CHARACTERIZATION AND CLASSIFICATION OF SOME SOILS FOR ARABLE CROP PRODUCTION IN OWERRI, IMO STATE, NIGERIA.

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ABSTRACT

This study was conducted to characterize and classify soils in Owerri area of Imo State, Nigeria for the improvement of agricultural productivity of the area. Three (3) pedons were dug and described in the study area. Samples were collected and routine laboratory analyses were done using recommended FAO procedures. Data obtained were analyzed using mean and coefficient of variation. Results revealed that soil colour of horizons varied from brown (7.5 YR 4/6) moist through dark brown (7.5YR 4/4) moist, light brown (7.5 YR 5/3) moist to reddish brown (7.5 YR 7/4) moist and to red (2.5 YR 4/6) moist. Soil consistence varied from slightly sticky to sticky when wet, friable when moist and loose when dry. Soil texture of the surface soils for Pedon 2 and Pedon 3 were sandy loam and loamy sand for pedon 1 while the subsoils in all the three locations were sandy clay loam. The bulk densities were low (1.41 mg – 1.63mg). The soils were moderately to strongly acidic (4.84 – 6.52). The levels of organic carbon, total nitrogen, available phosphorus and effective cation exchange capacity ranged from (0.21 – 1.59%), (0.02 – 0.13%), (0.53 – 7.36mgkg^{-1}), (2.47 cmolkg) respectively and were generally low to moderate. Base saturation ranged from 71.00 – 83.30% was rated high to very high and were irregularly distributed with profile depth. Exchangeable cations were very low to moderate. The soils of the area are of low fertility status, therefore, it is recommended that application of organic and inorganic fertilizers should be incorporated for maximum yield.

Keywords: Characterization, Arable crops, Classification, Pedon, Crop Production

INTRODUCTION

Soil is a dynamic resource that supports plant life. It is made up of different sized mineral particles, organic matter, and numerous species of living organisms. Thus, soil has biological, chemical, and physical properties, some of which are dynamic and can change in response to how the soil is managed. Soils are classified as natural bodies on the basis of their profile characteristics (Brady and Weil, 1999). Changes in the capacity of soil to function are reflected in soil properties that change in response to management or climate. Soil's productivity can be limited by the factors such as the soil characteristics, agro-ecological factors, topography, parent material, land use and management among others. To avert this limitation, the need for a systematic investigation of the soil resource with respect to their extent, distribution characteristic, behaviour and nutrient status is crucial for developing a productive and sustainable agricultural system.

Most framers in Southeastern Nigeria regard the soil to be the same in every aspect because they are all the same based on geographical location. Onweremadu (2007) reported that characterization and classification of soil of any given location help in generating soil related data which are useful in proper and sustained use of soil resource. There is an increasing demand for information on soils as a means to produce food. Agriculture is the predominant economic activity in Nigeria and because of agricultural development and increasing demand for data in Nigeria, much work is carried out on soil characterization. The coupling of soil characterization, classification and soil mapping provides a powerful resource for the benefit of mankind especially in the area of food security and environmental sustainability**.**

The information obtained from the characterization of soils would also enable farmers to rationally plan the development and use of the lands accordingly, so as to put available agricultural lands to their best uses for sustainable food production.

Different soil individuals require different land use and management practices for optimum and sustainable performance. This is only possible if there is adequate information on the physicochemical properties of the soil type in question. Too frequently, farmers and other land users in the South-eastern Nigeria have treated or handled the soils of this sub-region in a similar manner, wrongly believing that all the soils are the same. This wrong notion and approach has often led to seriously low return on investment, both for agricultural production and other land use types. Therefore, this study was aimed at characterizing and classifying soils of Owerri, Imo

State according to USDA Soil Taxonomy and World Reference Base (WRB).

MATERIALS AND METHOD

Study Area

The study was conducted in Owerri, Imo State, Nigeria. It lies between latitude 05° 17^1 and 05° 49^1 N and longitude 07° 54^1 and 06° 56^1 E. The area has a humid tropical climate. The mean annual rainfall is about 2,500mm. It has annual temperature range of 27 - 32 C and annual relative humidity range of 85 - 90% (NIMET, 2011).

Field Sampling

Free survey method was used in the choice of sampling sites based on landscape changes. The soils profiles were dug, described and soil samples were collected based on horizon differentiation according to FAO procedures (FAO, 2006).

The physical and chemical characteristics of the mapping units identified in the area were used in the characterization and classification of soil. Soil colour was determined *in situ* from genetic horizons moist using Munsel Colour Chat. The soil colours observed helped in the delineation of horizon boundaries and determination of drainage conditions. The soils were characterized after Soil Survey Staff (2010) and World Reference Base (2006) and classified according to Soil Survey Staff (2010) and World Reference Base (2006). Soil samples were collected from genetic horizons of three (3) pedons representing three (3) mapping units using a trowel. Collected samples were put into well labeled polythene bags. Undisturbed core samples were also collected from genetic horizon of modal profile for bulk density analysis. The samples in well labeled polythene bags were air dried, crushed and sieved using 2 mm sieve for physical and chemical analysis.

Laboratory Analysis

Particle size distribution was determined by hydrometer method (Gee and Or, 2002). Soil organic carbon was measured by wet digestion (Nelson and Sommers, 1996). Soil pH was measured with an electrode on 1:2.5 soil-water ratio (Hendershot *et al;* 1993). Exchangeable base were extracted with ammonium acetate (NH_40A_C). Exchangeable calcium and magnesium were determined by ethylene diamineatra acetic acid titration method while exchangeable potassium and sodium were estimated by flame photometer (Jackson, 1962). Available phosphorus was determined by Bray II method (Olsen and Sommers, 1982). While soil Bulk density was measured by undisturbed core sampling method after drying the soil samples in an oven at 105^0C to constant weights (Grossman and Reinsch, 2003).

Statistical Analysis

The data collected were presented on tables, variation among soil properties was established using coefficient or variation and the relationship among soil properties was estimated using correlations.

Soil Classification

Field and laboratory data were used to classify the soils using USDA Soil Taxonomy (Soil Survey Staff, 2010) and World Reference Base (WRS) (FAO, 2006) Classification systems.

Data Analysis

Generated data were subjected to descriptive statistical tools of mean, standard deviation and coefficient of variation.

RESULTS AND DISCUSSION

Morphological Properties of Soils

The morphological properties of soils were shown in Table 1. All the colours were measured under wet condition. Pedon 1 had colour ranging from 2.5 YR 4/6 moist (red) to 7.5 YR 4/4 moist (dark brown), pedon 2 ranged from 7.5 YR 5/3 moist (light brown) to 7.5 YR 7/4 moist (reddish brown) while pedon 3 ranged from 7.5 YR 4/2moist (dark grey) to 7.5 YR 4/6 moist (brown). Soil consistence in pedon 1, pedon 2 and pedon 3 had consistence ranged slightly sticky to sticky when wet, friable when moist and loose when dry.

The Physical Characteristics

The physical characteristics of the representative pedons were presented in Table 2. The result shows that the pedons were generally dominance of sand fraction and decreases with increase in depth with the highest sand occurring in pedon 2 followed by pedon 1 and the lowest occurred at pedon 3. Mean sand were 73.10%, 69.60%, 68.93% respectively.

Clay content ranged from 10.40 % - 30 – 40 % and increases with increasing soil depth with mean values of 25.60 %, 21.40 %, 25.773 % in pedon 1, pedon 2 and pedon 3, respectively. The consistent clay increase down the profile in all the pedons may be due to illuviation and formation of argillic horizon in Bt1 similar results were obtained by silt content ranged from 2.00 % - 8.00 % having no geometric increase or decrease in the study area Adamu (2013). The values of silt were lowest compared to those of sand and clay fractions. The textural class of the studied area was predominantly say loam at the surface horizon and sandy clay loam at the sub-horizons. The sandy nature of these soils could be attributed to the nature of parent materials which is coastal plain sand. Bulk density of the soil ranges from 1.31 mg/m^3 – 1.63 mg/m^3. The highest mean value 1.71mg/m^3 was recorded at pedon 1. The observed values in the study area are within the ideal range for seed germination and roots penetration. The chemical properties of soils in the study area were shown in Table 5. The pH of the soils as measured in water ranges from 4.84 – 6.52 in the study area with mean values; 5.20, 5.61 and 6.40 for pedon 1, pedon 2 and pedon 3, respectively, the highest mean value

occurred in pedon 3. The pH values recorded in the study area are rated; very strongly acidic to slightly acidic (FMANR 2012). Soil organic carbon content in the study area decrease geometrically with increase in soil depth ranging from 0.21% - 1.59%, with mean values of 0.52%, 0.72% and 0.76% for pedon 1, pedon 2 and pedon 3, respectively. The highest mean value occurred at pedon 3. The organic carbon content are rated low using some standards (FMANR 2012). The organic content was relatively higher at the surface soil which correspond with (Abayneh and Ashenafi, 2006) who reported that organic matter content of soils decreased regularly with soil depth in almost all the soils type. Total exchangeable acidity (TEA) of the soil which is a sum of Al and H concentration in the soil were moderate, it ranges from 0.70 cmol kg^{-1} – 1.60 cmol kg^{-1}, with mea values of 1.02 cmol kg^{-1}, 0.9 $cmolkg^{-1}$ and 1.15 $cmolkg^{-1}$ for pedon 1, pedon 2 and pedon 3. Total nitrogen of the soil decrease progressively with increase in soil depth and rated to be low in the study area. Its value ranges from 0.02% - 0.13%, having the highest mean value 0.06, peon 2 and 0.06 pedon 3. The low nitrogen status in the study area could be attributed to leaching and N volatilization as a result of burning which is a major cultural practice in the study area. The findings agree with Lal (1995), who observed that burning hastened volatilization of available nitrogen and thereby depletes the soil total nitrogen.

Available phosphorus of the soil ranges from 0.53mgKg^{-1} – 7.36 mgKg^{-1} with mean values of 1.76mgKg^{-1}, 2.81mgKg^{-1} and 3.62 mgKg^{-1} for pedon 1, pedon 2 and pedon 3 respectively and are rated low, which could be attributed to the acidic nature of the soil. Cation exchange capacity (CEC) decreases geometrically with respect to soil depth in the study area ranging from 2.47cmol kg^{-1} - 7.83 cmol kg^{-1}, with mean values of 4.47 cmol kg^{-1}, 4.10 cmol kg^{-1} and 5.14 cmol kg^{-1} for pedon 1, pedon 2 and pedon 3 respectively. The mean value is rated to be low (FMANR 2012) and could be as a result of high exchangeable bases in the study area . Percentage base saturation of the study is rated high to very high. The values ranges from 71.00 % - 83.30 %, with mean values; 76.10 %, 77.40 % and 74.77 % for pedons 1, 2 and 3 respectively. The high base saturation of the soil could be related to the pH of the studied area, which is consistent to the findings of Miller and Donahue (1995) who observed that the decreasing acidity leaves more exchangeable bases.

Table 1: Morphological Properties of Soils

Horizon	Depth (CM)	Colour Wet	Texture	Consistence Wet	moist	dry	Structure
		Pedon 1					
Ap	0-20	7.5YR 4/4	SL	np	ns	Vfr	W, gr
AB	20 -60	5YR 4/4	SCL	Sp	ss	fr	W – msbk
Bt1	60 - 105	2.5YR 4/6	SCL	Sp	ss	fr	M- csbk
Bt2	105 - 150	2.5YR 4/6	SCL	Sp	ss	fr	M- Csbk
Bt3	150 - 200	2.5YR 4/8	SCL	Sp	ss	fr	Cr-Csbk
		Pedon 2					
Ap	0-23	7.5YR 5/3	LS	np	ns	Vfr	W, F-msbk
Bt1	23 - 45	7.5YR 6/4	SCL	np	ns	vfr	W, fsbk
Bt2	45 - 96	7.5YR 6/4	SCL	np	ns	sfr	M- Crsbk
Bt3	96 -185	7.5YR 7/4	SCL	np	ns	vfr	**F – M sbk**
		Pedon 3					
Ap	0-35	7.5YR 4/2	LS	np	ns	Vfr	W, gr
Bt1	35 - 95	7.5YR 5/4	SCL	np	ns	vfr	W-m sbk
Bt2	95 - 175	7.5YR 4/6	SCL	np	ss	fr	Cr –sbk

SL = Sandy loam, SCL = Sandy clay loam, LS = Loamy sand
Consistence: np = non plastic, sp = slightly plastic, fr = Friable

Structure : SBK = Subangular blocky, gr = granular

Table 2: Physical Properties of the Studied Sites

Pedon	Horizon	Depth Cm	Sand %	Silt %	Clay %	B.D (Mg/m^3)	T C
				Pedon 1			
1	**Ap**	0-20	83.60	6.00	10.40	1.74	LS
	AB	20-60	69.60	2.00	28.40	1.73	SCL
	Bt1	60-105	69.60	4.00	28.40	1.50	SCL
	Bt2	105-150	65.60	4.00	30.40	1.81	SCL
	Bt3	150-200	63.60	6.00	30.40	1.75	SCL
		MEAN	**69.60**	**4.40**	**25.60**	**1.71**	
		C.V (%)	**11.70**	**38.00**	**33.40**	**7.00**	
		CV Ranking	**Low**	**High**	**Moderate**	**Low**	
				Pedon 2			
2	**Ap**	0- 23	79.60	8.00	12;40	1.70	LS
	AB	23 - 45	73.60	4.00	22.40	1.65	SCL
	Bt1	45- 96	69.60	6.00	24.40	1.64	SCL
	Bt2	96-185	69.60	4.00	26.40	1.31	SCL
		MEAN	**73.10**	**5.50**	**21.40**	**1.58**	
		C.V (%)	**6.50**	**34.80**	**29.10**	**11.30**	
		CV Ranking	**Low**	**Moderate**	**Moderate**	**Low**	
				Pedon 3			
3	**Ap**	0-35	75.60	8.00	16.40	1.65	LS
	Bt1	35 - 95	65.60	4.00	30.40	1.63	SCL
	Bt2	95 - 175	65.60	4.00	30.40	1.78	SCL
		MEAN	**68.93**	**5.33**	**25.73**	**1.69**	
		C.V (%)	**8.40**	**43.30**	**31.40**	**4.80**	
		CV Ranking	**Low**	**High**	**Moderate**	**Low**	

Where TC = Textural Class, SL = Sandy Loam, LS = Loam Sand, B.D = Bulk Density, CV = Coefficient of Variation, SCL = Sandy Clay Loam,

Table 3: Chemical Characteristics of the Studied Area

Horizon	Depth Cm	pH(H20)	O.C.%	O.M.%	TEA	A3	H+	T.N%	Ca	Mg	K	Na	ECEC	%BS	Avail. P	
						Cmolkg^{-1} ←			→		Cmolkg^{-1} ←					mgkg^{-1}
							Pedon 1									
Ap	0-20	5.56	0.93	1.61	1.30	0.90	0.40	0.08	3.60	1.40	0.17	0.14	6.61	80.30	3.26	4.56
AB	20-60	5.17	0.85	1.47	0.80	0.40	0.40	0.07	2.40	1.20	0.16	0.11	4.67	82.80	3.07	3.69
Bt1	60 - 105	5.27	0.39	0.68	1.00	1.00	0.20	0.03	1.60	1.20	0.25	0.10	4.35	72.40	1.35	1.60
Bt2	105 -150	5.17	0.23	0.41	0.70	0.70	0.40	0.02	1.80	1.00	0.22	0.13	4.23	74.00	0.53	0.90
Bt3	150-200	4.84	0.21	0.37	0.50	0.50	0.20	0.02	1.20	0.40	0.12	0.05	2.47	71.00	0.59	0.96
	MEAN	**5.20**	**0.52**	**0.91**	**0.70**	**0.70**	**1.02**	**0.04**	**2.12**	**1.04**	**0.18**	**0.11**	**4.47**	**76.10**	**1.76**	**2.34**
	C.V (%)	**5.00**	**66.00**	**65.10**	**25.40**	**36.40**	**34.20**	**65.50**	**44.00**	**37.00**	**27.90**	**33.10**	**33.00**	**6.80**	**75.20**	**71.7**
	Ranking	**LV**	**HV**	**HV**	**MV**	**MV**	**MV**	**HV**	**HV**	**HV**	**MV**	**MV**	**MV**	**LV**	**HV**	**HV**
							Pedon 2									
Ap	0-23	6.18	1.59	2.75	1.20	0.90	0.30	0.13	2.40	2.00	0.15	0.07	5.32	79.30	7.36	
AB	23-45	5.64	0.73	1.27	0.70	0.40	0.30	0.06	2.00	1.20	0.14	0.17	4.21	83.30	2.62	
Bt1	45 - 95	5.29	0.29	0.51	0.90	0.70	0.20	0.03	1.60	0.80	0.27	0.13	3.70	75.60	0.66	
Bt2	95 - 185	5.32	0.27	0.48	0.90	0.60	0.30	0.02	1.20	0.80	0.15	0.10	3.15	71.40	0.60	
	MEAN	**5.61**	**0.72**	**1.25**	**0.93**	**0.65**	**0.28**	**0.06**	**1.80**	**1.20**	**0.18**	**0.12**	**4.10**	**77.40**	**2.81**	
	C.V (%)	**7.40**	**85.80**	**84.90**	**22.30**	**32.00**	**18.20**	**82.80**	**28.70**	**47.10**	**34.80**	**36.40**	**22.60**	**6.60**	**98.30**	
	Ranking	**LV**	**HV**	**HV**	**MV**	**MV**	**MV**	**HV**	**MV**	**HV**	**MV**	**MV**	**MV**	**LV**	**HV**	
							Pedon 3									
Ap	0-35	6.35	1.51	2.60	1.60	1.50	0.10	0.13	4.00	2.00	0.14	0.09	7.83	72.50	5.86	
Bt1	35-95	6.30	1.41	0.72	1.15	0.70	0.45	0.03	1.60	1.20	0.15	0.10	4.20	72.60	4.11	
Bt2	95-175	6.52	0.37	0.65	0.70	0.60	0.10	0.03	1.20	1.20	0.15	0.13	3.38	79.20	0.90	
	MEAN	**6.40**	**0.76**	**1.32**	**1.15**	**0.93**	**0.22**	**0.06**	**2.27**	**1.47**	**0.15**	**0.11**	**5.14**	**74.77**	**3.62**	
	C.V (%)	**1.80**	**84.80**	**83.60**	**39.10**	**52.90**	**93.30**	**91.20**	**66.80**	**31.50**	**3.90**	**19.50**	**46.10**	**5.10**	**69.40**	
	Ranking	**LV**	**HV**	**HV**	**HV**	**HV**	**HV**	**HV**	**HV**	**MV**	**LV**	**MV**	**HV**	**LV**	**HV**	

KEY: O.C = Organic Carbon, O.M = Organic Matter, TEA = Total Exchangeable Acidity, T.N = Total Nitrogen
ECEC = Effective Cation Exchange Capacity, %BS = Percentage Base Saturation.
Avalable p = Available phosphorus

Soil Classification

Classification of the study area as shown on Table 4.4 below were done based on the analytical result of the soil physical and chemical properties of the soil and environmental observations carried out during the studies. Soils are classified using USDA Soils Classification System (Soil Survey Staff; 2010) and World Reference Base system (WRB).

The soils of the studied area are classified generally as Alfisols; which exhibits clay contents accumulation in the subsoil more than topsoil and Base saturation greater than 35%. It has also been reported that most prevalent soils in south eastern Nigeria including Imo State is dominantly Alfisols, Inceptisols, Ultisols, Entisols, and Oxisols, (Lekwa and whiteside., 1986).

CONCLUSION

The study has shown that the soils of the studied areas were highly weathered belonging to Alfisols. There were clay accumulation at the subsurface soils and base saturation were greater than 35%. The studied areas had low fertility status as shown in low organic carbon content, total nitrogen, available P and low cation exchange capacity. However, cultural and management practices such as crop rotation, bush fallowing, organic manuring should be incorporated into the soil to improve soil fertility and structural stability.

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