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POTASSIUM FORMS IN PARTICLE SIZE FRACTIONS OF SOILS ON A TOPOSEQUENCE IN MBANO, SOUTHEASTERN NIGERIA

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ABSTRACT: *Potassium distribution of a toposequence provides management information for landscape sustainability. Potassium forms (total, structural, Fixed, Available, Exchangeable and Solution) in bulk and particle size fractions of soils on a toposequence in Mbano, Southeastern Nigeria were studied. Total, structural, fixed, available, exchangeable and solution K in bulk soil, sand, silt and clay particle size fractions ranged between 0.44-0.88, 0.21-0.59, 0.09-0.22, 0.13-0.33, 0.09-0.22 and 0.04-0.11 and 0.45-0.73, 0.05-0.27, 0.06-0.20, 0.11-0.26, 0.07-0.17 and 0.04-0.08 cmol+ kg*$^{-1}$ *in A and AB horizons respectively. Also, concentration of most K forms in bulk soil and particle size fractions decreased in the order total > structural > available > fixed > exchangeable > solution for both horizons. Equally, within each horizon K forms varied with physiographic positions (summit, mid-slope and toe-slope) with concentrations of bulk soil, sand and clay particle size fractions better in the summit and that of the silt size fraction in the toe-slope of the A horizon while those of bulk soil and all particle fractions size fractions better in the toe-slope of the AB horizon. Furthermore, in each physiographic position, K enrichment of soil particle size fractions for A and AB horizons decreased in the order clay > silt > sand. Bulk soil and particle size K fractions correlated (P < 0.05) with soil ECEC, pH, OM, P, total N, sand, silt, clay and silt/clay ratio. In, general distribution of K forms in particle size fractions along a toposequence suggests the need for consideration of active soil portions for sustainable K management of the environment.*

KEYWORDS: Potassium Forms, Particle Size, Toposequence, Mbano and Southeastern Nigeria

INTRODUCTION

Potassium is one of the three most essential nutrient elements that are usually included in fertilizer formulation. It plays significant role in plant physiological processes, animal and microbial nutrition and in environmental sustainability (Yawson et al., 2011; Lakudzala, 2013). Soil K exists in different forms as; solution, exchangeable, non-exchangeable or fixed and mineral or structural forms. Solution K is the most negligible fraction that is readily taken up by plants and microbes or lost via leaching (Sparks, 2000). Exchangeable K represents the portion electrostatically bound to the outer surface of clay minerals and humic substances and readily exchangeable with soil cations and available to plants, non-exchangeable or fixed K constitutes the fraction held between adjacent tetrahedral layers of dioctahedral and trioctahedral micas, vermiculite and intergrade minerals that is sparingly or moderately available to plants while mineral or structural K includes the fraction that is bonded within crystal structures of soil mineral particles (Sadusky et al., 1987; Sparks, 2000; Uzoho and Ekeh, 2014). Distribution of soil K forms varies and includes a decreasing order of total > structural or mineral > non-exchangeable or fixed > available > solution K in most soils (Sparks, 2000;

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Igwe et al., 2008; Ndukwu et al., 2012; Ajiboye and Ogunwale, 2012; Uzoho and Ekeh, 2014). Also, in the soil system, concentration of K forms varies with soil particle size fractions. For instance, high concentration of K forms have been reported in clay fractions of soils developed over talc in Ejiba, Kogi state, Nigeria (Ajiboye and Ogunwale 2008) and talc overburden soils of Nigeria (Ajiboye and Ogunwale, 2012), silt fractions of some flood plain soils of eastern Nigeria (Igwe et al., 2008) and sand fractions of soil horizons of some Atlantic Coastal Plain Sands (Parker et al., 1989) and Iranian arid soils (Najafi-Ghiri and Abtahi, 2013). Variation in K concentration amongst particle size fractions could be due to differences in their mineralogical composition (Najafi-Ghiri and Abtahi, 2013) or availability of surfaces for their retention. It has been indicated that carbohydrate contents were higher in the fine than coarse soil particle size fractions due to the high surface area and retention capacity of the fine soil fractions (Spaccini et al., 2001).

Within the environment, concentration of soil K forms may vary with landscape positions especially in soils along a toposequence (Samndi and Tijjani (2014). According to Akpan-Idiok (2005), toposequence refers to related soils of varying characteristics due primarily to the influence of topography. It could also be a succession of sites from the crest to the valley bottom that contains a range of soil profiles which are representative of the landscape and soils (Juo and Moormann, 1981). Toposequence influences K distribution due to the importance of slope on erosion, transportation and deposition of materials (Krasilnikov et al., 2005; Uzoho and Okechukwu, 2014). It has been reported that erosion and sediment deposition processes influenced soil organic matter distribution along the topography of a landscape, with low lying positions higher than the upper slope (Onti and Schulte, 2012).

Though K status of soils of southeastern Nigeria have been extensively studied (Unamba-Oparah, 1987; Igwe et al., 2008; Ndukwu et al., 2012; Uzoho and Ekeh, 2014), there appears to be a dearth of information on their status on soils along a toposequence. The objectives of this present study were therefore to determine the variability in particle size fractions of K forms in soils on a toposequence in Mbano, southeastern Nigeria and to evaluate the relationship between these forms in bulk soil and particle size fractions and selected soil properties.

MATERIALS AND METHODS

Study Location and Site Description

The study location was Isiala Mbano on Latitudes 5^0 24^I and 5^0 63^I N and Longitudes 7 02^I and 7^0 74^I E. Its mean annual rainfall ranged between 2200-3000 mm, mean monthly temperature of $26\text{-}35^0$ and mean daily humidity range of 65-85% (IPEDC, 2006). Main economic activities of the area include farming, trading and artisanry. Climax vegetation of the site consisted of Christmas flower (Eupatorium odoratum) and oil palm (Elaeis guinensis) with the soil types involving Typic Paleodult in the summit and mid-slope and Ruptic Hapludult in the toe-slope (USDA, 2004).

Sample Collection and Preparation

Three profile pits were sunk on each of the physiographic positions; the summit, mid-slope and toe-slope of the toposequnce and duplicate soil samples collected from each horizon of the profile according to natural horizonization. The soil samples were air dried and passed through

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a 2 mm diameter sieve and subsamples of some fine earth soil fractions obtained separated into sand, silt and clay size fractions using the method described by Amelong et al. (1998).

Laboratory Analyses

Routine analyses were conducted on subsamples of the fine earth soil fractions using standard methods. Particle size distribution (Gee and Or, 2002), pH in 1:2.5 soil/water or KCL ratio (Thomas, 1996), organic carbon (Nelson and Sommers, 1996) and the value converted to organic matter by multiplication using a factor of 1.724 (Van Bemmelen factor), total N (Bremner, 1996), available P (Olson and Sommers, 1982), Exchangeable bases (Thomas, 1996) and ECEC as a summation of values of exchangeable bases and acidity. Potassium forms of the soil particle size fractions from the A and AB horizons were determined using the following methods; total K (Jackson, 1958), fixed K (Pratt, 1965), exchangeable K (Thomas, 1996) and structural K as the difference between total K and sum of the other K forms (exchangeable and fixed K).

Statistical Analysis

Data of K forms at various physiographic positions of the soils were subjected to analysis of variance (ANOVA) and means separated using LSD at 5% probability. Also K forms were correlated with selected soil properties using correlation analysis while relationship between particle size and bulk soil K concentration was evaluated using regression analysis. All the statistical analyses were conducted using Genstat statistical package (Buyse 2004).

RESULTS

Soil Characterization

Soils were dominantly sandy with textural classes varying as sandy loam and loamy sand down the profiles (Table 1). Silt/clay ratios of the soils varied and were less than unity. Soil pH was low with values below 5.50. Total N, OM, available P and ECEC were low and decreased with soil depth. Values of soil fertility attributes (N, P and ECEC) varied amongst the physiographic positions but linearly related to the soil organic matter.

Potassium Forms

Bulk soil K forms (water soluble, exchangeable, none exchangeable, structural and total) differed significantly (LSD 0.05) for each physiographic position (summit, mid and toe slopes) in the A horizon along the toposequence (Table 2). Potassium forms decreased in the order total K > structural > available > none exchangeable > exchangeable > solution for each physiographic position. Amongst physiographic positions, total and K forms decreased in the order summit > toe-slope > mid slope. Also, K concentrations amongst particle size fractions (sand, silk and clay) of the soils differed distinctly (LSD 0.05) in each physiographic position of the toposequence, with the order for K fractions similar to that for the bulk soil. In each physiographic position, concentrations of total and K forms in the particle size fractions were higher in the clay than silk and sand fractions. Best K concentration in the clay fraction could be due to increased surface and high adsorption capacity. It has been noted that increased carbohydrate concentration with particle fineness was due to high surface area and sorption capacity Amongst, physiographic positions, concentrations of total and K forms in various

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particle size fractions varied, with most of the forms better in the summit and toe-slope than the mid-slope. Enrichment of total and K forms increased with particle fineness, being a decreased sequence of clay > silt > sand for each physiographic position of the toposequence. Toe and mid slopes were more enriched than the summit, probably due to the deposition of K reach materials as they are transported by erosion.

In Table 3, bulk soil K content of the AB horizon of soils at various physiographic positions of the toposequence differed (LSD 0.05). Order for each physiographic position was a decreasing sequence of available > exchangeable > solution = nonexchangeable > structural, structural > nonexchangeable > available > exchangeable > solution and structural > available > nonexchangeable > exchangeable > solution in the summit, mid-slope and toe-slope respectively. Concentration of total and most K forms were better in the Toe-slope, followed by the mid-slope and the summit. The K forms in particle size fractions varied and increased with particle fineness. Potassium concentration in particle size fractions varied and decreased in the order clay > silt > sand in each physiographic position of the toposequence. Total and most K form concentrations were better in the toe-slope than mid-slope and summit. In all physiographic positions, total and K forms enrichment were better the finer the soil particle fractions with the degree being a decreasing sequence of mid-slope > toe-slope > summit.

Table 1. Selected Properties of Soils Along the Toposequence Studied

Horizon	Soil Depth	Sand	Silt	Clay	Total N	OM	Slit/ Clay ratio	pH (H_2O)	pH (KCL)	P	ECEC	TC
	cm	g kg^{-1}								mg kg^{-1}	Cmol (+) kg^{-1}	
Summit												
A	0-20	842.00	18.00	139.00	0.80	4.95	0.13	5.42	4.30	4.20	8.48	SL
AB	20-45	782.00	54.00	163.00	0.50	1.84	0.33	5.19	4.11	3.10	8.23	SL
Bt1	45-60	782.00	14.00	203.00	0.30	1.36	0.07	5.02	4.06	2.80	6.71	LS
Bt2	60-120	762.00	14.00	223.00	0.40	1.31	0.06	5.01	4.03	2.10	5.97	LS
Mid-Slope												
A	0-22	842.00	14.00	143.00	0.60	3.43	0.10	5.43	4.34	2.30	8.49	SL
AB	22-39	742.00	44.00	213.00	0.40	1.60	0.21	5.15	4.28	1.80	7.65	LS
Bt1	39-56	742.00	54.00	203.00	0.30	1.12	0.27	5.08	4.18	2.10	7.16	LS
Bt2	56-123	742.00	54.00	203.00	0.20	1.09	0.27	5.02	4.16	1.10	5.42	LS
Toe-Slope												
A	0-18	822.00	14.00	163.00	0.50	1.66	0.09	5.59	4.34	2.10	8.19	SL
AB	18-35	802.00	54.00	143.00	0.40	1.90	0.38	5.02	4.09	1.40	7.13	SL
Bt1	35-51	812.00	34.00	154.00	0.27	2.14	0.22	5.00	4.03	1.75	6.07	SL

SL = Sandy loam, LS = Loamy sand and OM = Organic matter

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Table 2. Potassium Forms (cmol+ kg^{-1}) in Particle Size Fractions of A Horizon of Soils Along the Toposequence

					Enrichment Factors		
K Forms	Bulk Soil	Sand	Silt	Clay	Sand	Silt	Clay
Summit							
Solution	0.11	0.06	0.07	0.13	0.54	0.62	1.13
Exchangeable	0.22	0.13	0.13	0.22	0.59	0.61	1.00
Available	0.33	0.19	0.20	0.35	0.57	0.61	1.05
Nonexchangeable	0.22	0.11	0.14	0.22	0.48	0.61	0.60
Structural	0.59	0.36	0.43	0.70	0.61	1.19	1.19
Total	0.88	0.50	0.62	0.95	0.57	0.71	1.09
LSD 0.05	0.05	0.04	0.04	0.04	0.01	0.02	0.73
Mid-Slope							
Solution	0.04	0.02	0.03	0.10	0.51	0.73	2.73
Exchangeable	0.09	0.07	0.07	0.25	0.71	0.72	2.70
Available	0.13	0.09	0.09	0.35	0.65	0.72	2.71
Nonexchangeable	0.09	0.08	0.08	0.11	0.89	0.91	1.18
Structural	0.21	0.18	0.22	0.27	0.86	1.03	1.26
Total	0.44	0.35	0.40	0.73	1.47	1.85	2.32
LSD 0.05	0.00	0.01	0.04	0.00	0.03	0.03	0.13
Toe-Slope							
Solution	0.07	0.04	0.14	0.16	0.60	1.90	2.26
Exchangeable	0.09	0.09	0.20	0.31	0.92	2.22	3.38
Available	0.16	0.13	0.34	0.47	0.78	2.08	2.89
Nonexchangeable	0.10	0.09	0.11	0.16	0.90	1.16	1.68
Structural	0.49	0.20	0.23	0.30	0.40	0.46	0.60
Total	0.49	0.41	0.68	0.93	0.84	1.38	1.89
LSD 0.05	0.03	0.04	0.00	0.04	0.13	0.00	0.00

Table 3. Potassium Forms (cmol+ kg^{-1}) in Particle Size Fractions of AB Horizon of Soils Along the Toposequence

					Enrichment Factors		
K Forms	Bulk Soil	Sand	Silt	Clay	Sand	Silt	Clay
Summit							
Solution	0.06	0.04	0.04	0.05	0.62	0.72	0.90
Exchangeable	0.17	0.05	0.09	0.10	0.29	0.52	0.58
Available	0.23	0.09	0.13	0.15	0.38	0.57	0.66
Nonexchangeable	0.06	0.06	0.07	0.10	0.93	1.05	1.62
Structural	0.05	0.02	0.07	0.04	0.40	1.38	0.79
Total	0.58	0.32	0.41	0.57	0.57	0.74	1.03
LSD 0.05	0.03	0.03	0.03	0.00	0.14	0.00	0.03
Mid-Slope							

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Solution	0.04	0.03	0.04	0.05	0.92	1.11	1.46
Exchangeable	0.07	0.04	0.07	0.07	0.58	0.83	0.95
Available	0.11	0.08	0.10	0.12	0.70	0.92	1.04
Nonexchangeable	0.15	0.04	0.05	0.17	0.29	0.35	1.18
Structural	0.18	0.17	0.22	0.24	0.92	1.21	1.30
Total	0.45	0.29	0.38	0.53	1.49	1.85	2.32
LSD 0.05	0.03	0.03	0.01	0.00	0.13	0.00	0.03
Toe-Slope							
Solution	0.08	0.09	0.13	0.16	1.09	1.59	1.90
Exchangeable	0.17	0.16	0.19	0.27	0.91	1.12	1.56
Available	0.26	0.25	0.33	0.43	0.97	1.25	1.67
Nonexchangeable	0.20	0.15	0.19	0.26	0.72	0.92	1.25
Structural	0.27	0.20	0.25	0.34	0.74	0.93	1.26
Total	0.73	0.60	0.77	1.03	0.81	1.05	1.40
LSD 0.05	0.00	0.03	0.00	0.04	0.01	0.00	0.00

Relationship between Potassium Forms and Selected Soil Properties and Bulk Soil and Particle Size Potassium Concentrations

Potassium forms (solution, exchangeable, available, nonexchangeable, structural and total) in bulk soil correlated none significantly ($P < 0.05$) with sand, silt, clay, silt/clay ratio and pH but significantly with ECEC and available P (Table 4). Organic matter distinctly ($P < 0.05$) correlated with bulk soil available, exchangeable, structural and total K but none with solution and nonexchangeable K. There was no serious relationship between total N with bulk soil solution, nonexchangeable and structural but with available, exchangeable and total K. Sand K (available, solution, exchangeable, nonexchangeable, structural and total) was not seriously correlated ($P < 0.05$) with silt, silt/clay ratio and soil pH but with available P. Sand solution K was distinctly ($P < 0.05$) related with sand ($r = 0.41$), ECEC ($r = 0.72$), OM ($r = 0.84$) and total N ($r = -0.42$). Sand available K correlated seriously with ECEC ($r = 0.58$) and OM ($r = 0.42$), exchangeable K with sand ($r = 0.42$), clay (-0.48), ECEC ($r = 0.57$) and OM ($r = 0.57$), nonexchangeable K with only OM ($r = 0.50$), structural K with clay ($r = -0.43$) and total K with clay (-0.39), ECEC ($r = 0.50$) and OM ($r = 0.51$). Silt K contents were Significantly ($P < 0.05$) correlated with available P but not with sand, silt, silt/clay ratio and pH. There was also significant ($P < 0.05$) correlation between silt available K with ECEC ($r = 0.55$), OM ($r = 0.67$) and total N ($r = -0.52$), silk solution K with ECEC (0.46), silt exchangeable K with ECEC ($r = 0.46$), OM ($r = 0.44$) and total N ($r = -0.57$), silt nonexchangeable K with clay (-0.55), ECEC ($r = 0.41$) and OM ($r = 0.63$), silt structural K with clay ($r = -0.45$) and silt total K with ECEC ($r = 0.49$) and OM ($r = 0.55$). There was no serious ($P < 0.05$) correlation between available, solution, exchangeable, nonexchangeable, structural and total clay K with sand, silt, silt/clay ratio and pH but with clay content. Also, relations between clay available K with total N ($r = 0.38$), solution K with available P, clay exchangeable K with total N, clay nonexchangeable K with ECEC ($r = 0.57$), OM ($r = 0.56$) and P ($r = 0.93$), clay structural K with OM ($r = 0.39$) and P ($r = 0.81$) and clay total K with P ($r = 0.78$) were significant ($P < 0.05$). In general, K forms had high relationship with phosphorus probably due to good interaction between both ions. Lack of distinct relationship between K and pH signifies that there is probably no serious

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impact of soil reaction on K forms. Equally, the sand, silt and silt/clay showed no serious relationship with the forms probably due to lack of surfaces for K interactions.

Relationship between bulk soil and particle size (sand, silt and clay) K forms is shown in Table 5. Available K in the sand, silt and clay fractions accounted for about 24% of that in the bulk soil. Also, sand fraction contributed much of the bulk soil available K than the clay and silt fractions as attested by coefficients of 0.45, 0.34 and 0.17 for sand, clay and silt fractions respectively. Exchangeable K in the bulk soil was contributed by 33% of those of the sand, silt and clay fractions with the order decreasing as Sand > clay > silt fraction as attested by slopes of 1.18, 0.34 and 0.10 respectively. Equally the sand fraction accounted for much of the bulk soil available and total K with 44 and 49% of bulk soil concentration predicted by those of the particle size fractions (sand, silt and clay). Particle size nonexchangeable and structural K fractions accounted for 80 and 73% of the bulk soil concentrations respectively,

Table 4. Simple Correlation between Selected Soil Properties and K Forms

	Sand	Silt	Clay	Si/Cl ratio	ECEC	OM	Total N	P	pH
Bk avail K	0.10	-0.07	-0.09	-0.13	-0.67	0.61	-0.44	0.88	0.11
Bk Sol K	0.06	0.08	-0.14	0.05	0.64	0.28	-0.24	0.75	0.11
Bk exch K	0.02	-0.03	0.00	-0.11	0.68	0.48	-0.45	0.78	0.09
Bk nonexch K	0.17	0.14	-0.33	0.19	0.46	0.33	-0.11	0.81	0.07
Bk Structural K	0.21	0.13	-0.38	0.21	0.38	0.38	-0.08	0.81	0.05
Bk Total K	0.05	0.05	-0.11	0.02	0.56	0.53	-0.40	0.90	0.03
Sa avail K	0.19	0.05	-0.30	0.08	0.58	0.42	-0.17	0.87	0.13
Sa Sol K	0.41	-0.29	-0.37	-0.28	0.72	0.84	-0.42	0.91	0.24
Sa exch K	0.42	-0.14	-0.48	-0.05	0.57	0.57	0.02	0.92	0.28
Sa nonexch K	0.25	-0.18	-0.23	-0.14	0.34	0.50	0.17	0.80	0.28
Sa Structural K	0.25	0.11	-0.43	0.21	0.29	0.33	0.05	0.75	0.08
Sa Total K	0.27	0.01	-0.39	0.08	0.50	0.51	-0.12	0.90	0.14
Si avail K	0.18	0.02	-0.27	0.03	0.55	0.67	-0.52	0.89	-0.01
Si Sol K	-0.27	0.20	0.24	0.08	0.46	0.09	-0.13	0.69	0.03
Si exch K	0.08	0.23	-0.27	0.29	0.46	0.44	-0.57	0.73	-0.16
Si nonexch K	0.36	0.05	-0.55	0.17	0.41	0.63	-0.31	0.87	0.01
Si Structural K	0.27	0.08	-0.45	0.19	0.34	0.37	0.01	0.78	0.09
Si Total K	0.19	0.09	-0.33	0.13	0.49	0.55	-0.33	0.91	0.01
Cl avail K	0.35	0.05	-0.53	0.23	0.02	0.09	0.38	0.37	0.13
Cl Sol K	0.32	0.06	-0.49	0.20	0.32	0.15	0.25	0.60	0.19
Cl exch K	0.30	0.10	-0.49	0.27	-0.08	-0.10	0.48	0.17	0.12
Cl nonexch K	0.30	-0.05	-0.38	0.00	0.57	0.56	-0.13	0.93	0.19
Cl Structural K	0.23	0.11	-0.41	0.20	0.35	0.39	-0.05	0.81	0.06
Cl Total K	0.27	0.09	-0.44	0.20	0.33	0.37	0.01	0.78	0.09

Bk = bulk soil, Sa = sand fraction, Si = silt fraction and Cl = clay fraction, avail = available, Exch = Exchangeable, nonexch = Nonexchangeable. Sol = solution

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Table 5. Multiple Regression of K forms in bulk soil versus those in Particle Size Fractions

Parameter	Regression Equation	R^2
Bk Soil Solution K	$Y_{bk\ (sol.\ K)} = 0.022 + 0.45_{Sa.sol.\ K} - 0.17_{Si.\ sol.\ K} + 0.34Cl_{sol.\ K}$	0.24
Bk Exch K	$Y_{bk\ (exch.\ K)} = 0.10 + 1.18_{Sa.exch.\ K} + 0.01_{Si.\ exch.\ K} - 0.34Cl_{sol.\ K}$	0.33
Bk. Avail. K	$Y_{bk\ (avail.\ K)} = 0.10 + 1.22_{Sa.avail.\ K} - 0.14_{Si.avail.\ K} - 0.13Clavail_{.\ K}$	0.44
Bk nonexch. K	$Y_{bk\ (avail.\ K)} = 1.17\ _{Cl\ nonexch\ K} - 0.35\ _{Sa.nonexch.\ K} - 0.08_{Si.nonexch.\ K} - 0.020$	0.80
Bk struct. K	$Y_{bk\ (struct.\ K)} = 0.16 + 2.7\ _{Sa.struct.\ K} - 2.95\ _{Si.struct.\ K} + 1.05\ _{Cl\ struct.\ K}$	0.73
Bk Total K	$Y_{bk\ (total.\ K)} = 0.16 + 1.97_{Sa.total\ K} - 0.45_{Si.\ total\ K} - 0.17\ Cl_{total.\ K}$	0.49

Bk = bulk, Sol. = Solution, Exch= Exchangeable, Avail = Available, Struct = Structure and Sa = Sand, Si = Silt and Cl = Clay.

with clay nonexchangeable K (slope = 1.17) and silt structural K (slope = 2.70) being most important.

DISCUSSION

Sandiness of the soils could be due to the nature of the parent material which is Coastal Plain Sands (Orajiaka, 1975; Enwezor et al., 1990). Low silt/clay ratios of less than unity indicate that the soils are highly weathered (Noma et al., 2005) and pedogenically ferraltic in nature (Essoka and Esu, 2000). Soils were acidic and attributed to intense leaching of bases by the high tropical rainfall (Enwezor et al., 1990; Uzoho et al., 2007). Also the low pH values of below 5.50 indicate that the soils could suffer from aluminium toxicity. It has been indicated that aluminium toxicity occurs in soils of pH below 5.50 with severity increasing with decreased pH values (Ernani et al., 2002; White et al., 2006). Soil organic matter, available P, total N and ECEC were below critical limits for soils of Southeastern Nigeria (Enwezor et al., 1990). Also the ECEC, available P and total N were linearly related to the soil organic and attributed to the fact that fertility of tropical soils are related to the organic matter content (Noma et al., 2005). Variation in K distribution in decreasing order of total K > structural > available > none exchangeable > exchangeable > solution have been reported by others (Sparks, 2000; Igwe et al., 2008; Ndukwu et al., 2012; Ajiboye and Ogunwale, 2012; Uzoho and Ekeh, 2014). Concentration of total and particle size K in the A horizon was better in the summit probably due to high agricultural activity and increased K fertilizer application while the high value in the toe-slope for the AB horizon could be due to high leaching and movement of materials by gravity. High K concentration in clay than the other particle size fractions have been reported (Ajiboye and Ogunwale 2008; Ajiboye and Ogunwale, 2012) and ascribed to the increased surface area and high sorption capacity (Spaccini et al., 2001). Other workers have reported better concentration in the silt (Igwe et al., 2008) and sand (Najafi-Ghiri and Abtahi, 2013). Variation in K concentration of particle size fractions have been attributed to differences in their mineralogical compositions (Najafi-Ghiri and Abtahi, 2013). Greater K enrichment of the clay fraction could also be due to the existence of large surfaces for K retention. Correlation between soil properties and soil K has been widely reported (Igwe et al., 2008; Ajiboye and Ogunwale, 2012; Uzoho and Ekeh, 2014)

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CONCLUSION

It could be concluded that distribution of soil K forms differed with the physiographic positions of a toposequence with the sequence for various physiographic positions of the A horizon being a decreasing order of total K > structural > available > none exchangeable > exchangeable > solution K. Also, the order for the AB horizon was a deceasing sequence of available > exchangeable > solution = nonexchangeable > structural for the summit, structural > nonexchangeable > available > exchangeable > solution for the mid-slope and structural > available > nonexchangeable > exchangeable > solution for toe-slope. In general, concentration of K forms along the toposequence was better in the summit for the A horizon and toe-slope for the AB horizon. Clay sized soil fractions was more enriched and had higher K concentration than the sand and silt fractions. Equally, most K fractions were seriously affected by selected soil properties especially P, OM, N, clay and ECEC. Finally, a regression model indicated that sand K concentration contributed much of the bulk soil K than the other soil fractions.

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