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Properties and Classification of Urban Agricultural Soils along River Salanta (Sharada), Kano, Nigeria.

Mukhtar, A.A.[1] and Samndi, A. M.[2]

[1]*Department of Agronomy, Faculty of Agriculture, Nasarawa State University Keffi, P.M.B 135. Nasarawa, Nigeria.*

[2]*Department of Soil Science Faculty of Agriculture Bayero University Kano, Nigeria.*

Corresponding Author: dattijoh@nsuk.edu.ng

Abstract

River Salanta is a slow flowing river that flows through Sharada and Challawa industrial areas of Kano city and located on latitude 11º 63' N to N11º 67' N and longitude 8º 43' E to 8º56' E. The study was conducted to classify the soils along the bank of this urban river, the main purpose of any classification is to establish groups or classes of soils under study in a manner useful for practical and applied purposes in predicting their behaviour, identifying their best uses and, estimating their productivity. Three pedons were georeferenced, sunk and described on the field. Morphologically the pedon 1 was moderately shallow (80 cm), pedon 2 was deep (107 cm) and pedon 3 was very deep (165 cm). Bulk densities were generally low across the three pedon (1.01-1.35 gcm^{-3}), the three pedons have sand dominated texture (653.6 – 873.6gkg^{-1}) soil pH were moderate to slightly alkaline (7.59-8.86) across the three pedons, Cation Exchange Capacity (NH_4OAc), P, TN, and base saturation were 7.75 – 6.11cmolkg^{-1}, 10.22 – 26.85 mgkg^{-1}, 0.7 – 0.035mgkg^{-1}, and 68.39 – 80.83% respectively. The three pedons were classified according to the USDA Soil Taxonomy as Typic Endoaqualfs, while applying the WRB; the soils were classified as Eutric Gleysols.

Keywords: *Properties, Classification, Urban agricultural soils, Sharada.*

INTRODUCTION

Soil classification is the systematic arrangement of soils into groups or categories on the basis of their characteristics (Jones *et al*., 2013). The main purpose of any classification is to establish groups or classes of soils under study in a manner useful for practical and applied purposes in predicting their behaviour, identifying their best uses, estimating their productivity and providing objects or units for research and for extending and extrapolating research results (Jones *et al*., 2013; Soil Survey Staff, 2006; IUSS, 2006). It has been established that in Kano some farmers use sludge along the urban rivers as manure for crop production, which has both negative and positive effects on soil's physical and chemical properties and with their associated health hazard (Olofin, 1999; Tanko, 2004). None of these studies have gone further to determine the morphological properties and as well classify the soils at the bank of this respective urban river. This study was carried out on urban agricultural soils along the bank of River Salanta (Sharada) in Kano metropolis.

Materials and Methods

Setting of the Study Area: River *Salanta* is a slow flowing river that flows through Sharada and Challawa industrial areas of Kano city and located on latitude 11º 63' N to N11º 67' N and longitude 8º 43' E to 8º56' E. The river has an average speed of about 4.5km/h, with a mean depth of 2meters and a width of about 6.5meters (Antwi 1980). Hydromorphic soils tend to occur throughout Kano state, where annual flooding occurs; these soils are dark grayish in colour and have high content of clay. The climate of the area is tropical wet and dry, which has an annual rainfall of about 1200mm and duration of 2 - 3 hours, average intensity of 50mm/hr (Edonga *et al*., 2000).

Field Studies: Field studies were carried out along River Salanta, three profile pits were sunk in April 2014. The profile pits were described and sampled based on their genetic horizon differentiations. Soil morphological characteristics were described according to the procedure in the USDA Soil Survey Staff Manual (Soil Survey Staff, 2002). The following features were observed, Soil colour using the munsell colour chart, soil depth, mottles, texture, consistency, horizon boundary, roots, concretions, pore distribution.

Laboratory Analysis: The bulk soil samples collected were air-dried and gently crushed in porcelain mortar and passed through a 2 mm sieve. Particle size distribution was determined by the hydrometer method (Gee and Or 2002). The soil pH was determined in water using a ratio of 1:2.5 (IITA, 1979). Exchangeable Ca, Mg, Na and K were extracted with 1M ammonium acetate (1M NH4OAc) solution buffered at pH 7.0, as described by Anderson and Ingram (1998). Potassium and Na in the extract were read on flame analyzer, while Ca and Mg were read with atomic absorption spectrophotometer (AAS). Cation exchange capacity of the soil was determined with 1M NH_4OAc (1M ammonium acetate), buffered at pH 7.0 (Chapman, 1965; Rhodes, 1982). The Effective Cation Exchange Capacity (ECEC) was obtained by the summation of exchangeable bases and exchange acidity. Organic carbon was determined by the wet oxidation method of Walkley- Black as described by Nelson and Sommers (1982). The total nitrogen content of the soil was determined using the macro kjeldahl technique as described by Bremner (1982). Available phosphorus was extracted using the Bray No.1 method (Bray and Kurtz, 1945). Phosphorus in the extract was estimated colorimetrically in molybdo-phosphoricblue method as described by Murphy and Riley (1962).

Results and Discussions

Morphological Properties: The morphological properties (summarized in table 1) showed that the pedon 1 (80 cm) was moderately shallow while pedon 2 (107 cm) and three (165 cm) were deep to very deep. Soil depths were restricted by presence of water table and depth variation maybe due to variation in topography between the profile pits. Surface soils developed across Salanta River were dark brown (10YR3/3) to brown (7.5YR3/2, 7.5YR5/4) while Subsurface horizons were brown (7.5YR5/4), dark grayish brown to light brownish grey (10YR4/2 to 10YR6/2), The brownish colouration at the surface soils might also be attributed to organic matter in the soil which agreed with the reports of Nuhu (1983), which states that brownish colouration in surface horizons, were due to presence of organic matter which is the main colouring agent in surface soils. Pedon two had mottled subsoils which are dark yellowish brown (5YR6/8, 5YR3/4) few medium coarse mottles, which was attributed to poor drainage oxidation-reduction cycles, as the soil dry out in dry season, which leads to iron oxide segregation in form of mottles.

The surface soils of Sharada were moderate medium subangular blocky while subsoils were massive in structure. The subangular blocky structures could be attributed to greater pedogenic development such as clay illuviation. Horizonation appear clear between the surface and subsurface layer, the Soils were well developed from the degree of horizonation at subsurface B horizon. There was a general increase in clay content with increasing profile depth, an avidence of elluviation-illuviation processes.

Table 1: Soil morphological properties and classification of Salanta (Sharada) study site.

orizon	Depth (cm)	Musl colour Dry	moist	Txt	Mottles Colour	Quantity	Structure	Consistency Wet	moist	Boundary	Features
Pedon 1	**SDP1**	**Typic Endoaqualfs**									
Ap	0-14		10YR3/3	SL	-----	----	2msbk	ss sp,	Vfr	cs	Commn vesicular fine pores.many fine roots
AB	14-34		10YR3/2	SL	-----	----	2msbk	ss,sp	Fi	cs	Few common fine pores. Few
Bw1	34-65		7.5YR 3/2	SL	-----	----	1msbk	ss sp	Fr	cs	Common tabular pores withmany roots.
Bw2	65-80+		7.5YR 5/4	LS	-----	----	ma	so po	L		
Pedon 2	**SDP2**	**Typic Endoaqualfs**									
Ap	0-23		7.5YR3/2	LS	-----	----	1msbk	ss sp	Fi	cw	Few common,tabular fine pores with many roots.
AB	23-35		10YR3/4	SL	-----	----	2msbk	Nt np	l fr	cs	Many vesicular fine coarse pores with few roots.
Bt	35-64		10YR4/2	SL	-----	----	3msbk	Ns np	Fri sh	ds	Few vesicular fine pores with few roots.
Btg1	64-85		10YR5/2	SL	-----	----	3msbk	St sp	Fi	ds	Very few vesicular fine pores with very few coarse roots.
Btg2	85-107+		10YR5/3	LS	-----	----	ma	St sp	Fr		
Pedon 3	**SDP3**	**Typic Endoaqualfs**									
Ap	0-38		7.5YR5/4	SL			1msbk	Ns np	Fr	as	Common, fine pores.many roots.
Bw1	38-70		10YR4/3	SL	10YR 4/4		3msbk	Ns np	Fr	cs	Many tabular fine pores. Few roots
Bwg1	70-109		10YR5/2	LS		f f	ma	Ns np	Fr	cs	Few vesicular fine pores.
Bwg2	109-143		10YR6/3	LS	5YR6/8.	f c	ma	Ns np	Fr	ds	Very few tabular pores with coarse roots.
Bwg3	143-165		10YR6/2	SL			ma	Ns np	Fr		

Symbols used are given in Soil Survey Manual (Soil Survey Staff, 1951, 1993).

Physico-chemical Properties: From the view of Table 2, revealed that sand content of the study site varied from 653.6 to 853.6 (mean 766.9gkg^{-1}) in the Ap horizons. The values for the sand content in the underlaying horizon were in the order 653.6 and 873.6 (mean 796.2gkg^{-1}). The subsoil horizons were silty clay in texture being finer than the surface horizons; this might be attributed to illuviation of clay. As the sites studied were derived from Alluvial and Aeolian sand deposit materials (Olofin, 1985), the textures of the three pedons were almost similar with sandy loam dominating. The dominance of sand at the banks of the streams could be explained by the reports of Olofin (1985) that in Kano region, Alluvial sand and gravels are the dominant particles on river terraces. The subsoil horizons were silty clay in texture being finer than the surface horizons and this might be attributed to illuviation of clay.

Bulk density values for Ap horizons ranged from 1.16, to 1.19, (1.19), while subsurface horizons were 1.30, 1.26, 1.26, (1.27) gcm^{-3}. Bulk densities across the three pedons were low both for surface and subsurface, however, values at Ap horizons were lower than subsurface implying these values increase with increase profile depth. The increase in bulk density at the lower parts of the profiles may be attributed to low faunal and rooting activities which help to loosen the soil and creates macropores, (Buol, *et al.* 1973).

The pH values were in the order of 7.58, 8.14 and 7.90 (mean 7.87), while Subsurface values were in the order of 8.02, 8.07, 8.72 (8.27), The ratings of pH (in water) for both surface and subsurface horizons are moderate to slightly alkaline in all the three pedons (Esu, 1990; Landon, 1991). Landon (1991), repoted 5.5 –7.0 as the medium pH even though the lower range may be too acidic for some crops. The slightly increase in pH values could be attributed to the quality of the irrigation water. The moderate to slightly alkaline pH nature of the soil is not an indication of sodicity (Pitty, 1979) because high pH translate sodicity problem (Rowell, 1994). The exchangeable bases comprise of exchangeable calcium, magnesium, potassium and sodium. The Ca values in the surface horizons were 2.40, 2.80, 4.00 (mean 3.07), 4.40, 3.2, 3.6 (3.73) cmol(+)kg^{-1} at the subsurface horizon respectively. The soils in the basins of most rivers contain appreciable Ca especially those under irrigation, if pH values are within the range of neutral to slightly alkaline (Foth, 1990). It has also been stated that calcium and magnesium are the dominant bases in fadama soils (Singh, 1997; Mustapha, 2003). The values obtained in this study are in close agreement with those reported by Adamu and Dawaki (2008b) for some sites along the basin of the Challawa River. Potassium (K) content was in the order 0.33, 0.07, 0.07 (mean 0.16), the values of K in the surface horizons were rated as medium in Sharada A similar observation was made by Adamu and Dawaki (2008a). Adamu and Dawaki (2008b) reported K values as high as 2.33cmol/kg in some segments of the Challawa basin. The high K values obtained despite the leaching tendency of the soil might likely be ascribed to excess fertilizer nutrient applied, probably as compound fertilizer such as NPK. The values of cation exchange capacity (CEC-NH_4OAc) in the surface horizons were 7.54, 6.06, and 6.56 (mean 6.72) while the corresponding values in the underlying horizons were in the order 7.99, 6.88, 5.81 (mean 6.89) cmol(+)kg^{-1}. The values of CEC were higher in the surface soil than the subsurface soil, this might probably be associated with the difference in concentrations of organic matter which is responsible for over 80% of CEC in savannah soils (Jones, 1973). The base saturation (CEC - NH_4OAc) for surface horizons of Sharada site were 57.64, 78.01, 87.42 (mean 74.36), while the subsurface values ranged from 72.73 to 85.29 (77.69) percent. The mean values for all the pedon indicate high base saturation since their respective base saturation values were all above 50% implying that the soils might be classified under Alfisols (Soil Survey Staff, 2010).

Table 2: Soil physical properties of Salanta (Sharada) study sites.

Horizon	Depth (cm)	Sand ---------	Clay gkg^{-1}	Silt ---------	Txt	BD - gcm	PD $^{-3}$---	TP (%)	Si/C
Pedon 1- SDP1 upper slope Latitude 11^{0} 57' 781'' N Longitude 08^{0} 30' 435'' E 496m a.s.l.									
Ap	0-14	653.6	108	238.4	SaC	1.16	2.55	55.04	2.21
AB	14-34	653.6	88	258.4	SL	1.26	2.50	49.60	2.94
Bw1	34-65	793.6	108	98.4	SL	1.30	2.44	46.72	0.91
Bw2	65-80	873.6	88	38.4	LS	1.32	2.37	44.30	0.44
Pedon 1- SDP2 Mid slope Latitude 11^{0} 57' 673'' N Longituded 08^{0} 30' 528'' E 486m a.s.l.									
Ap	0-23	793.6	108	98.4	SL	1.17	2.56	54.30	0.91
AB	23-35	793.6	108	98.4	SL	1.23	2.48	50.40	0.91
Bt	35-64	733.6	158	108.4	SL	1.26	2.42	47.93	0.69
Btg1	64-85	753.6	148	98.4	SL	1.30	2.40	45.83	0.66
Btg2	85-107	773.6	128	98.4	LS	1.33	2.30	42.17	0.77
Pedon 3- SDP3 lower slope Latitude 110 57' 635'' N Longitude 080 30' 569'' E 483									
Ap	0-38	853.6	88	58.96	LS	1.17	2.55	54.12	0.67
Bw	38-70	753.6	148	98.4	SL	1.23	2.48	50.40	0.67
Btg1	70-109	753.6	158	88.4	LS	1.26	2.45	48.57	0.55
Bwg2	109-143	833.6	128	38.4	LS	1.30	2.39	54.61	0.30
Bwg3	143-165	793.0	171	43.2	SL	1.33	2.37	43.88	0.25

*BD= bulk density, PD= particle density, TP= total porosity and m.s.l. = meters above sea level.

Table 3: Soil Chemical properties of Salanta (Sharada) study site.

Horizon	Depth (cm)	O.C	OM gkg^{-1}	TN	Av.P (mgkg^{-1})	SAR	C/N
Pedon 1- SDP1 upper slope Latitude 11^0 57' 781'' N Longitude 08^{0}30' 435'' E 491m a.s.l.							
Ap	0-14	13.8	23.8	0.7	10.22	0.27	19.7
AB	14-34	18.4	31.7	0.7	10.26	0.20	26.2
Bw1	34-65	2.2	3.8	0.7	22.20	0.07	3.1
Bw2	65-80+	2.8	4.8	0.7	8.60	0.05	4.0
Pedon 2 SDP2 mid slope Latitude 11^0 57' 673'' N Longiude 08^0 30' 528'' E 486m							
Ap	0-23	8.4	14.5	0.7	11.56	0.13	12.0
AB	23-35	2.2	3.8	0.7	23.15	0.08	3.1
Bw	35-64	4.6	25.2	0.35	10.19	0.10	13.1
Bwtg1	64-85	1.6	2.8	0.35	11.19	0.12	4.6
Bwtg2	85-107+	2.6	4.5	0.7	15.74	0.15	3.7
Pedon 3- SDP3 lower slope Latitude 11^0 57' 635'' N 08^0 30' 569'' E 483m a.s.l.							
Ap	0-38	0.42	0.72	0.7	26.85	0.02	6.0
Bw	38-70	0.36	0.62	0.35	20.37	0.05	1.0
Bwg1	70-109	0.20	0.34	0.35	17.59	0.02	0.57
Bwg2	109-143	0.96	1.66	0.7	13.89	0.10	1.37
Bwg3	143-165+	0.26	0.45	0.35	13.89	0.46	0.47

O.M = organic matter, O.C = organic carbon, TN = total nitrogen, A.P = available phosphorus, EC = electrical conductivity, SAR = sodium adsorption ratio, C/N = carbon nitrogen ratio

The organic carbon values for surface horizons were 13.8, 8.4, 4.2, (mean 8.8), The corresponding subsoil horizon values were 0.22, 0.16, 0.20, (mean 0.19) gkkg^{-1}, The values of both surface and subsoil horizons in the entire site were rated as low to medium (Esu, 1991). Generally values < 10.0gkg^{-1} are regarded as low, In most of the profile, the values in surface horizons were much higher than those in the subsoil horizons; there was a slight decrease in OC content with increase in profile depth. The sharp decrease in organic carbon with depth from the Ap horizons to the subsoils horizons might be attributed to immobilization of organic carbon by clay in the underlying horizons in forms of organo-clay-complexes (Mortland, 1970; Ogunwale, 1973). The total nitrogen values in the surface horizons varied as 0.7, 0.7, 0.7, (mean 0.7), The values for the subsoil horizons ranged from 0.7, 0.4, 0.4, (mean 0.5) gkg^{-1}.The available phosphorus content values varied from 10.22, 11.56, 26.85, (mean 16.21), In the subsoil horizons available P were in the order 22.20, 10.19, 17.59, (mean 16.66) gkg^{-1}. Using the ranking of Landon (1991), available P were rated medium across the three profiles and the medium values in available P across the pedons might also be attributed to intensity of soil weathering or disturbance, the degree of P-fixation with Fe and Ca and continuous application of mineral P fertilizer as indicated by Paulos (1996).

Soil classification: The soils of the study area were classified using the USDA Soil Taxonomy (Soil Survey Staff, 2010), and World Reference Base (FAO/ISSS, 1998). The differentiating properties used for the classification included some morphological, physical and chemical properties.

The soil moisture regime of the study area is considered as Ustic, as it has an annual rainfall of 1204.64mm and the amount is concentrated between 5 - 6 months. This implies that the soil is moist for more than 180 cumulative days and is dry for 90 or more cumulative days also implying there is a limited moisture level suitable for plant growth (Soil Survey Staff, 1998, 1999). However all the three pedons at Salanta (Sharada) were poorly drained, thus considered as having an Aquic moisture regime. The mean annual soil temperature of the study area is more than 22^{o}C. The mean summer and mean winter soil temperatures differ by more than 6^{o}C, therefore the soil temperature regime of the study area is Hyperthermic (Soil Survey Staff, 2010). The epipedons were too thin, too light, poor in humus, poor in bivalent cations, low in phosphorus (>250$mgkg^{-1}$), to be mollic, anthropic, histic, melanic, plaggen or umbric epipedons. The soils had a colour value of 3 to 4 YR (moist) and a chroma of of 3, in the surface horizons, thus were considered as being Ochric epipedon. Pedons at Salanta had significant accumulations of illuviated layer-latice silicate clays formed below the elluvial horizons.

USDA Soil Taxonomy System: At order level, all the three pedons at Salanta were classified as Alfisols because they have higher base saturation of greather than 50% (by NH_4OAc) in addition to the argillic B horizon. At the suborder level, all the three pedons at Sharada (SDP1, SDP2 and SDP3) were classified as Aqualfs, because the soils were saturated with water long enough to exhibit gray colours and presence of reddish or brownish Fe mottles. At the great group level, pedons at Sharada (SDP1, SDP2 and SDP3) were all classified as Endoaqualfs, at the subgroup level, all the pedons at Sharada were classified as Typic Endoaqualfs.

Classification according to World Reference Base for Soil Resource: At the World reference base for Soil resources, all pedons at Sharada study site were classified as Gleysols because, they were saturated with water for long enough periods to develop a characteristics gleyic colour pattern (reddish brownish/yellowish).

Table 4: Summary of Soil Classification (USDA and WRB System).

Site	Pedon	USDA	WRB
Sharada (SD)	SD P1	Typic Endoaqualfs	Eutric Gleysols
	SD P2	Typic Endoaqualfs	Eutric Gleysols
	SD P3	Typic Endoaqualfs	Eutric Gleysols

SD = Sharada. P= Profile.

Conclusion

From the results obtained the three pedons were morately shallow, deep and very deep, low bulk densities and sandy loam dominated the textural classes. According to the USDA system of soil classification at the Subgroup level were classified as Typic Endoaqualfs and were classified as Eutric Gleysol according to world reference base for soil resource. Table 4 summarized the two system of classification.

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