm, fr = friable, h = hard, s = sticky, ns = non-sticky.

3.2 Physical and Chemical Properties

Table 2 shows the physical and chemical properties of the studied areas. The soil texture from the laboratory analysis was sandy loam to clay in most of the areas. The soils were sandier in Iyiaba, Omampe and Agbo (mean $\geq$ 697 g kg^{-1} $\leq$ 797gkg^{-1}) while it was clay in Orashi (mean = 473 g kg^{-1}). Soil texture has earlier been defined as a near permanent attribute of the soil and hardily does it easily change due to land use, management or conservation [2]. There was a little variation (CV $\geq$ 4 % $\leq$ 10 %) of sand fractions of the soil matrix in the Omampe and Agbo locations. Sand, silt and clay varied moderately (CV $\geq$ 16 % $\leq$ 19 %) in Orashi. The bulk density increased down the natural horizons and was at values (mean $\geq$ 1.21 gcm^{-3} $\leq$ 1.33 gcm^{-3}) that will allow vigorous growth of plant roots and soil organisms. The variation in bulk density of the studied locations was mostly moderate (CV $\geq$16 % $\leq$ 20 %) except in Iyiaba soils were there was a little variation. Bulk density influences availability and flow (lateral or vertical) of soil water and the growth of the plant roots. The results indicated that the soils had values that stood at its optimality (Obi *et al.*, 2015).

The soil reactions were moderately acidic (pH = 5.26 – 5.42) from the upper to the lower horizon (Table 2). This could be due to the parent material from which the soils are derived. The values of pH in KCl (4.75 – 5.09) are lower than pH in H_2O indicating a net negative charge of the exchange complex throughout the horizons. The base (KCl) must have precipitated more acidity in the soil solution. Recommendations of fertilizers for controlling proneness of the soils of the location to acidity must be based on the results from the pH in KCl to ensure that reserved acidity in the soil solution will be taken care of. There was little variation (CV $\geq$1 % $\leq$ 8 %) in soil reaction down the horizons in all the locations. The concentrations of the exchangeable cations (Ca, Mg, Na and K) were low having $\geq$ 0.01 $\leq$ 3.83 Cmolkg^{-1} in the horizons. Ca and Na varied moderately (CV $\geq$ 20% $\leq$ 33%) in the Iyiaba soils while Ca, Mg and Na varied highly (CV $\geq$ 50% $\leq$ 69%) in the Omampe soils. The Effective Cation Exchange Capacity (ECEC) of soils of the study area was generally low ranging from 5.8 – 18.9 Cmolkg^{-1}. Soils of the coastal plain sands origin had earlier been reported to be made of low ECEC, basic cations and base saturation (Lekwa and Whiteside, 1986; Ogban and Ekerette, 2001). The organic carbon contents decreasing with depth indicates that the activity of organisms is more pronounced in the upper horizon (Table 2). Generally, organic matter content of the soils were low (mean = 3.71 – 6.64 %) and varied moderately (CV $\geq$ 14% $\leq$ 92%) in the study area.

Table 2: The Physical Properties of the Studied Location

Ho	Depth cm	pH H_2O	pH KCl	Ca	Mg	Na	K	TEB	ECEC	BS %	Av.P	OC	Sand	Silt	Clay	CA	BD g cm^{-3}	TC
				---------------------cmol kg^{-1}----------------									------- g kg^{-1}------					
Iyiaba																		
A	0 -25	5.83	5.03	0.33	3.20	0.01	0.01	3.55	6.31	56.23	8.96	18.55	749.6	152.8	97.6	0.06	0.99	SL
B	25 -65	5.31	5.08	4.83	3.50	0.01	0.01	8.35	9.51	87.80	3.85	1.79	709.6	13.8	157.6	0.06	1.03	SL
Btg1	65-82	5.55	4.98	2.83	3.40	0.01	0.01	6.23	9.25	67.56	5.81	0.99	589.6	152.8	257.6	0.04	1.25	SCL
Btg2	82-120	5.13	4.89	3.99	3.80	0.01	0.02	7.82	9.18	85.18	3.08	1.99	769.6	52.8	177.6	0.05	1.28	SL
BC	120-170	5.32	4.88	0.50	1.30	0.02	0.02	1.82	4.34	41.92	1.96	2.19	669.6	72.8	257.6	0.02	1.52	SCL
	mean	**5.42**	**4.97**	**2.50**	**3.04**	**0.01**	**0.02**	**5.56**	**7.72**	**67.74**	**4.73**	**5.10**	**697.6**	**112.8**	**189.6**	**0.05**	**1.21**	
	CV (%)	**5.50**	**1.30**	**32.9**	**9.30**	**22.80**	**20.2**	**19.9**			**40.80**	**13.90**	**18.20**	**62.70**	**29.80**		**1.70**	
Omampe																		
A	0-20	5.21	4.82	2.67	2.20	0.01	0.01	4.88	6.64	73.5	13.51	5.39	849.6	32.8	117.6	0.06	1.02	LS
AB	20-56	5.54	5.21	0.18	0.40	0.01	0.02	0.61	1.09	55.8	13.37	5.19	869.6	32.8	97.6	0.02	1.21	LS
Btg1	56-92	5.06	4.63	4.67	2.90	0.01	0.02	7.59	10.79	70.33	7.2	2.39	669.6	12.8	317.6	0.03	1.38	SCL
Btg2	92-160	5.35	4.58	2.50	1.80	0.01	0.02	4.32	4.70	90.00	6.44	1.39	829.6	52.8	117.6	0.04	1.46	SL
BC	160-200	5.14	4.49	1.83	1.70	0.01	0.01	3.55	5.71	57.98	4.34	1.29	769.6	12.8	217.6	0.03	1.59	SCL
	mean	**5.26**	**4.75**	**2.37**	**1.80**	**0.01**	**0.01**	**4.19**	**5.81**	**69.52**	**8.97**	**5.10**	**797.6**	**28.8**	**173.6**	**0.04**	**1.33**	
	CV (%)	**3.60**	**6.00**	**68.3**	**50.8**	**64.90**	**23.6**	**60**			**46.90**	**64.50**	**10.10**	**58.10**	**53.70**		**16.7**	
Orashi																		
Ap	0-24	5.20	5.03	2.83	4.00	0.003	0.11	1.96	4.8	40.8	0.06	10.3	429.6	212.8	74	0.06	0.98	LC
AB	24-43	5.33	4.81	4.67	3.40	0.033	0.01	1.51	4.0	37.8	0.06	7.20	429.6	132.8	114	0.04	1.26	C
Btg1	43-73	5.81	5.23	3.33	3.20	0.002	0.11	1.39	3.2	43.4	0.07	3.90	289.6	152.8	124	0.03	1.29	CL
Btg2	73-140	5.14	4.53	5.50	2.60	0.002	0.10	2.37	4.9	48.4	0.05	2.50	329.6	152.8	125	0.04	1.33	C
BCg	140-170	5.98	5.61	0.08	4.20	0.063	0.01	1.90	4.0	47.5	0.04	9.80	329.6	172.8	74	0.05	1.45	C
	mean	**5.49**	**5.04**	**3.28**	**3.48**	**0.021**	**0.02**	**6.80**	**18.92**	**46.61**	**3.46**	**3.71**	**361.6**	**164.8**	**473.6**	**0.04**	**1.26**	
	CV (%)	**6.90**	**8.10**	**63.4**	**18.4**	**91.90**	**21.6**	**22.7**			**44.60**	**75.50**	**17.80**	**18.40**	**16.50**		**13.70**	
Agbo																		
A	0-23	5.96	5.48	3.16	2.70	0.07	0.01	5.95	11.67	50.97	3.86	16.75	709.6	132.8	157.6	0.07	1.08	SL
AB	23-55	5.00	4.72	3.00	2.90	0.01	0.02	5.92	9.64	61.41	4.06	2.39	769.6	72.8	157.6	0.06	1.25	SL
C	55-140	5.95	5.08	5.33	3.10	0.01	0.03	8.45	11.05	30.75	12.81	0.79	729.6	102.8	167.6	0.07	1.59	SL
	mean	**5.64**	**5.09**	**3.83**	**2.90**	**0.03**	**0.02**	**6.77**	**10.79**	**47.71**	**6.91**	**6.64**	**736.2**	**102.8**	**160.9**	**0.07**	**1.31**	
	CV (%)	**9.80**	**7.50**	**34**	**6.90**	**93.5**	**9.80**	**21.5**			**74**	**92.30**	**4.10**	**29.20**	**3.60**		**19.90**	

Ho- Horizon, TEB- Total exchangeable bases, CEC- Cation exchange capacity, BS- Base saturation, OC- Organic carbon, sand, TC- Textural class, BD- Bulk density, LS- Loamy sand, SL- Sandy loam SCL- Sandy Clay Loam, LC- Loamy clay, C- Clay, CA = Clay activity.

3.3 Classification of Sampled Pedons

All the soils of the studied locations (except Iyiaba) had a fragipan subsurface diagnostic horizon within the pedon and a base saturation (ECEC at 1 N NH_4OAc pH 7) greater than 35 percent at the 140 cm depth below the mineral soil surface. As a result, the soils can be classified as Alfisols (Table 3). This was because the soils satisfied all the conditions as stated above and in soil Taxonomy (Soil Survey Staff, 2006). Because all soils in the study area have audic moisture regime, they could be classified under the Suborder- Udalfs. Omampe and Agbo pedons both had a glossic horizon and a fragipan within 100 cm of the mineral soil surface and as such could be classified under the great group Fraglossudalfs, the Orashipedon had a fragipan within 100 cm of the mineral soil surface and could be classified under the great group Fragiudalfs while the Iyiaba pedon had a kandic horizon (ECEC/Clay < 12 cmol per kg of Clay) and do not have a densic, lithic, paralithic, or petroferric contact within 150 cm of the mineral soil surface and could be classified under the great group Kandiudalfs. The pedons of Omampe and Agbo did not meet any criteria to qualify them to be classified in any of other subgroups and thus was classified as TypicFraglossudalfs, the aforementioned criteria as well qualified the Orashi pedon to be classified as TypicFragiudualfs while the Iyiaba pedon was classified as ArenicPlinthicKandiudalfs because the soils met sandy or sandy-skeletal particle size class criteria throughout a layer extending from the mineral soil surface to the top of a kandic horizon at a depth of 50 to 100 cm and had plinthite in horizons within 150 cm of the mineral soil surface.

Table 3: Classification of the Sampled Pedons

Pedon	Soil Order	Sub-order	Great group	USDA Subgroup
Iyiaba	Alfisols	Udalfs	Kandiudalfs	ArenicPlinthicKandiudalfs
Omampe	Alfisols	Udalfs	Fraglossudalfs	TypicFraglossudalfs
Orashi	Alfisols	Udalfs	Fragiudalfs	TypicFragiudalfs
Agbo	Alfisols	Udalfs	Fraglossudalfs	TypicFraglossudalfs

4.0. Conclusion

The morphological characterization of the pedons was indicative of soils from similar taxa but differing texture and differentiae. The soils were deep although drainage was poor in some of the locations which could be as a result of poor infiltration, percolation and seepage that could have resulted from the differing texture. The soil colour was evident of pedons where redoximorphic features had occurred as a result of the ongoing reactions. The soils had low base saturation, organic carbon contents and effective cation exchange capacity. From the results of the morphological, physical and chemical characterization, the soils were classified- Iyiabapedon as *ArenicPlinthicKandiudalfs*, Omampe and Agbopedons as TypicFraglossudalfs and Orashipedon as TypicFragiudualfs.

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