

Kinetics of Potassium Desorption in Soils Formed over Varying Lithologies using Batch Technique in Abia, Southeastern Nigeria.

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Abstract

This study investigated the kinetics of potassium desorption on two soils formed over varying lithologies in Abia, Southeastern Nigeria. A free survey technique was used for the study. Profile pits were sited according to selected parent materials. Profile digging, description and sampling were done according to the procedure of the USDA National resources conservation services (NRCS) guidelines for profile description. The kinetics of potassium desorption on these soils were determined using batch technique. The kinetic equations used to estimate data were zero-order, first-order, second-order, Elovich equation and parabolic diffusion. Results showed that sand content was high in Amakama soil (Sand = 669.0 g kg⁻¹) compared to lbeku soil (Sand = 150.13 g kg⁻¹). Clay content was higher in lbeku soil (Clay = 696.5 g kg⁻¹) than Amakama soil (Clay = 287.0 g kg⁻¹). Organic carbon and ECEC were higher in lbeku Soil (OC = 1.05 g kg⁻¹; ECEC = 35.18 cmol kg⁻¹) compared to Amakama soil (OC = 0.80 g kg⁻¹; ECEC = 6.9 cmol kg⁻¹). The first order reaction predicted the pattern of potassium desorption better than other kinetic equation for the two soils studied. The reactions were resolved into two linear portions. The first portion was faster while the second was relatively slower in reaction. The rate of potassium desorption was lower in lbeku soil than Amakama soil which was indicated by the desorption rate coefficient (K_d). Percentage K released was more in Amakama soil compared to lbeku soil. Desorption rate coefficient correlated positively with organic C (r = 0.83*; P < 0.05) and negatively with Clay (r = -0.83*; P < 0.05) in Amakama soil. In lbeku soil, no significant relationship was found between desorption rate coefficient (K_d) and soil properties. This study therefore concluded that lbeku soil would sustain crop production without potassium fertilization, while Amakama soil would require K fertilizer application for optimum crop performance. Further studies on potassium uptake by plant in these soils would be necessary to validate the kinetics of potassium desorption and to evaluate K availability to plants.

Keywords: Batch Technique, Kinetics, Potassium Desorption, Soils, Parent Material.

1. Introduction

Equilibrium reactions existing between solution and exchangeable phases of soil K, influences potassium chemistry (Ghafoor & Mohamad, 2011). The rate and direction of these reactions determine whether applied K will be leached into lower soil horizons, absorbed by plants, converted into unavailable forms or released into available forms. Although the distribution of various forms of K differ from soil to soil as a function of the dominant soil minerals present, total K reserves are generally large. With the adoption of high yielding crop varieties under intensive cropping, K from soils may get depleted and reduced due to various long term field experiments (Brar *et al.*, 2008). Although soil K status is generally assessed from exchangeable K, non exchangeable K is also known to contribute significantly to plant nutrition (Bertsch & Thomas, 1985), especially when exchangeable K content is low (Schneider, 1997). The ease with which K is released from non-exchangeable sources gives an index of the ability of these soils to supply K to various crops. Studies on the mineralogy and distribution of K among different soil compartments can contribute to a better understanding of K dynamics.

There are dynamic equilibrium and kinetic reactions between the different forms of soil K that affect the level of soil solution K at any particular time, and thus, the amount of readily available K for plants. Levels of soils solution K are determined by the equilibria and kinetic reactions between the other forms of K (Sadusky *et al.*, 1987). Release and fixation of K are kinetic processes because they depend on the K concentration and competing cations mainly calcium and magnesium in the soil solution (Mitsios & Rowel, 1987; Hinsinger, 1998; Moritsuka *et al.*, 2004). Some of the clay minerals like smectite and kaolinite easily release all of their adsorbed K than do illite and vermiculite (Mengel & Uhlenbecker, 1993). It is generally accepted that trioctahedral micas, such as biotite and phlogopite, can release K more readily than dioctahedral ones, such as muscovite (Fanning *et al.*, 1989).

In intensively farmed agricultural soils, the reserves of fixed K are built up little by little and are influenced by soil parent materials, degree of weathering, and nutrient balance (Bertsch & Thomas, 1985; Quemener, 1986; Simonsson *et al.*, 2007). NajafiGhiri (2014) observed that some organic and inorganic soil amendments may affect K dynamics, distribution, release and fixation. Jalali (2011) working on five calcareous soils of Iran with organic residues, reported decreased K release rate in the following order: vegetable wastes, sun flower waste > poultry manure > potato waste > rape waste > sheep manure > fruit waste > tree leaves > weeds residue. Schneider *et al.*, (2013) investigated on kinetics of potassium sorption – desorption and fixation on a Gleyic Cambisol. Hence, reported the first – order model to practically describe the exchangeable – K levels during the K – fixation capacity experiments.

Most kinetic studies with potassium and other ions have employed batch technique which usually requires centrifugation to obtain a clear supernatant solution for subsequent analysis (Sparks, Zelanzky & Martens, 1980). Most of these studies employed large solution/soil ratios where the concentration in the solution and the quantity adsorbed works simultaneously. In batch-type experiments, the soil particles immediately contact the initial solution concentration (Sparks & Rechcigl, 1982). In calcareous soils, Ca^{2+} is the most common cation replacing interlayer K. The K⁺ in the interlayer can be exchanged by the hydrated cation such as Ca^{2+} . The Ca^{2+} in the soil mineral can be able to release K.

In Abia Southeastern Nigeria, the soils of the area have been intensively weathered with excessive leaching due to high rainfall and temperature. These tropical soils have suffered drastic reductions in K and soil organic matter due to soil erosion and inappropriate land uses (Mbagwu, 1992; Lal, 1995) thereby making K – predictions inconsistent. Mixed

mineralogy which is common in these soils have also made the fate of added k as fertilizer and the responses of crops to applied k different and unpredictable. The available K status after fertilization therefore depends upon K sorption and desorption capacity of these soils. The knowledge of potassium extraction and release is important in other to predict and improve the rate of fertilizer application in soils (Sparks *et al.*, 1980; Rezaei *et al.*, 2009). This study therefore investigated the kinetics of potassium desorption of soils formed over varying lithologies using batch technique.

2. Materials and Methods

2.1. Study Area

The study was conducted at Amakama and Ajata-Ibeku both in Umuahia, Abia State, Southeastern Nigeria, The study area is located on latitude 05° 26' 40" N and Longitude 07° 78'49" E for Amakama while Ajata-Ibeku lies within latitude 05° 32' 51" N and longitude 07° 33' 34" E. The soils of Amakama are formed from Coastal Plain Sand (Benin formation) while the soils of Ajata-Ibeku are formed from Bende-Ameki Clay Shale group. Topography is nearly flat at Amakama while in Ajata-Ibeku, the landscape is highly dissected with deeply incised valleys due to differential erosion of the Sandstone and Shale that make up Bende – Ameki formation (Chikezie, Eswaran, Asawalam & Ano, 2010). It has a humid tropical climate with annual rainfall which ranging from 1750 mm to 3000 mm and a mean annual temperature of 27 – 35 °C. Farming is a dominant socio-economic activity of the area. Farmers still stick to traditional slash and burn system of clearing and soil fertility regeneration is by natural bush fallow.

2.2. Field Studies

A free survey technique guided by the geological map of the study area was used for study. Two profile pits were dug each at Amakama and Ajata-Ibeku. The profile pits were sited according to selected parent materials. The spatial positioning of all the profile pits was determined using a hand- held Global positioning system (GPS) receiver. Profile digging, description and sampling were done according to the procedures of the USDA Natural Resources conservation Service (NRCS) guidelines for profile description (Soil Survey Staff, 2002). Profile pits were described and sampled for routine analyses. Soil samples were air-dried, gently crushed and sieved using 2-mm Sieve in preparation for laboratory analyses.

2.3. Laboratory Analyses

Particle size distribution was determined by hydrometer method (Gee & Or, 2002). Soil pH was determined in water using 1:2.5 Soil – liquid ratio (Thomas, 1996). Exchangeable cations (Ca, Mg, K and Na) were determined by IN Ammonium acetate extraction procedure (Thomas, 1996). Calcium and magnesium were determined using atomic absorption spectrophotometer while sodium and potassium was determined using flame photometer (Jackson, 1962). Exchangeable acidity was determined in IN KCl (Mclean, 1982). Organic carbon was determined by wet oxidation method (Nelson & Sommer, 1996). Effective cation exchange capacity was determined by summation of exchangeable bases plus exchangeable acidity expressed in cmol kg^{-1}

2.4. Kinetics of potassium – desorption on soils

A batch equilibrium experiment was conducted using CaCl_2 solution as follows: Prior to initiation of Kinetic desorption studies, 30 g of soil samples were saturated with 1M CaCl_2

solution. This was done by weighing 30 g of the soil samples into 100 ml plastic containers. 50 ml of IM CaCl₂ solution was added into each of those containers. The samples were shaken on a reciprocal shaker for 2hrs and were filtered through a whatman No. 42 filter paper. The soil samples were subsequently washed with distilled water until a negative test for chloride ion was obtained with silver nitrate (AgNO₃).

The soil samples were further saturated with IM KCl solution. This was done by adding 50 ml of IM KCl solution into different plastic containers containing the soil samples. The samples were shaken on a reciprocal shaker for 2 hrs and were filtered through whatman No. 42 filter paper. The soil samples were washed with distilled water until a negative test for chloride ion was obtained with silver nitrate (AgNO₃). The soil samples were air-dried and used for potassium desorption studies.

2.5. Kinetics of desorption studies

Desorption studies were conducted by using soils that were equilibrated with IM KCl. 0.5 g of potassium saturated soils was weighed into different test tubes. 10 ml of 0.01M CaCl₂ solution was added to the saturated soils and were shaken on a reciprocal shaker for 3mins. After equilibration, the samples were centrifuged for 2 mins. 5 ml of the supernatant was pipetted into 25 ml volumetric flask and was made up to the mark with distilled water. Potassium in the leachate was determined by flame photometer. The above procedure was repeated for different time intervals: 10, 15, 20, 80, 140, 200, 260, 320, 380, 440 and 500mins. Potassium desorbed was calculated. Potassium desorption with time was fitted into different kinetic equations, namely: Zero order, First order, Second order, Elovich equation and Parabolic diffusion as described below

Zero –order equation

$$\left[1 - \frac{C_t}{C_\infty} \right] = a - bt \tag{1}$$

First – order equation

$$\text{Log} \left[\frac{1 - C_t}{C_\infty} \right] = a - bt \tag{2}$$

Second-order equation

$$\frac{1}{C_t} = \frac{1}{C_\infty} + Kt \tag{3}$$

Elovich equation

$$C_t = a + b \ln t \tag{4}$$

Parabolic diffusion

$$\frac{C_t}{C_\infty} = a + bt^{1/2} \tag{5}$$

where C_∞ = maximum desorbable K (it was found from the equilibrium plots of K release versus time)

C_t = K release after time t.

t = time (mins), a and b are the constants.

(Sparks, 1985)

Apparent rate coefficient (mins) (Kd) which is the desorption rate coefficient was calculated from the slope of each of the first -order plot. The coefficient of determination (R²) and standard error of estimate (SE) were calculated for each equation.

Statistical Analysis: Mean and standard deviation were determined using SAS, (2003) while coefficient of variation was determined using the procedure of Wilding et al. (1994). Relationship between rates of k-desorption and some soil properties was determined using correlation coefficient.

3. Results and Discussion

Table 1 shows the results of some properties of the soils of the studied area. There were some marked differences between the soils obtained from Amakama and Ibeku. Amakama soil which was formed from Coasted Plain Sand had higher values of Sand (Sand = 669.0 g kg⁻¹) compared to Ibeku soil (Sand = 150.13 g kg⁻¹). This is possibly due to the parent material from which the soils are formed. Clay content was higher in Ibeku soil (Clay = 696.5 g kg⁻¹) compared to Amakama soil (Clay = 287.0 g kg⁻¹). The high clay content in Ibeku soil suggests differences in the parent material (Bende-Ameki Shale group) and clay minerals in the study sites. Soils are strongly acidic and ranged from pH 4.6 - 4.7. This may be attributed to the combined influence of parent materials and climate on pedogenesis. Exchangeable acidity was higher in Ibeku soil (EA= 25.6 cmol kg⁻¹) than Amakama soil (EA= 6.8 cmol kg⁻¹) suggesting aluminum toxicity. Variability in exchangeable acidity could be attributed to high rainfall and temperature in the study area. The high temperature and rainfall in this agro-ecological zone favours intensive weathering and rapid leaching. This may have led to the washing away and leaching of the basic cations leaving the acidic cations. Effective cation exchange capacity (ECEC) was lower in Amakama soil (ECEC= 6.9 cmol kg⁻¹) compared to Ibeku soil (ECEC= 35.18 cmol kg⁻¹) possibly due to low clay and organic matter (OC). Generally, the ECEC of a soil low in organic matter is a reflection of its clay mineralogy, with the expanding minerals having higher CEC (ECEC) than non-expanding types (Kaolinite) (Igwe *et al.*, 1999). However, the low ECEC in Amakama soil is indicative of the low capacity of this soil to retain nutrients, thus making the soil unsuitable for intensive agriculture (Kparmwang *et al.*, 2004). Organic C was higher in Ibeku soil (OC= 1.05 g kg⁻¹) than Amakama soil (OC= 0.80 g kg⁻¹). The high organic matter (OC) observed in Ibeku soil may be due to the presence of organic materials in the study site which could have a major impact on the mineralization rates thereby increasing soil carbon directly (Antill *et al.*, 2001).

Table 1: Some physicochemical characteristics of the studied soils

Location	Horizon	Depth (cm)	Sand gkg ⁻¹	Silt	Clay	Texture	pH	EA cmolkg ⁻¹	ECEC	AL sat	OC gkg ⁻¹		
Amakama	Ap1	0-13	758.0		36.0	206.0	SCL	4.5	11.10	11.60	83.0	2.07	
	Ap2	13-27	727.0		31.0	242.0	SCL	4.6	9.80	9.90	93.0	1.43	
	Bo1	27-63	681.0		37.0	282.0	SCL	4.6	6.60	6.60	-	0.57	
	Bo2	63-99	639.0		48.0	313.0	SCL	4.7	6.50	6.50	-	0.43	
	Bo3	99-127	650.0	37.0	313.0		SCL	4.7	5.10	5.20	92.0	0.37	
	Bo4	127-159	585.0		87.0	328.0	SCL	4.8	4.70	4.70	-	0.25	
	Bo5	159-210	643.0		32.0	325.0	SCL	4.9	3.90	3.90	-	0.23	
		Mean		669.0		44.0	287.0		4.7	6.80	6.90	38.3	0.80
		SD		58.3		19.7	46.0		0.13	2.69	2.83	42.3	0.71
		CV		8.7		44.9	16.3		2.9	39.4	40.9	98.6	92.6
Ibeku	Ap1	0-9	341.0	267.0	392.0	SiCL	5.0	24.4	33.6	25.0		3.39	
	Ap2	9-28		317.0	228.0	455.0	SiC	4.8	25.5	29.4	58.0	2.26	
	Bt	28-60		103.3	148.0	749.0	C	4.8	22.8	26.5	74.0	0.98	
	2Btg	60-80		62.0	121.0	817.0	C	4.7	24.6	29.4	78.0	0.57	
	2Bssg1	80-101	84.0	111.0	805.0	C	4.7	25.7	30.7	81.0	0.41	2Bssg2	
	101-128	127.0	92.0	781.0	C	4.5	29.2	38.7	66.0	0.29			
	2Bssg3	128-164	81.0		87.0	832.0	C	3.8	29.4	46.7	40.0	0.25	
	2Bgss	164-190	86.0		173.0	741.0		4.2	22.9	46.4	09.0	0.27	
		Mean		150.13	153.4	696.5		4.6	25.6	35.18	53.9	1.05	
		SD		112.3		65.4	172.2		0.39	2.53	7.89	26.5	1.16
	CV		75.0		42.6	24.7		8.5	9.9	22.4	49.2	90.2	

EA= Exchangeable acidity, ECEC= Effective cation exchange capacity, Alsat= Aluminium saturation, OC= Organic carbon, SCL= SandyClayLoam, SiCL=SiltyClayLoam, C=Clay, SD=Standard deviation, CV=Coefficient of variation.

3.1. Kinetics of K desorption in Soils

Results of statistical analysis showed that first order reaction predicted better the pattern of K desorption from two soils studied than other kinetic equations by high R^2 values and low standard error values (SE) (Tables 2 and Table 3). The plot of $\log(1-C_t/C_\infty)$ versus time indicated that the rate of potassium desorption for the two soils studied was linear (Figs 1a, 1b, 2a and 2b). The reaction occurred into two concurrent reactions each having different desorption rate coefficient (Kd) as the apparent desorption rate coefficient and is directly proportional to the rate of K released. The first reaction was from 5 – 20 mins (Reaction 1) (R1) and represented the rapid stage of K released, with higher desorption rate coefficient (Kd) (Figs 1a, 1b, 2a, 2b, Reaction 1 and Table 3). It was relatively faster than the second reaction which was a slow reaction and ranged from 80-320mins (Reaction 2) (R2) (Figs 1a, 1b, 2a, 2b Reaction 2 and Table 3). This sequence showed that two different mechanisms controlled the K release from the two soils studied (Sivasubramanian & Talibudeen, 1972; Sparks *et al.*, 1980; Youssef *et al.*, 2013). The initial rapid phase indicated the release of K from external surface and edge sites of the clay minerals and soils (Jardine and Sparks, 1984a). Additionally, Chikezie *et al.* (2010) reported that Amakama soil has mixed mineralogy dominated by Kaolinite, small quantities of goethite, gibbsite and haematite while Ibeku soil has kaolinite at the upper 100 cm of the profile and detectable quantities of montmorillonite, small quantities of goethite, gibbsite, and plagioclase feldspar. Since Kaolinite clay minerals do not have interlayer spaces, therefore, the rate of desorption of K at the initial phase (5 – 20 mins) applies to K desorbed from these minerals. The second rate of reaction (80 – 320 mins) was slower and ascribed to potassium desorbed from interlayer spaces of 2:1 Clay minerals (Jardine and Sparks, 1984b). The rate coefficient of K desorption (Kd) in the first and second reaction was higher in Amakama soil compared to Ibeku soil (Table 3). It ranged from 1.52×10^{-2} to 4.56×10^{-2} (min^{-1}) in reaction 1 and from 4.31×10^{-3} to 1.11×10^{-2} (min^{-1}) in reaction 2 in Amakama soil, while in Ibeku soil, it ranged from 2.40×10^{-2} to 3.68×10^{-2} (min^{-1}) in reaction 1 and from 5.20×10^{-3} to 7.76×10^{-3} in reaction 2 (Table 3). These differences may have been attributed to the differences in type and content of minerals in clay fractions (Sparks *et al.*, 1989; MamRasul & Al-Obaidi, 2011). Sparks and Huang (1985) & Sparks (2000) reported that factors such as tetrahedral ration, hydroxyl orientation, chemical composition, particle size, degree of K depletion, layer charge alteration, hydronium ions, biological activities, inorganic cations, wetting and drying factors and the nature of soil environment governs the release of K by cation exchange reactions and dissolution processes followed and formation of weathering products. However, the rate of K desorption was higher in Amakama soil than Ibeku soil. The higher rate of desorption of K from Amakama soil could be related to leaching and high temperature prevalent in the area, ECEC and reduction/ removal of AL-organic matter complex. Leaching promotes the release of K from K-bearing minerals by carrying away the products, while increase in temperature increases the rate of K release (Sparks & Huang, 1985; Sparks, 2000). Singh & Gilkes, (1992); Chikezie *et al.* (2010) reported that Amakama soil which has kaolinite a 1:1 clay mineral and a product of acid weathering favours intensive weathering and rapid leaching due to high rainfall and temperature. This process allowed the high release of K in the study site. Furthermore, Ibeku soil desorbed K constantly at a slower rate than Amakama soil as indicated by the low desorption rate coefficient (Kd) possibly due to higher clay content and organic matter. The presence of hydroxyl-Al associated with organic matter may have blocked the interlayer surfaces in soils of Ibeku, making it difficult for K to be desorbed (Jardine & Sparks, 1984b; Sparks, 2000). This process has led to the partial collapse of this mineral in Ibeku soil (Nadia *et al.*, 2013). Also, the wetting and drying

processes in lbeku soils may have had influence on the slow desorption of k. The slow release of k upon drying may be due to the presence of hydroxyl-Al interlayer which blocks or retard the interlayer diffusion of k ions in lbeku soil. This process may have changed the b dimension of this mineral, the degree of tetrahedral rotation, and the length and strength of the K-O bond (Sparks, 2000).

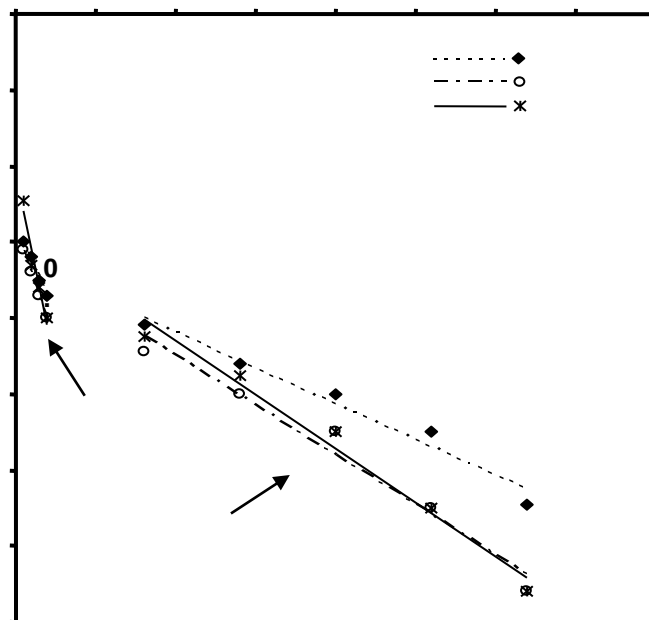
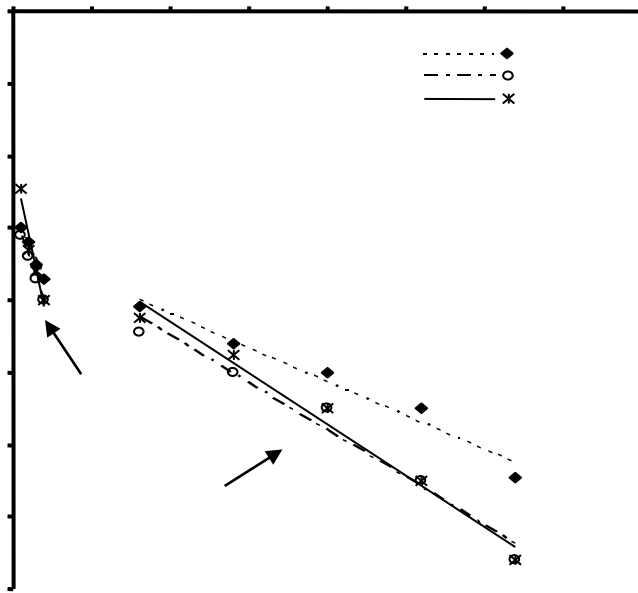
Table 2: Coefficient of Determination (R²) of First – Order Kinetic equation for the Desorption of Potassium on two soils of the study Sites.

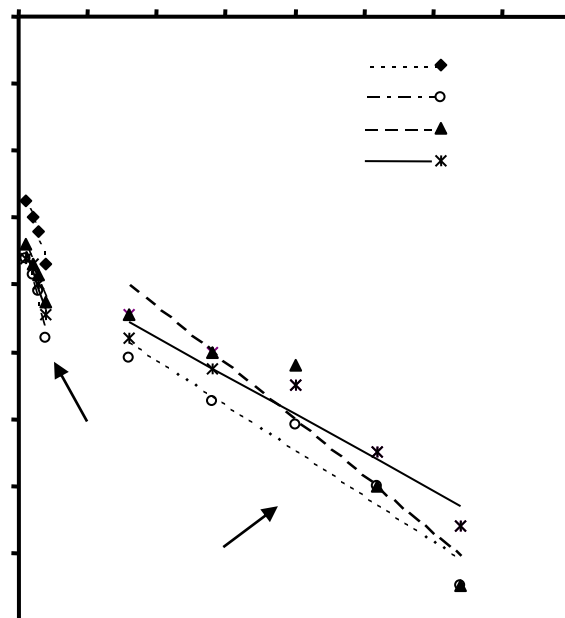
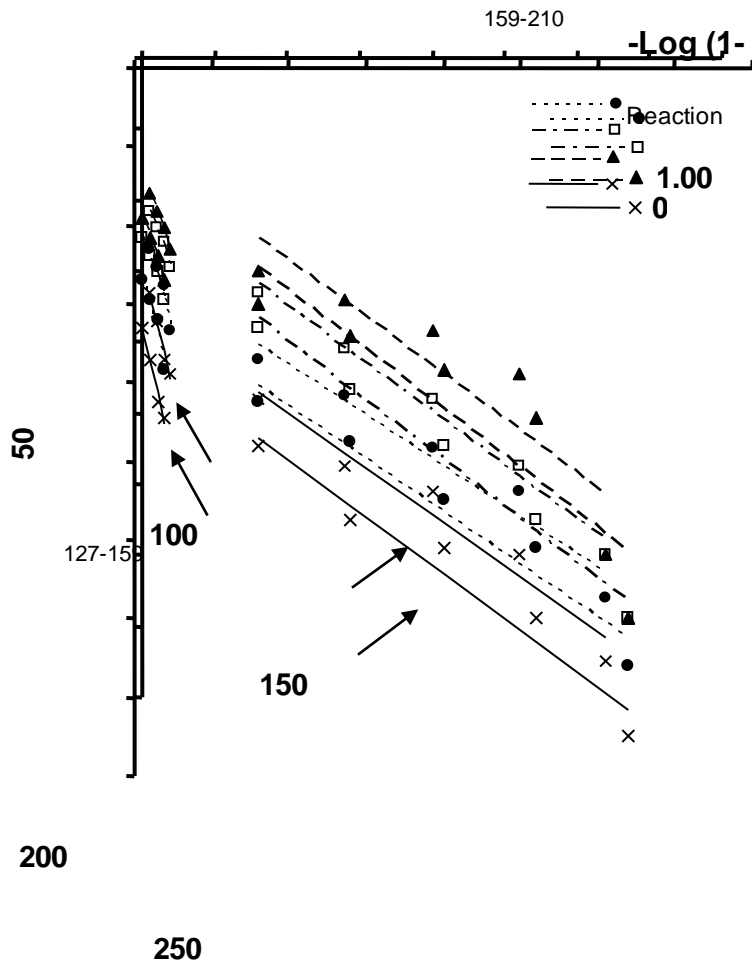
Location		Horizon Depth (cm)	5-20mins Regression Equation	R ²	80-320mins Regression Equation	R ²
Amakama	Ap1	0-13	Y=0.265 + 0.0114X	0.99	Y=0.110 + 0.0048X	0.96
	Ap2	13-27	Y=0.455 + 0.0066X	0.99	Y=0.329 + 0.0030X	0.89
	Bo1	27-63	Y=0.575 + 0.0136X	0.99	Y=0.569 + 0.0031X	0.86
	Bo2	63-99	Y=0.505 + 0.0166X	0.98	Y=0.675 + 0.0021X	0.95
	Bo3	99-127	Y=0.550 + 0.0096X	0.99	Y=0.653 + 0.0019X	0.97
	Bo4	127-159	Y=0.560 + 0.0120X	1.00	Y=0.642 + 0.0026X	0.97
	Bo5	159-210	Y=0.420 + 0.0198X	0.94	Y=0.581 + 0.0028X	0.98
Ibeku	Ap1	0-9	Y=0.450 + 0.0148X	0.93	Y=0.591 + 0.0027X	0.95
	Ap2	9-28	Y=0.375 + 0.0104X	0.99	Y=0.395 + 0.0030X	0.99
	Bt	28-60	Y=0.325 + 0.0106X	0.99	Y=0.265 + 0.0030X	0.82
	2Btg	60-80	Y=0.585 + 0.0160X	0.97	Y=0.709 + 0.0029X	0.95
	2Bssg1	80-101	Y=0.480 + 0.0122X	0.96	Y=0.642 + 0.0026X	0.97
	2Bssg2	101-128	Y=0.625 + 0.0154X	0.92	Y=0.761 + 0.0027X	0.93
	2Bssg3	128-164	Y=0.625 + 0.0108X	0.97	Y=0.533 + 0.034X	0.90
	2Bgss	164-190	Y=0.645 + 0.0114X	0.93	Y=0.003 + 0.67X	0.99

Table 3: Potassium Desorption Rate Coefficient (Kd) and Standard Error of Estimate for the Desorption Reaction on the Soils of the Study sites

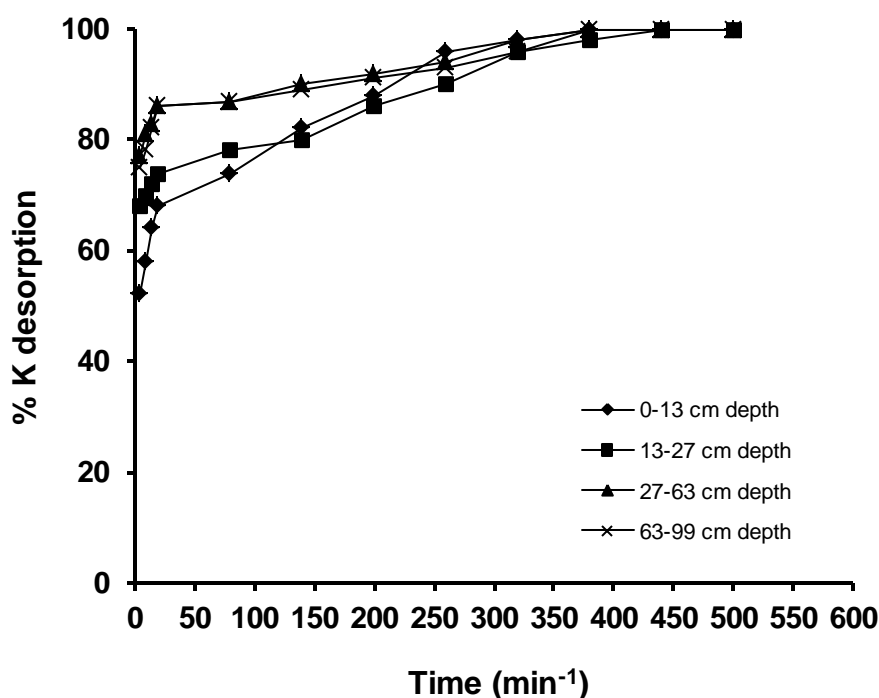
Location		Horizon Depth (cm)	5-20mins Kd (min ⁻¹)	SE	80-320mins Kd (min ⁻¹)	SE
Amakama	Ap1	0-13	2.63 X 10 ⁻²	0.00035	1.11 X 10 ⁻²	0.00059
	Ap2	13-27	1.52 X 10 ⁻²	0.00035	6.84 X 10 ⁻³	0.00061
	Bo1	27-63	3.13 X 10 ⁻²	0.00085	7.07 X 10 ⁻³	0.00072
	Bo2	63-99	3.82 X 10 ⁻²	0.00159	4.88 X 10 ⁻³	0.00027
	Bo3	99-127	2.21 X 10 ⁻²	0.00057	4.31 X 10 ⁻³	0.00019
	Bo4	127-159	2.76 X 10 ⁻²	0	5.99 X 10 ⁻³	0.00027
	Bo5	159-210	4.56 X 10 ⁻²	0.00339	6.49 X 10 ⁻³	0.00024
Ibeku	Ap1	0-9	3.41 x 10 ⁻²	0.00277	6.17 X10 ⁻³	0.00034
	Ap2	9-28	2.40 x 10 ⁻²	0.00085	6.96 X 10 ⁻³	0.00020
	Bt	28-60	2.44 x 10 ⁻²	0.00035	6.96 X 10 ⁻³	0.00082
	2Bg	60-80	3.68 x 10 ⁻²	0.00190	6.63 X 10 ⁻³	0.00036
	2Bssg1	80-101	2.81 x 10 ⁻²	0.00187	5.99 X 10 ⁻³	0.00027
	2Bssg2	101-128	3.55 x 10 ⁻²	0.00312	6.17 X 10 ⁻³	0.00041
	2Bssg3	128-164	2.49 x 10 ⁻²	0.00130	7.76 X 10 ⁻³	0.00063
	2Bgss	164-190	2.63 x 10 ⁻²	0.00222	5.25 X 10 ⁻³	0.00036

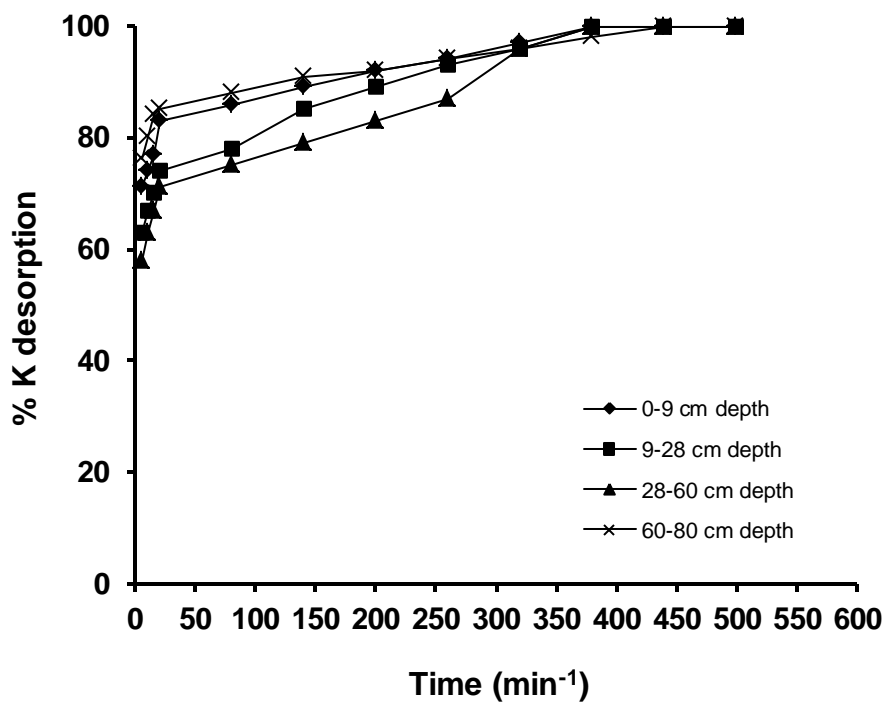
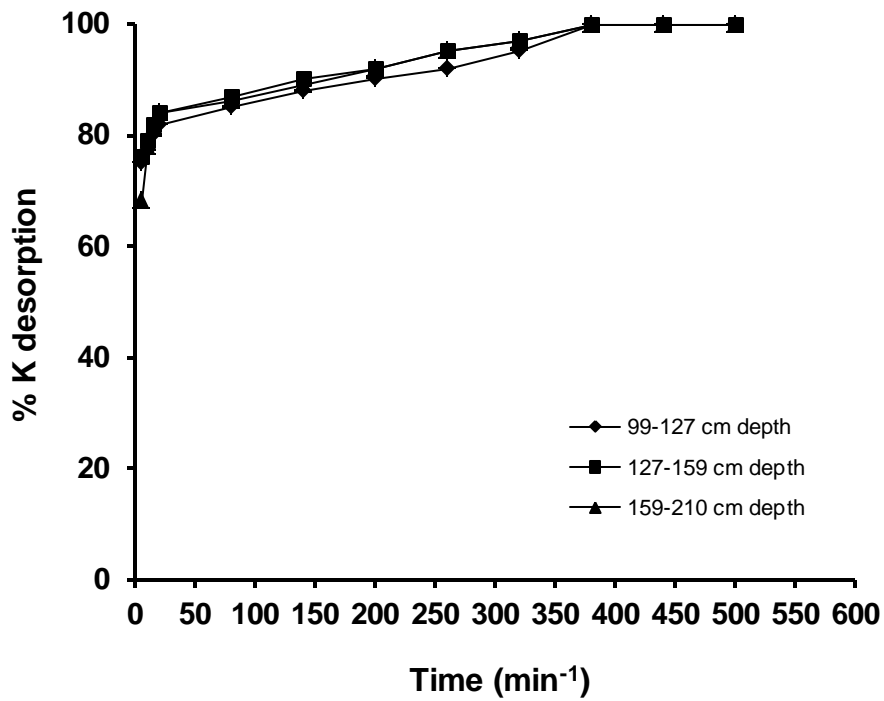
Kd = Desorption rate Coefficient, SE = Standard Error of estimate

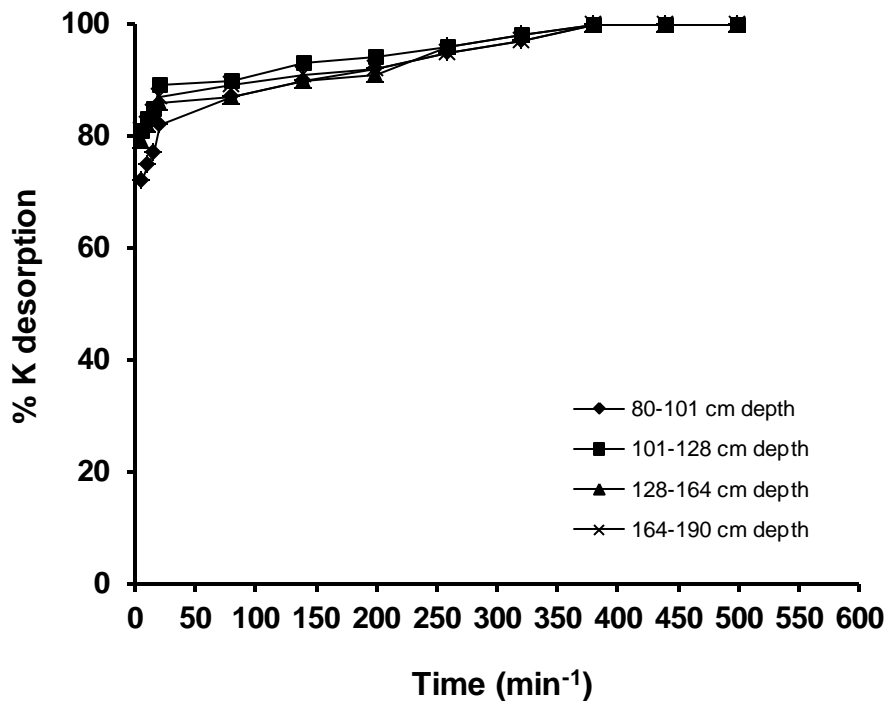




Comparatively, the percentage K released from the solid phase was more in Amakama soil compared to Ibeku soil (Figs 3a, 3b, 4a and 4b). It increased from 45 % and reached its maximum at 98% (Figs 3a and 3b) while in Ibeku soil, percentage K released was 15% less than that in Amakama soil. It increased from 58 % at the initial time of contact between the soil and potassium in solution to 98% where it reached a plateau (Figs 4a and 4b). The high percentage K released from Amakama soil could be attributed to the influence of organic acid (Oxalic and Citric acid) from the weathering of this rock- forming mineral (Song & Huang, 1988). The high weathering in the area would lead to Amakama soil releasing more K through the formation of K- organic acid complexes leading to the loss of K. Also, the sandy nature of the area may have lead to the loss of K through leaching (Sparks, 2000).







The result of the correlation between desorption rate coefficient (K_d) and some soil properties for the two soils studied (Table 4) showed that desorption rate coefficient (K_d) correlated positively with organic C ($r = 0.83^*$, $P < 0.05$) and negatively with clay ($r = -0.83^*$; $P < 0.05$). Meanwhile in Ibeku soil, desorption rate coefficient (K_d) had very poor relationship with soil properties (Table 4). The poor correlation between K-desorption and soil properties may be due to the desorption sites having competition among these components (Kaiser and Zech, 1997).

Table 4: Correlation Coefficient for Linear Relationship between Desorption rate coefficient (Kd) and some soil properties for the two soils studies

Soil properties	Amakama		Ibeku	
	5-20 (mins) (R ₁) r ₁	80-320 mins (R ₂) r ₂	5-20 mins (R ₁) r ₁	80-320 mins(R ₂) r ₂
Clay	0.52 ^{ns}	-0.83*	0.02 ^{ns}	0.07 ^{ns}
Organic Carbon	-0.51 ^{ns}	0.83*	0.08 ^{ns}	0.40 ^{ns}
pH	0.60 ^{ns}	-0.59 ^{ns}	0.32 ^{ns}	-0.22 ^{ns}
ECEC	-0.55 ^{ns}	0.75 ^{ns}	-0.13 ^{ns}	-0.09 ^{ns}

ECEC = Effective Cation exchange capacity, * = Significant at P < 0.05, ns = Not Significant at P < 0.05, R1= Reaction 1, R2= Reaction 2.

4. Conclusion

This study showed that K – desorption differed among the soils studied due to influence of soil physicochemical and mineralogical properties and soil environmental factors. The rates of K desorption was characterized by a rapid initial desorption which lasted from 5 – 20 mins, followed by a slower desorption which proceeded from 80 to 320 mins.

The rate of desorption of K was lower in Ibeku soil than Amakama soil. Potassium desorption reaction in Ibeku soil was influenced by organic matter (organic C) and clay while leaching, high temperature and organic acids from weathering of the rock- forming minerals contributed to the rate of desorption of K in Amakama soil. Correlation analysis showed that the rate of K – desorption was also affected by soil properties. The study therefore revealed that Ibeku soil would retain more K than Amakama soil in terms of fertilizer application. Also, a lack of crop response to added K would be more in Amakama soil due to loss of K through leaching. Retention of K in this soil can only be enhanced after application of lime. Application of fertilizer can be done through split does, since movement of applied K has been related to the method of application. Further studies on K uptake by plant in these soils would be suggested to validate the kinetics of potassium desorption and K availability to plants.

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