CHARACTERIZATION AND VARIABILITY OF SOILS FORMED ON A TOPOSEQUENTIAL FLOODPLAIN IN URATTA, SOUTH EASTERN NIGERIA

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Abstract: The study was carried out on a floodplain formed by Okitankwu River, Uratta South-eastern Nigeria with the aim of characterizing and studying the variability of soils of the area for optimal management and utilization. A transect survey technique was used to align the physiographic positions at an equidistance of 100 m. Three pedons were dug on each of the physiographic positions which consist of the upland, terrace and backswamp. Samples were collected and subjected to routine analysis. Data generated was analyzed statistically using coefficient of variation. The pH (H_2O) indicated that soils were moderately acidic with ranges of 5.37- 5.48 at upland, 5.38 - 5.50 at terrace, and 5.39 – 5.93 at backswamp. However, the soil horizon of each physiographic position show that soils were generally low to moderate in cation exchange capacity (2.80 – 6.80) cmol/kg, low to moderate in percent base saturation (24.19 – 65.22) % and low in organic matter content (0.15 – 3.41 %). The coefficient of variation (CV) showed that sand contents and pH values had low variation in all the physiographic positions. High variation in organic carbon and total nitrogen were recorded in all the physiographic positions, while total exchangeable acidity, effective cation exchange capacity and base saturation indicated moderate variation in all physiographic positions. These results provide a baseline data of Uratta floodplain soils. The information obtained from this study indicates that the soils need adequate management for a sustainable utilization.

Keywords: Characterization, floodplain, physiographic, survey, toposequence, variability

Introduction

Floodplains (wetlands) are areas bordering or adjacent to the course of the rivers or streams. Generally, they have low gradient and are liable to seasonal flooding during the rainy season. The lowlands of floodplains that are periodically inundated during normal flood aid in the mitigation of flood (Cunningham and Cunningham, 2004). Floodplains are usually fertile, flat, and easily farmed. In most of the developed world floodplains are widely farmed and cleared of vegetation. Farmers go to flooded areas for their activities because they are usually very fertile for farming; there is availability of water and nutrient for crop growth in these areas. But in developing world floodplains are largely ignored because the agronomic task on the soils are more arduous and tedious than on upland soils (Eshette, 1990).

Irrespective of the various uses of floodplains, several workers (Obi, 1984; Ojanuga *et al.*, 1996) have observed that in Nigeria floodplain soils are unknown, undeveloped and underutilized. The complexity of their habitat coupled with paucity of scientific knowledge of most of the wetland soils in Nigeria have contributed to their underutilization (Omoti, 2001). The characteristics of the floodplain varied widely in accordance with the multiplicity and diversity of ecologies with which they are associated (Eshette, 1994).

The use of floodplains for arable cropping usually depends on the hydrological characteristics, particularly the flooding regime. Crops grown on the floodplains include maize, cowpea, rice, okra, melon, pumpkin, garden egg, pepper, yam, etc. (Eshette, 1993). It has therefore, become imperative in these days of declining productivity from upland agriculture to expand arable cropping into these vast and hitherto little exploited floodplain resources.

The significance of soil variability from one site to another on a given landscape, based on the examination of soil survey maps; reveals that variability seldom coincide with management boundaries of fields that are used by farmers for agricultural crops. As a consequence, soil properties in one section of the field may require management system quite different from those that are best for other sections of the same field (Soil Survey Staff, 1993). However, floodplains characteristics and potentials are little understood (Ogban and Babalola, 2003). The need to expand for food production and effective soil management practices in floodplain soils necessitated this investigation which aimed to ascertain the characteristics and variability of soils on a toposequential floodplain.

Materials and Methods

Study area

The study was conducted on a toposequential floodplain along Okitankwu River at Uratta (Fig. 1) in Imo State, South-eastern Nigeria lying between latitudes 5° 15' N – 5° 52' N and longitude 7° 00'E - 7° 30' E, with a mean elevation of about 70 meters above sea level. The geomorphology of the area comprises mainly of floodplain and the Coastal Plain Sand (Ofomata, 1987). The area is characterized by a flat relief and hydromorphism which is caused by both high level water table and seasonal flooding. The area is in the rainforest zone of Southern Nigeria with an annual rainfall range of 1500 to 2200 mm (Ministry of Agriculture, 2010). The average annual atmospheric temperature is above 20°C (Ministry of Agriculture, 2010). It is characterized by abundance of many plant species. Vegetation is made-up of canopies with sun-loving ones appearing as emergent. Trees and shrubs are seen in large mass while some areas are dominated by grasses. Farming is a major socio-economic activity, with arable farming predominating.

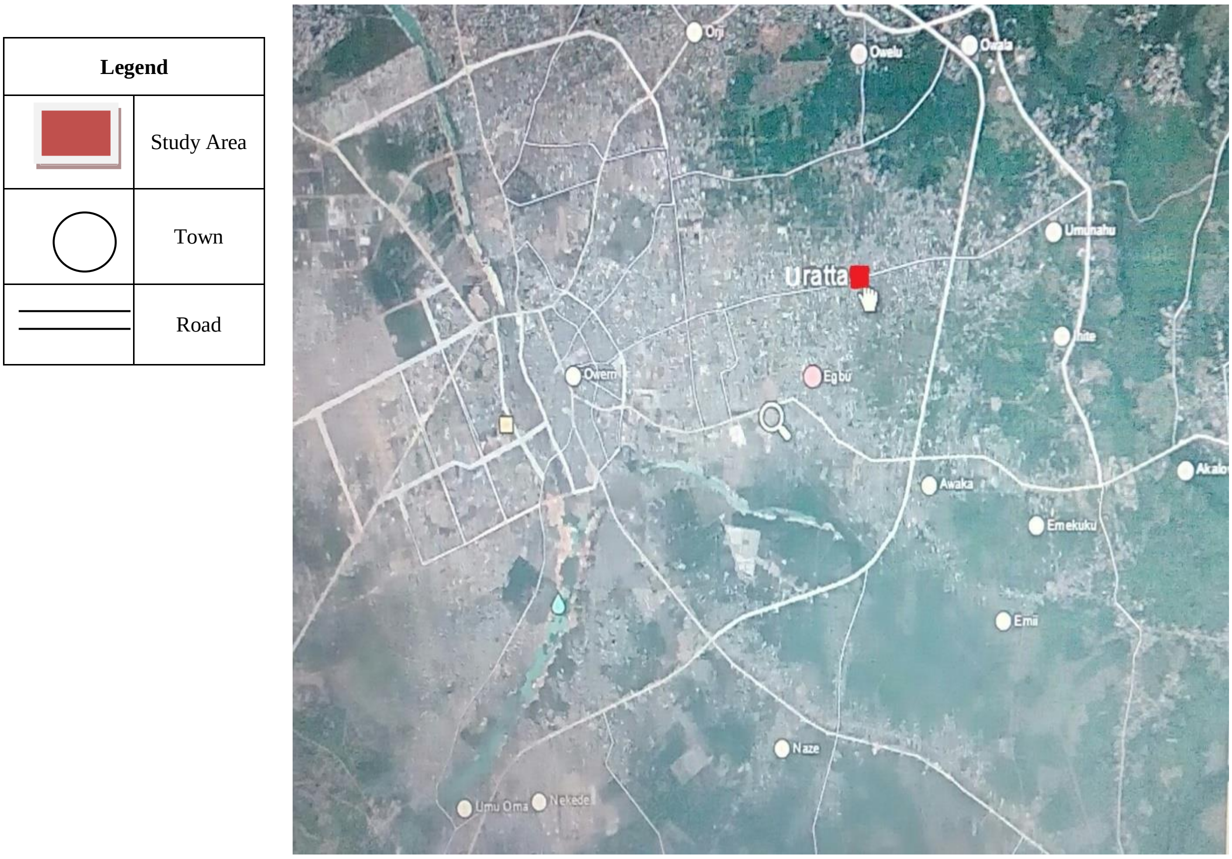

Fig. 1: Location map of the study area (Google Imagery, 2016)

Field studies

The site selected for this study was guided by observed variability in geomorphic feature form of terrain change with movement towards the river. It was a survey by transect approach. Transverse was cut across running from the upland passing through terrace and to the backswamp. A pedon was dug on each physiographic position given rise to a total of three pedons. Profile description and sampling were done according to FAO guidelines (FAO, 2006).

Laboratory analysis

Particle size distribution was determined by Bouyoucos hydrometer method (Gee and Or, 2002). Soil pH was measured electrometrically using glass electrode pH meter in a solid-liquid ratio of 1:2.5 (Hendershot *et al.*, 1993). Total nitrogen was determined by micro-Kjeldahl digestion technique method (Bremner, 1996). Exchangeable bases were determined by the neutral ammonium acetate procedure buffered at pH 7.0 (Thomas, 1982). Exchangeable acidity was got by a method described by McLean (1982). Total carbon was analyzed by wet digestion (Nelson and Sommers, 1982). Phosphorous was determined by Bray ll method according to the procedure of Nelson and Sommers (1982). Cation Exchange Capacity was determined using neutral ammonium acetate leachate method (Summer and Miller, 1996). Dispersion ratio was used to determine the erodibility of the soils in which greater than 15 % are erodible and less than 15 % are not erodible.

Data analysis

The data obtained were subjected to descriptive statistics and coefficient of variation according to Wilding *et al*. (1994).

Results and Discussion

The results of physical properties of soils in the floodplain area are shown in Table 1. The backswamp, terrace, and upland soils as shown in the results were predominance of sandy loam to loamy sand as their textural classes. The backswamp had the thickest A-horizon (26 cm) relative to terrace with thickness of 24 cm whereas the upland had a thickness of 15 cm. It is equally observed that the thickness of A-horizon increases from the upland to the backswamp and might be as a result of lateral movement of soil materials by runoff down to the slope especially since it has been under cultivation for a long period of time. The general sandy nature of the study site could be as a result of parent material (Onweremadu, 2007). The upland had higher values of sand fraction than the flooded areas. The backswamp and terrace had preponderance of clay fractions (15.3 % and 13.1 %) while the upland had average clay value of 12.85 %. The distribution of clay fraction down the profile showed low variability on the upland and backswamp while at the terrace it had moderate variation. This variability may be as a result of slope factors, soil structure and clay type. The percent clay alone the slope will encourage plant growth through enhanced moisture and nutrient status of the soil mostly at the backswamp. Smith *et al.* (1998) observed that particle size distribution specifically silt and clay fraction with organic matter content have good relationship with specific surface area, soil compatibility and compressibility, all of which affect productivity of soils. The mean values of soils dispersion ratio (49.72 – 75.83) implies that these soils are erodible (Middleton, 1930). These mean values of dispersion ratio were higher at the terrace and backswamp along the slope suggesting higher soil erodibility in those locations. The erodibility of the study site could be attributed to activities of man over the years, through bush burning, cultivation and indiscriminate cutting of trees such that most of the land area is exposed to agents of soil erosion. Igwe (2005) observed that the higher the dispersion ratio the greater the ability of the soil to disperse. Soil dispersion ratio indicated low variability at the upland (4.93 %) and backswamp (9.19 %) while moderate variability was observed at the terrace (16.71 %). The variability could be attributed to runoff, slope factors, organic matter content and soil texture. Erodibility can contribute to high leaching and washing away of soil nutrients which will invariably affect crop yield. Perhaps, the use of organic matter and fertilizer alongside other soil management practices should be encouraged in the study area in order to attain high yield and sustainability.

Table 1: Physical properties of studied soils

Horizon	Depth (cm)	PSD in Water Sand	PSD in Water Clay	PSD in Water Silt	TC	SCR	PSD in Calgon Sand	PSD in Calgon Clay	PSD in Calgon Silt	TC	SCR	DR(%)
			(%)					(%)				
					BACKSWAMP							
A	0-26	78.9	13.1	8	LS	0.61	66.6	19.4	14	SL	0.72	63.17
AB	26-55	77.9	15.1	7	SL	0.46	70.6	19.4	10	SL	0.52	75.17
Bt_1	55-96	76.9	17.1	6	SL	0.35	70.6	21.4	8	SL	0.37	78.57
Bt_2	96-125	75.9	16.1	8	SL	0.49	70.6	17.4	12	SL	0.69	81.97
Bt_3	125-160	75.9	15.1	9	SL	0.59	70.6	23.4	6	SL	0.26	81.91
Mean		77.1	15.3	7.6		0.49	69.8	20.2	10		0.51	75.83
CV (%)		1.52	6.69	13.12		23.89	2.29	10.10	28.28		34.93	9.19
					TERRACE							
A	0-24	81.9	12.1	6	LS	0.49	80.6	15.4	4	SL	0.26	93.29
AB	24-46	82.9	11.1	6	LS	0.54	70.6	23.4	6	SCL	0.26	58.16
Bt_1	46-68	80.9	14.1	5	LS	0.36	72.6	23.4	4	SCL	0.17	71.17
Bt_2	68-92	80.9	13.1	6	LS	0.46	70.6	23.4	6	SCL	0.26	64.97
Bt_3	92-134	78.9	17.1	4	SL	0.23	66.6	27.4	6	SCL	0.22	63.17
Bt_4	134-200	80.9	11.1	8	LS	0.72	72.6	23.4	4		0.17	69.71
Mean		81.1	13.1	5.8		0.44	72.28	22.73	5		0.22	68.16
CV (%)		1.49	15.88	20.86		39.87	5.88	15.80	24.50		18.37	16.71
					UPLAND							
A	0-15	83.9	11.1	5	LS	0.45	66.6	29.4	4	SCL	0.14	48.20
AB	15-68	82.9	13.1	4	LS	0.31	64.6	31.4	4	SCL	0.13	48.31
Bt_1	68-126	81.9	12.1	6	LS	0.49	62.6	33.4	4	SCL	0.12	48.39
Bt_2	126-200	80.9	15.1	4	SL	0.27	64.6	29.4	6	SCL	0.20	53.96
Mean		82.4	12.85	4.75		0.37	64.6	30.9	4.5		0.15	49.72
CV (%)		1.36	11.52	17.47		31.27	2.19	19.25	5.44		20.82	4.93

TC= textural class, SCR= silt clay ratio, LS= loamy sand, SL= sandy loam, PSD= particle size distribution, DR= dispersion ratio, CV= coefficient of variation, < 15= low variability, >/= 15<35= moderate variability, > 35= high variability

Table 2: Chemical properties of studied soils

Horizon	Depth (cm)	pH (H_2O)	pH (KCl)	TEB (cmol/kg)	TEA (cmol/kg)	CEC (cmol/kg)	ECEC (cmol/kg)	BS (%)	OC (%)	OM (%)	TN (%)	AP (mg/kg)
						BACKSWAMP						
A	0-26	5.89	4.88	3.91	0.96	6.8	4.87	57.50	1.98	3.41	0.189	2.8
AB	26-55	5.46	4.78	1.65	0.72	5.2	2.37	31.73	1.14	1.97	0.158	3.2
Bt_1	55-96	5.67	4.99	2.98	1.04	5.6	4.02	53.21	0.66	1.14	0.053	3.1
Bt_2	96-125	5.93	5.11	1.50	1.20	6.2	2.78	24.19	0.53	0.91	0.053	2.3
Bt_3	125-160	5.45	4.75	0.99	1.12	2.8	2.11	34.36	0.26	0.46	0.021	3.5
Mean		5.57	4.9	2.06	1.02	5.32	3.23	40.19	0.91	1.58	0.095	3
CV (%)		3.57	5.22	52.71	16.37	25.78	30.30	32.07	66.43	65.75	69.52	13.58
						TERRACE						
A	0-24	5.44	4.96	3.00	1.44	4.6	4.44	65.22	1.64	2.83	0.184	2.2
AB	24-46	5.43	4.77	2.23	1.04	5.4	3.27	41.29	1.58	2.73	0.131	2.2
Bt_1	46-68	5.38	4.58	1.41	0.96	3.6	2.37	39.17	0.92	1.59	0.110	2.7
Bt_2	68-92	5.49	4.88	2.47	1.12	5.8	3.39	42.59	0.26	0.46	0.068	2.4
Bt_3	92-134	5.43	4.95	1.76	1.44	5.0	3.20	35.20	0.26	0.46	0.042	3.1
Bt_4	134-200	5.5	4.99	1.70	0.88	3.6	2.58	47.22	0.88	0.15	0.032	2.0
Mean		5.45	4.86	2.10	1.15	4.67	3.24	45.12	0.79	1.37	0.094	2.4
CV (%)		0.75	2.93	25.46	19.12	7.94	20.92	21.47	80.45	79.89	57.01	15.4
						UPLAND						
A	0-15	5.39	4.72	1.94	1.04	5.4	2.98	35.93	1.85	3.19	0.168	5.4
AB	15-68	5.48	4.99	1.12	0.72	4.6	1.84	24.38	0.84	1.44	0.079	3.4
Bt_1	68-126	5.37	4.79	1.71	0.64	5.2	2.35	32.89	0.35	0.61	0.063	2.3
Bt_2	126-200	5.46	5.02	1.95	0.80	5.0	2.75	39.00	0.31	0.53	0.042	3.6
Mean		5.43	4.88	1.68	0.80	5.1	2.48	33.05	0.84	1.40	0.088	3.68
CV (%)		0.85	2.62	20.07	18.69	5.88	17.45	16.56	73.89	74.30	54.56	30.22

TEB= total exchangeable bases, CEC= cation exchange capacity, ECEC= effective cation exchange capacity, BS= base saturation, OC= organic carbon, OM= organic matter, TN= total nitrogen, Av.P= available phosphorous, TEA= total exchangeable acidity, CV= coefficient of variation, < 15 =low variability, >/= 15<35= moderate variability, > 35= high variability

The study reviewed that soil pH (H_2O) (Table 2) were moderately acidic in all the physiographic positions according to the ratings of Chude *et al*. (2011). The level of soil acidity decreased with increasing slope gradient. The soil pH both in water (H_2O) and potassium chloride solution (KCl) recorded low variability in all the pedons. This may be attributed to acidic nature of the tropical soils (Udo, 1980) and the prevalence of high precipitation which results to the washing off and eluviation of basic cations in the soil. This is one of the major characteristics of tropical soils that are always subjected to severe weathering resulting from its harsh climate. Soil acidity has a negative effect on nutrient availability especially phosphorous. This pH level could have also accounted for the low exchangeable bases especially calcium. Mean Soil organic matter values were 1.58 % for backswamp, 1.37% for terrace and 1.40% for upland. Higher values of organic matter were found in backswamp when compared with other physiographic positions. The results showed that organic matter content decreased down the profile and increased with an irregular trend down the slope (backswamp). These could be possible as a result of variation in deposition of organic material down the slope. Another possible reason is that the backswamp is nearer the water table and reduction reaction takes place more leading to limited oxidation of organic matter. It may equally have resulted to the high variability of organic matter (OM) along the slope. The low values of OM in other physiographic positions (terrace and upland) may be due to high mineralization of organic materials deposited which is peculiar to tropical climate.

Similarly, increase in activities of decomposers may lead to exhaustion and subsequent immobilization of OM by microbes (Unamba-Oparah, 2005). The higher organic matter content might result in higher agricultural productivity in backswamp relative to other slope gradient. The total nitrogen content of the different pedons were low when compared with critical limit (1.5- 2.0 %) of Chude *et al.* (2011) and follows a similar trend to that of organic matter. This also shows that increase application of nitrogen fertilizers in the lower slopes by farmers can lead to excessive nitrogen accumulation in the soil, which may result in the adverse agronomic and environmental consequences, if soils were not subject to proper analysis and treatment thereafter. The low N values of the floodplains may be as a result of nitrogen losses through leaching under flooded situation. Flooding causes depletion of nutrient element in floodplains, which could affect crop production drastically. Nelson and Terry (1996) observed drastic loss of soil nitrogen after flooding. Therefore, low nitrogen content of the soil if not supplemented with fertilizer will grossly amount to poor yield of crops. The available phosphorous of the study site had mean of 2.3 mg/kg at backswamp, 2.4 and 3.68 mg/kg for terrace and upland, respectively. The pedons recorded moderate variability at the upland while low variability was recorded at the terrace and backswamp. The higher values of Av.P on upland soil may be largely due to the soil management practices as well as cultural practices which include the use of organic and inorganic fertilizers, which serve as source of slow and uniform release of phosphorus.

Also delay in the fixation of phosphorous in the soil. The low level of available P also, suggest that P may chemically bound as Fe and Al phosphate due to high acidity in the sandy soils (Ibia and Udo, 1993; Effion g*et al.*, 2006) or that P is removed by sedimentation (Patrick, 1990). The CEC of the pedons has moderate variability at the backswamp and low variability at the terrace and upland. The CEC of the pedons were generally low when compared with the ranking of Landon (1991) indicating the inability of the soils to retain nutrient and water. The CEC of the studied pedons can be an index of low chemical weathering activity of the soil (Okunsami and Oyediran, 1985) and level of soil pH. However, the quantity of cations that a soil can retain against leaching is determined by the magnitude of the cation exchange capacity of the soil. Higher values of CEC were found at the backswamp and upland. This implies that exchangeable cations are likely to be washed easily at the terrace. According to Brady and Weil (1999) nutrient leaching results not only in declining soil fertility but also in environmental problems caused by the accumulation of nutrients in the ground water and the eutrophication of river. The CEC of soils formed in fine materials appears higher than those of coarse fine loamy materials (Eshette, 1985). Low level of cation exchange capacity in soils could be associated with tidal imports, distance from the coast, fresh water input, runoff and see page (Ukpong, 2000). Base saturation recorded a moderate variability of values 32.07%, 21.47% and 33.05% at the backswamp, terrace and upland, respectively. Lower percent base saturation at the upland may also indicate that the exchangeable cations which are mostly soluble are moved down the slope by agents of soil erosion and are deposited on the backswamp because it is the zone of reduced moisture movement (Anikwe *et al.*, 1999).

Conclusion

The results of the study revealed that the floodplains have higher fertility potentials compare to the uplands. However, this shows that the floodplain has potentials of producing high yield of crops. It is also an indication that the floodplain requires minimal soil management practices when compared to the uplands. The results of the study also reveals the erodibility rate of the pedons at each physiographic position which will be a guide to land user in order to adopt soil management practices that will reduce erosion activities. Also, soil mining on floodplain areas should be discouraged so as to conserve it for sustainable use.

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