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Properties and Classification of Urban Agricultural Soils along River Kofar Ruwa in Kano Metropolis, Nigeria

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Abstract

This study was conducted on irrigated land along the bank ofRiver Kofar Ruwa in metropolitan Kano, with the aim of assessing its morphological, physico-chemical properties and hence classifying the soils. Three profile pits (FSP1, FSP2 and FSP3) were dug and studied, soil samples collected from pedogenetic horizons were analysed for particle size distribution, pH, fertility related properties. Results indicated that the soils were very deep (163-177 cm), pedon one and two were well drained while pedon three was poorly drained. In terms of chemical characteristic, the soils are slightly alkaline (pH ranged between 7.96 and 8.59) with low to medium CEC values (between 7.71 and 12.85 cmol (+) kg-1) and generally low in organic matter on the average (4.0 and 10.4 gkg^{-1}), exchangeable bases were medium to high. Bulk densities were generally low (1.02 and 1.24 gcm^{-3}). According to USDA soil taxonomy, the three profiles were characterizedand classified as Typic Kandustalf (FSP1 and FSP2) and Typic Endoaqualfs (FSP3). Using the WRB system FSP1 and FSP2 were classified as Haplic Acrisols while FSP3 was classified as Eutric Gleysols.
***Keywords**: Properties, Classification, Typic Endoaqualfs, Haplic Gleysols.*

INTRODUCTION

Kano metropolis is situated between latitude 11^0 25' N and 12^0 47' N and longitude 8^0 22' E to 8^0 39' E and lies 472m above sea level.Soil properties vary in spatial and temporal directions (Sokouti and Mahdian, 2011) and in Kanolands within the metropolis are mostly exploited with urban agriculture through the use of waste and water to sustain agricultural activities within the urban city (Mohan, 2005).

Various studies have established the presence of some heavy metals in some domestic and industrial effluents discharged into the urban streams and Rivers (Jakara, Getsi, Salanta and Kofar ruwa), and in the waters used for irrigation (Sahoo and Klopker, 1985; Binns *et al.,* 2003; Dawaki and Alassan, 2008; Wakawa *et al*.,2008). None of these studies have gone further to classify the respective soil based on morphological features along the bank of this urban river (Kofar Ruwa).

MATERIALS AND METHODS

Description of Study Area: The *Kofar Ruwa*river is located between latitude 12^o 64’ N to N12^o 65’ N and longitude 8^o 62’ E to 8^o 71’ E in a low-lying *fadama* depression adjacent to the north-eastern part of the old city wall. The site is situated in the floodplain of a small tributary of the *Jakara* river, which serves as a drain for urban wastewater in the built-up area immediately to the north of the city wall.

Soils of the Sudan Savanna zones are classified as *Entisols, Inceptisols, Ultisols and Alfisols*, which were developed mainly from Basement Complex parent materials. They are well-drained and brownish to reddish in colour and deep, except where iron pans are exposed, or occurred near the surface (Olofin, 1985). Kano state has a tropical climate which is characterized by the occurrence of distinct wet and dry seasons (Owonubi, *et a*l., 1991). Kano is in the dry sub humid agro ecological zone of Nigeria (Ojanuga, 2006). It has two seasonal periods which consist of four to five months of wet season and a long dry season lasting from October to April (Ado, 2006). This implies that water is not always available all year round for crop production.

Field studies

Field studies were carried out along the bank of river Kofar ruwa, profile pits were sunk in April 2014, during the peak of irrigation activities and before the onset of the rain so as to avoid the effect of leaching and dilution and three profile pits (FSP1, FSP2 and FSP3) were sunk across the bank. The pedons were described for their morphological properties which include soil colour, texture, structure, consistence, horizon boundary conditions and miscellaneous features such as cutans, roots, pores, etc. Following profile description, bulk and soil samples were collected from the genetic horizons for physical and chemical analyses in the laboratory.

Laboratory analysis

Soil samples were air-dried in the laboratory, ground and sieved through 2 mm sieve, and the fine earth (< 2 mm) used for laboratory analyses. Particle size distribution was determined by the hydrometer method, using sodium hexametephosphate (Calgon) as the dispersant (Gee and Or, 2002), Bulk density was determined gravimetrically using core samplers. Measurement of soil pH was done in a 1:2.5 suspension in water and $CaCl_2$, the extraction of Ca, Mg, K and Na was made using 1N NH4OAc (pH7) solution, Ca^{2+} and Mg^{2+} in solution were read on an atomic absorption spectrophotometer, while K^+ and Na^+ were read on the flame emission photometer. Cation exchange capacity was determined by the NH_4OAc saturation method. Organic carbon was determined by the dichromate wet oxidation method, Total nitrogen content was determined using the Micro-Kjeldahl digestion method as described by (Bremner, 1996) and Available phosphorus was extracted using the Bray 1 method (Bray and Kurtz, 1945).

RESULTS AND DISCUSSION

Morphological properties

The morphological characteristics of the soils along the bank were presented in Table 1. Soil profile FSP1, FSP2 and FSP3 were generally very deep that is greater than 150 cm. Surface soil colour were brown to dark brown (10YR3/3, 10YR4/3) while subsurface soils were brown to yellowish brown (10YR 5/6, 10YR5/2 to 10YR4/3). Colour variation in Ap (surface) horizons might be ascribed to the kind, amount and distribution of organic matter, iron/manganese compound or stagnant water table as observed by Farshad (1984). The pedon (FSP3) with mottled subsoils had 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 pedons studied (FSP1, FSP2 and FSP3) had some similarities in consistence. They were generally non-sticky to slightly sticky (wet), very friable to friable (moist) in the Ap horizons. The subsoils were slightly sticky (wet), friable to very firm (moist). The increasing consistence down the profiles at Federal Secretariat might be attributed to clay illuviation. Singer and Munns (1999) reported a similar finding that as clay contents increases, the hardness of the dry soils increases.

The soil had weak, fine to medium subangualr blocky, moderate medium to coarse angular blocky in the surface horizons to moderate medium to coarse angular blocky and massive in the subsoils. The blocky structures could be attributed to greater pedogenic development such as clay illuviation at the site. The weak structure at the Ap horizons across the sites might be ascribed to tillage practices and continuous cultivation. The grade of the structure were observed to increase with depth probably from clay accumulation. The subangular blocky structures at Federal Secretariat could be due to greater pedogenic activities (Yaro, 2005).

Table 1: Soil Morphological properties and classification of Kofar Ruwa (Federal secretariat) study site.

Horizon	Depth (cm)		Munsell colour	Txt	Mottles		Structure	Constcy		Boundary	Features
		Dry	**Moist**		**Colour**	**Quantity**		**Wet**	**moist**		
Pedon 1	**FSP1**	**Typic Kandustalfs**			------	------					
Ap	0-23		10YR4/3	LS	-------		1msbk	so po	fr	cs	Few common vesicular pores with few roots.
AB	23-65		10YR4/4	LS							
Btg1	65-98		10YR4/6	SL	-------	------	2mabk	so po	fr	cs	Few common vesicular fine medium pores with few roots.
Btg2	98-135		10YR4/3	SL	7.5YR3/3	m2p	3mabk	ss,	fi	cs	Fewtabular medium pores with few roots.
2Bwg	135-160		10YR4/4	LS	10YR4/6	f2p	3msbk	so po	fr	cs	
2Btg2	160-177+		2.5Y 4/1	C	10YR4/4	m2p	3mabk	ss,p	fi		Vesicular fine pores.
Pedon 2	**FSP2**	**Typic Kandustalfs**									
Ap	0-20		10YR4/3	SL			2msbk	so po	fr	Ds	Many vesicular fine medium pores with many roots.
B	20-32		10YR4/4	SL	7.5YR5/8		3msbk	ss sp	fr	Cs	Few common vesicular fine medium pores. Few roots.
Btg	32-55		10YR4/1	SiL	7.5YR5/8	3mabk	ss	Fr	cs		
2Bg1	55-95		10YR5/2	SL	7.5 YR 5/6	c2d	2mabk	ss sp	fr	Cs	Few vesicular fine pores with few roots.
2Bg2	95-124		10YR6/3	LS	7.5YR 5/6	c2d	Ma	so po	fr		
2Bg3	124-163+		10YR4/3	LS	10YR 4/6	mcd	Ma	So po	fi	Cs	
Pedon 3	**FSP3**	**Typic Endoaqualfs**	10YR3/3	LS			2mabk	ss sp	fr	Cw	Common many vesicular fine pores. Many roots.
Ap	0-23		10YR4/3	LS	7.5YR5/2		1msbk				
Bt	23-49		2.5Y 4/1	C	10YR5/6	fid	3mabk	ss sp	vfrm	Cs	Many,fine medium
Bwg1	49-77		10YR 4/3	SL	7.5YR5/6	m3p	3mabk	ss sp	fr	Ds	Common vesicular fine pores.
Bwg2	77-121		10YR5/6	SL	10YR4/6	m3p	Ma	ss sp	fr	Ds	Common many tabular fine medium pores.
Bwg3	121-163+		10YR5/2	LS	10YR 4/4		Ma	So po	Fr		

Symbols used are giving in Soil Survey Staff Manual (Soil Survey Staff, 1951, 1993). FS= Federal Secretariat.

Particle size distribution data for the soils is presented in Table 2.Values of the sand content ranged from 633.6 to 833.6 (mean 726.9gkg^{-1}). The subsurface sand content is in the order 673.6, 633.6 and 813.6 (mean 706.9gkg^{-1}). In the profiles studied, sand content decreased with an increased soil depth. This might likely be attributed to illuviation process. For the respective study sites, all the surface horizons had high proportion of sand which could be attributed to alluvial sand deposition at the surface soils. The sand fraction distribution within profile does not seem to follow any definite pattern. This suggests that the soils were formed through sedimentation/ alluvial deposits. The distribution of particles sizes is a reflection of the sources and content of the materials in the sediments for the particular year.

Clay values at the Ap horizon ranged from 88 - 168 (mean 114.7gkg^{-1}), for the subsurface soil the values were 168 - 488 (mean 656.6gkg^{-1}).The clay content generally increased consistently with depth as a result of downward clay accumulations and site two (Federal Secretriate) had the highest accumulation of clay at the subsurface horizon; illuviation process was a dominant pedogenic process as clay increase with soil depth. Similar findings was made by Schaetzl and Anderson (2005) where they attributed increase in clay down the profile to pedogenic processes involving elluviation and illuviation of clay particles, neo-formations and transformation of primary minerals in the subsoils. Malgwi *et al* (2000) and Ojanuga (1975) attributed high clay materials in subsurface soils to sorting of soil materials by biological and/or agricultural activities.

Table 2: Soil physical properties of Federal secretariat study sites.

Horizon	Depth (cm)	Sand ------	Clay gkg^{-1}---	Silt ----------	Txt.	BD -gcm	PD $^{-3}$---	TP (%)	Si/C
Pedon 1- FSP1 upper slope Latitude 12^0 01'.649'' N Longitude 08^0 30'.628'' E 463m a.s.l.									
Ap	0-23	833.6	88	78.4	LS	1.15	2.62	56.11	0.89
AB	23-65	873.3	88	41.4	LS	1.26	2.58	51.16	0.47
Btg1	65-98	793.6	158	48.4	SL	1.27	2.55	49.80	0.31
Btg2	98-135	693.6	188	118.4	SL	1.40	2.46	43.09	0.62
2Bwg	135-160	703.6	188	108.4	LS	1.43	2.31	38.10	0.47
2Btg2	160-177	693.6	208	98.4	SL	1.44	2.04	29.42	0.57
Pedon 1- FSP2 Mid slope Latitude 12^0 01'.648'' N Longitude 08^0 30'.715'' E 462m a.s.l.									
Ap	0-20	713.6	128	158.4	SL	1.15	2.61	55.94	1.23
B	20-37	753.6	138	108.4	SL	1.24	2.58	51.94	0.79
Btg	37-55	503.6	38.8	108.4	SiL	1.27	2.48	48.79	0.23
2Bg1	55-95	613.6	508	338.4	SL	1.30	2.41	43.15	0.66
2Bg2	95-124	833.6	98	68.4	LS	1.34	2.33	39.91	0.64
2Bg3	124-163	813.6	108	78.4	LS	1.34	2.29	37.55	0.67
Pedon 3- FSP3 lower slope Latitude 120 01'.651'' N Longitude 080 30'.752'' E 456m									
Ap	0-23	633.6	168	198.4	SL	1.02	2.50	59.20	1.18
Bt	23-49	610.6	200	190.4	SL	1.14	2.38	47.89	0.95
Bwg1	49-77	813.6	98	88.4	LS	1.24	2.26	44.64	0.90
Bwg2	77-121	713.6	168	118.4	SL	1.31	2.18	39.91	0.70
Bwg3	121-163	753.6	188	58.4	SL	1.33	2.07	35.75	0.29

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

Bulk density values and means (in parentheses) for Ap horizons ranged from 1.15 to 1.02, (1.11), gcm^{-3} respectively while the subsurface values varied between 1.27, 1.24, 1.21, (1.24), gcm^{-3}. Values of bulk densities for the corresponding subsoil were higher than the surface soils implying that these values generally increased with increasing soil depths. The bulk densities values agree with the values suggested by Brady and Weil (1999) for cultivated sandy-loams and sand textured soils, and also the ranges were in close agreement with that of Dawaki *et al*., (2014) around Chalawa and Jakara (1- 1.3gcm^{-3}).

The total porosity values and means (in parenthese) in the Ap horizon ranged from 55.94 to 59.20 (57.08) while total porosity values of the underlying horizons ranged as 43.09 to 44.64 (43.89) percent for Federal Secretariat respectively. Total porosity across the three pedons decrease with profile depth and this might be attributed to tillage practices at the surface soils (Jones and Wild, 1975), significant illuviation of clay in most of the pedon thereby reducing the pore spaces down the profile depth, increase in bulk density and weigth of overlaying soils

Chemical properties of soils along Kofar Ruwa (Federal Secretariat) sites are presented in table 3. The pH (in water) values were in the order of 8.59, 7.96, 8.29, (8.28), in the surface horizons while the Subsurface values were in the order of 8.10, 8.23, 8.09, (8.14), respectively. The ratings of pH (in water) for both surface and subsurface horizons were slightly alkaline in all the three pedon (Esu, 1990; Landon, 1991). This might be due to the nature and concentration of the irrigation water at this site as they are densely populated and wastewaters are of domestic sources containing dissolved sodium from detergents.

The electrical conductivity (EC) values in the surface horizons were in the order of 0.87, 0.85, 0.46, (0.73) dSm^{-1} (Table 3) respectively and in a similar order, the subsoil horizon values varied from 0.45, 0.62, 0.42, (0.50) dSm^{-1}. The rating of electrical conductivity in the entire site both surface and subsoil horizons were neither saline nor sodic (Landon, 1991). The very low values of EC indicate non saline electrical conductivity class (Soil Survey Staff Division 1993). These imply that salinization is not a significant pedogenic process in the soils and the soils do not contain a concentration of soluble salts that may hamper the growth of plants in all the study areas. From the results of the study site, the EC is classified as non saline but the slightly alkaline pH and slightly high EC values observed at Kofar Ruwa (federal secretariat) is implying potent salinity hazards overtime, a problem which was also noted by Binns *et al*., (2003).

The values of cation exchange capacity (CEC-NH_4OAc) in the surface horizons were 9.10, 12.85, 11.56, (11.20) $cmol(+)kg^{-1}$ while the corresponding values in the underlying horizons were in the order 7.71, 9.37, 8.94, (8.67) $cmol(+)kg^{-1}$ soils. The values of CEC were higher in the surface soil than the subsurface soil and 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 CEC values in surface and subsurface horizons are rated medium. The slightly higher CEC values at the site could possibly be ascribed to higher clay and organic matter content as well as long-term irrigation with domestic sewage which are in agreement with the findings of Sing and Verloo, (1996).

The base saturation (CEC - NH_4OAc) for surface horizons of the three pedon were 83.18, 51.97, 66.82 (67.32) percent. The subsurface values ranged from 62.06 to 67.07 (64.25) percent respectively. The mean values for all the three 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 3: Soil chemical properties of Kofar Ruwa (Federal secretariat) study site.

Horizon	Depth	pH	EC	Ca	Mg	K	Na	TEB	BS(NH_4OAc)	CEC	ESP
	(cm)	H_2O	dSm^{-1}	------	Exc -$cmolkg^{-1-}$	Bas.---			%	$cmolkg^{-1}$	%
Pedon 1- FSP1 upper slope Latitude 120 01’ 649’’ N 080 30’ 628’’E 462m a.s.l.											
Ap	0-23	8.59	0.87	5.20	1.25	0.49	0.22	7.57	83.18	9.10	2.39
AB	23-65	8.74	0.66	2.80	1.67	0.37	0.20	4.63	64.15	7.21	2.84
Bg	65-98	8.10	0.64	4.80	1.67	0.33	0.19	6.98	72.92	9.58	2.00
2Btg1	98-135	8.14	0.45	2.40	1.25	0.54	0.18	4.78	62.06	7.71	2.32
2Bwg	135-160	8.19	0.44	2.80	1.67	0.33	0.15	4.53	50.67	8.94	1.72
2Btg2	160-177+	8.20	0.41	4.00	1.67	0.65	0.22	6.54	77.83	8.40	2.59
Pedon 1- FSP1 mid slope Latitude 110 57’ 635’’ N 080 30’ 569’’ E 483m a.s.l.											
Ap	0-23	7.96	0.85	3.60	1.25	1.00	0.41	6.68	51.97	12.85	3.18
B	23-37	8.19	0.56	4.80	1.67	0.68	0.33	7.06	68.44	10.31	3.22
Btg	37-55	7.86	0.33	3.20	1.25	0.91	0.38	6.16	60.66	10.15	3.78
2Bg1	55-95	8.23	0.62	4.00	1.67	0.33	0.38	5.96	63.61	9.37	4.09
2Bg2	95-124	8.15	0.33	4.40	1.25	0.07	0.15	6.29	98.64	6.38	2.41
2Bg3	124-163+	7.93	0.32	3.60	1.67	0.16	0.26	5.27	76.96	6.85	3.74
Pedon 3- FSP3 lower slope Latitude $11^0$57’ 635’’N Longitude 08^0 30’ 569’’ E 482m a.s.l.											
Ap	0-23	8.29	0.46	3.20	1.25	0.68	0.27	5.81	66.84	11.66	2.30
Bt	23-49	8.23	0.56	4.00	1.67	0.89	0.33	6.88	49.82	10.30	3.23
Bwg1	49-77	8.09	0.42	4.00	1.67	0.51	0.23	5.99	67.07	8.94	2.58
Bwg2	77-121	7.92	0.33	5.60	1.25	0.72	0.29	7.87	78.69	10.00	2.94
Bwg3	121-163+	8.23	0.33	3.20	1.25	0.47	0.24	5.58	58.83	9.48	2.56

pH, EC= Electrical Conductivity, Exc base= Exchangeable bases, TEB= Total Exchangeable bases, BS= Base saturation, NH_4OAc= Ammonium acetate, ESP= exchangeable Sodium Percentag

Table 4: Soil chemical properties of Federal secretariat site.

Horizon	Depth (cm)	O.C ----------	OM gkg^{-1}	TN ---------	Av. P $mgkg^{-1}$	SAR	C/N
Pedon 1 FSP1 upper slope Latitude 12⁰ 01' 649'' N Longitude 08⁰ 30' 628'' E 466m a.s.l.							
Ap	0-23	7.0	12.1	1.4	11.38	0.12	5.0
AB	23-65	2.4	4.1	0.35	11.29	0.14	6.8
Bg	65-98	5.0	8.6	0.7	8.33	0.10	7.1
2Btg1	98-135	4.2	7.2	0.7	17.59	0.13	6.0
2Bwg	135-160	2.8	4.8	0.59	12.96	0.11	4.7
2Btg2	160-177+	3.8	6.6	0.35	12.04	0.13	1.1
Pedon 2- FSP2 Mid slope Latitude 11⁰ 01' 648'' N Longitude 08⁰ 30' 715'' E 463m a.s.l.							
Ap	0-20	10.4	1.79	1.05	29.92	0.25	9.9
B	20-37	5.8	1.00	0.7	27.79	0.19	8.3
Btg	37-55	7.0	1.21	0.7	27.31	0.24	10.0
2Bg1	55-95	4.2	0.72	0.35	27.25	0.24	12.0
2Bg2	95-124	3.6	0.62	0.35	27.49	0.09	10.3
2Bg3	124-163+	3.6	0.62	0.35	27.43	0.16	10.3
Pedon 3 FSP3 lower slope Latitude 12⁰ 01' 651'' N Logitud 08⁰ 30' 752'' 462m a.s.l.							
Ap	0-23	0.80	13.8	0.7	28.52	0.17	1.14
Bt	23-49	0.58	10.0	1.05	27.67	0.20	0.55
Bwg1	49-77	0.44	7.5	0.35	27.91	0.14	1.25
Bwg2	77-121	0.40	0.69	0.35	27.43	0.16	1.14
Bwg3	121-163+	0.38	0.66	0.35	27.49	0.15	1.08

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, FS=federal secretariat, P=pedon.

The organic carbon values were presented in table 4. The values for surface horizons were 7.0, 10.4, 8.0, (8.5) gkg^{-1} and the corresponding subsoil horizon values were 4.2, 4.2, 4.0, (4.1) gkg^{-1}. The values of both surface and subsoil horizons in the entire site were rated as low (Esu, 1991). Generally values < 10.0gkg^{-1} are regarded as low, while values of 10-15gkg^{-1} are regarded as medium (Adamu, 1997). 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 soil organic carbon values were low but still within the values for soils found in Nigerian savannah that ranged between from 8.0-29gkg^{-1} (Jones, 1973) and is typical for savannah soils with sandy surface (Jones and Wild, 1975).

The total nitrogen values in the surface horizons varied as 1.4, 1.1, 0.7, (1.1) gkg^{-1}. The values for the subsoil horizons ranged from 0.7, 0.4, 0.4, (0.5) gkg^{-1}. Based on the ranking of Landon (1991), these values were all rated low to medium. The medium total N might not be unconnected with its association with domestic waste water. Typical waste water effluent from domestic source could supply nitrogen, phosphorus and potassium requirement of many crops thereby reducing the need for farmers to invest in chemical fertilizers (FAO, 1997).

The available phosphorus content values varied from 11.38, 29.79, 28.52, (23.23) $mgkg^{-1}$, in the surface horizons of the tree pedon. In the subsoil horizons, available P were in the order 17.59, 27.25, 27.91, (24.25) $mgkg^{-1}$ for the respective pedon. The values of the surface horizons were rated as being high. Subsoil horizons were rated as high. Using the ranking of Landon (1991), available P content might be rated as high. The effect of irrigating with domestic waste water might be attributed to the differences in P content across the sites. Phosphorus values were higher compared to those reported by Essiet (1992) in the Kano River project.

Soil classification

At the order level, all the (FSP1, FSP2 and FSP3) were classified as Alfisols because they have higher base saturation of greather than 50% (by NH_4OAc) in addition to the argillic B horizon (Soil Survey Staff, 2010).At the suborder level At Federal secretariat (FSP1 and FSP2) were classified as Ustalfs, because they had an Ustic moisture regime while Federal Secretariat (FSP3) at the suborder level was classified as Aqualfs due to poor drainaige. At the great group level, pedons one and two (FSP1, FSP2) were classified as Kandustalfs and FSP3 was classified asEndoaqualfs. At the subgroup level, thesoils were classified as Typic Kandsutalfs (FSP1 and FSP2) and Typic Endoaqualfs (FSP3).

According to World Reference Base for Soil Resource (2006),peodon 1 and 2 (FSP1 and FSP2) were classified as Acrisols due to higher clay content in the subsoil than in the topsoil as a result of pedogenic processes (especially clay migration) leading to argic subsoil horizon, with CEC of <24$cmolkg^{-1}$ and base saturation (NH_4OAc) greater than 50%. Pedon 3 (FSP3) was classified as Gleysols because of gleyic soil condition.

CONCLUSION

Properties (morphological, physical and chemical) of the soils showed that the soils across the three pedon (FSP1, FSP2 and FSP3) were very deep, low bulk density, sandy loam dominated the textural classes, fertility status ranged from low to moderate. All the the soils across pedons were generally classified as Alfisols.

REFERENCES

Adamu, G. K. (1997). An assessment of erodibility of selected soils under different land A case study of Airport Road – Katsina Road Kano Metropolis' Unpublished PG Dissertation, Department of Geography, Bayero University Kano.

Ado, K. I. (2006): A publication of the Research and Documentation Directorate, Kano State Government: Investnent Opportunities in Kano Center of Commerce. ISBN 978-8092-08-X 1st Eds.

Binns, J.A., Maconachie, R.A., Tanko, A.I. (2003), Water, Land and Health in Urban and Peri-Urban Food production: the case of Kano, Nigeria, Land Degradation Development 14, 431-444

Brady, N.C and Weil, R.R. (1999): The Nature and properties of soils (Twelfth Edition). Prentice- Hall Inc., London, 881p.

Bray, R.H., and Kurtz, L. T. (1945). Determination of total, organic and available forms of phosphorus in soils. Soil Science 59:39-46.

Bremner, J.M., (1996): Total -Nitrogen. In: D. L. Sparks (Editor) pp 1085- 1122: Methods of Soil Analysis Part 3 - Chemical Methods, SSSA Book Series 5: Madison, Wisconsin, USA.

Dawaki, M. U. Dikko, A. U. Noma, S. S. and Aliyu, U. (2014) Effects of waste water irrigation on quality of urban soils in Kano, Nigeria. International Journals of Plant and soil science. 4(4): 312-325, 2015; Article no.IJPSS.2015.032.

Essiet EU. (1992) The impact of irrigation on soil properties in Kano State in Olofin EA, Patrick S. Land administration and development in Northern Nigeria: Case Studies. Proceedings of the 2nd Workshop on Land Administration and Development in Northern Nigeria. Department of Geography. BUK;

Esu, I. E. (1990). Detailed soil survey of NIHORT farm at Bunkure, Kano State, Nigeria. Institure for Agricultural Research, ABU, Zaria.

Farshad, A.(1984): Some notes on soil sampling and Profile Description. ITC Enschede, the Netherlands.

Gee, G. W. and Or, D. (2002): Particle size analysis. p. 255-293-411. In: J. H. Dane and G. C. Topps (ed.) Methods of Soil Analysis, Part4: Physical and Mineralogical Methods. Soil Science Society of America Book Series Number 5: *American Society of Agronomy, Madison*, WI, pp 255- 293.

IUSS Working Group, WRB (2006): World Reference Base for Soil Resources. 2nd Edn. World Soil Resources Reports No. 103. Food and Agriculture Organization of the United Nations (FAO), IUSS Working Group. Rome. 145.

Jones M. J. (1973) The organic matter content of savannah soils of West Africa. Journals of Soil Science 24: 42 – 53.

Jones M.J, Wild A (1975) Soil of West Africa Savanna. Commonwealth Agricultural Bureaux, Harpenden.U.K. pp.24 Journal of Environmental Quality, 26:1038.

Landon, J. R. (1991) Booker tropical soil manual: a handbook for soil survey and agricultural land evaluation in the tropics and subtropics, 2nd ed., Longman Scientific & Technical,Harlow.

Malgwi, A.G Ojanuga, W.B Chude T. Kparmwang and B. A Raji, (2000): Morphological and Physical properties of Some Soils at Samaru, Zaria Nigeria. Nigerian Journal of Soil Research, vol. 1, pp 58-64.

Mohan, M. (2005): "Urban Land use/land cover change detection in national capital region, Delhi: A case study of faridabad district. Cairo, Egypt". FIG working week.

Ojanuga, A.G. (1975). Morphological, Physical and Chemical Characterization of Soils of Ife and Ondo, Nigerian Journal Science, 9; 225-269

Ojanuga, A.G., (2006): Management of fadama soils for food security and poverty alleviation. In: Management of fadama soils for enviromental quality, food security and poverty alleviation in Nigeria: Proceeding of 30th annual conference of the SSSNpp 14.

Olofin, E. A. (1985). Human responses to the natural environment in the Kano region. P. 216 in A. A. Barkindo, ed. Kano and its neighbours. ABU Press, Zaria.

Owonubi, J .J. Abdulmumin, S., Malgwi, W. B. and Muazu, S. (1991): Review of soil water balance studies in the Sudano-Sahelian Zone: Proceedings of the Niamey workshop. IAHS Publ. No. 199; M. V. K. Sivakumar, J. S. Wallace, C. Renard and Giroux (Eds): 18-23 Feb. ICRISAT, Niamey, Niger.

Sahoo, S. K. and Klopker, S. M. (1995) 'Determination of Heavy Metals in Effluent from Bompai Industrial Area Kano'. Indian Journal of Environmental Protection. 2: 18 -21.

Singer, M.J. and Munns, D.N. (1999): Soils: An Introduction, 4th ed. Pages 27-29, 48-49. Prentice Hall, Inc: Upper Saddle River, New Jersey.

Singh, S.P., Verloo, M.G., (1996). Accumulation and bioavailability of metals in semi-arid soils irrigated with sewage effluent. Meded Fac Landbouwkd Toegep Wet Univ Ghent 61, 63–67.

Soil Survey Staff, (2010): keys to soil taxonomy, 11th (ed). Basic system of soil classification for making and interpreting soil survey, natural resource conservation service, Agricultural dept. soil survey div. Washington Dc. USA sustainable Agriculture (in press)

Sokout R, Mahdian MH (2011). Spatial variability of macronutrient for soil fertilization management: A case study on Urmia plain. Int. J. Soil Sci. 6(1):49-59.

Yaro, D.T. (2005): The position of plinthite in a landscape and its effects on soil properties: Unpublished PhD., Thesis, Department of soil science, ABU Zaria. pp 49-75.