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A STUDY ON QUANTITY AND INTENSITY OF POTASSIUM IN THE ALLUVIAL SOILS IN BAGHDAD

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Abstract

Twelve soil samples were collected surround Baghdad province to study Potassium availability using quantity-intensity relationship, activity ratio (AR_e^K), the pool of Labile $K^+(K_L)$, Potential buffering capacity (PBC^K), coefficient parameters. The quantity-Intensity parameters of Potassium were studied to quantify Potassium release for the studied soils. Results showed, Potassium activity ratio (AR_e^K) is related to changes with labile potassium ($\pm\Delta K$) at equilibrium and increased together with increasing K^+ concentrations, and it is ranged between (0.44 and 11.39)x10^{-3} $(mol.L^{-1})^{1/2}$. The range of labile $K^+(K_L)$ values is equal to (0.37- 15.57) cmol.kg^{-1}, respectively, while the K^+ (PBC^K) fluctuated from 0.83 to 1.37 cmol.kg^{-1} $(mol.L^{-1})^{-1/2}$. The exchange in the ($-\Delta G$) ranged from -1.09 to -0.63 kJ.mol^{-1} and Gapon Selectivity Coefficient (k_G) ranged from 0.02 to 0.07 $(mol.L^{-1})^{1/2}$. The results also showed a high correlation between Illite and each of K_L (r=0.71*) , PBC^K (r=0.92**) and k_G (r=0.84**) in studied soils. The study provided more accurate information about potassium dynamics of the soils and make a significant role to operational K^+ management.

Keywords: Quantity intensity (Q/I) characteristics, Gapon Selectivity, buffering capacity, labile potassium free energy of replacement.

Introduction

Potassium (K^+) is considered the third largest and most dynamic nutrient and have different functions in plant metabolism. Generally, the reserves of total potassium are large, but only small quantities of them are instantly or slowly available to plants. The supply of crop with potassium is considered a complex phenomenon including various fractions of potassium in the soil. The Q/I relations of labile K regarded to its availability to the amount (Q) present. The activity ratio has been suggested as a measure of the intensity. The ability of a soil to maintain the activity ratio against depletion by plant roots partly comes from the pool of labile K, the rate of release of fixed K, diffusion and transport of K ions in the soil solution. The isolation of the potential buffering capacity for the pool of labile K could be determined through the Q/I relation over short periods. The determination of immediate Q/I has been conducted for a number of soils. The results were linear for all values of the range of activity ratios always encountered in agricultural soils and approximately familiar with ion-exchange equations. At low values of the activity ratio, the Q/I parameters were curved and asymptotic to the Q-axis (Beckett, 1964). Bilias and Barbayiannis, (2019) referred that the used thermodynamic approach in understanding, characterizing and evaluating K^+ supplying capacity of soil is the quantity-intensity (Q/I) isotherm of K+ and concluded that ΔG could be used as a reliable predictor of K availability, if showed that ΔG could be used as a reliable predictor of K availability, if CEC and illite K are taken into consideration, which helps in overcoming limitations arising from the complexity of K release and fixation dynamics that make conventional extraction methods often inadequate. Several methods in the lab were used to assess K supplying power of soils to plants, a fundamental approach based mainly on the labile pool of potassium was strongly advocated (Beckett, 1964). So far, the concentration of exchangeable potassium has been determined by the traditional method that employs chemical extractants. Al-Zubaidi and Yanni, (2008) reported insufficiency of exchangeable potassium alone for evaluating K availability under intensive cropping. This could be largely due to the fact that dynamic interactions among different K pools control plant availability of soil potassium. New techniques used depending upon adsorption isotherms and thermodynamic parameters such as ionic activity, activity coefficient, ionic strength, the free energy of replacement. several researchers are considered it an accurate method for evaluating potassium status and its availability in soils. These can be conducted through the study of the relationship that exists between changes in the concentration of adsorbed K to changes in the concentration of solution K; quantity/ intensity relationship (Uddin *et al*., 2011). In the Q/I curve the equilibrium activity ratio of K^+ (ARe^K) is a parameter for the intensity of labile K+ in the soil. Different soils exhibiting the same values of ARe^K with different values of capacity to maintain ARe^K when soil K^+ is depleted by the plant (Diatta *et al*., 2006). Higher values of labile K+ indicated a greater K+ release into soil solution resulting from a larger pool of soil K^+. A high value of the potential buffering capacity for K+ (PBCK) in the soil is indicative of a good K+ availability while a low PBCK value would propose a need for K^+ fertilization (Wang et al., 2004). In recent years, Many papers have been published to assess availability of K^+ in soils using Q/I concept or soil K^+ buffering characteristics (Samadi, 2006; Abaslo and Abtahi, 2008; Yawson *et al*., 2011; Bahmani *et al*., 2013; Lalitha and Dhakshinamoorthy, 2015; Bilias, 2018). The study aims to determine (Q/I) from some of the calcareous soils of surround Baghdad-Iraq and to relate them to soils availability.

Materials and Methods

Study Area and Sample Collection

Twelve samples of surface soil were collected from different locations around Baghdad province-Iraq. The climate of the study area is semi-arid and sub-tropical with an average annual rainfall of 150 mm. samples were dried, crushed and passed through a 2mm sieve, then the chemical and physical analyses were conducted. Soils belong to Fine, mixed, active, hyperthermic, calcareous. Typic torrifluvents. According to USDA (Soil Science Division Staff, 2017), some chemical and physical characteristics are determined as followed by (Page, 1982). Organic matter was determined by dichromate oxidation and the cation exchange capacity was obtained by dissolving soil with neutral 1N NH_4OAc method. Electrical Conductivity (EC) and soil (pH) were measured using 1:2.5 soil to water Suspension. Water soluble, exchangeable, and total K extracts were estimated by flame photometer. Mineralogy analyses, X-ray diffraction were performed on the <2 um clay fraction. sub-samples were treated with distilled water to remove the soluble salts then treated with NaOAc (at pH= 5) to remove the $CaCO_3$, and treated with sodium hypochlorite (NaOCl 14%). organic matter and Na-dithionite-citrate-bicarbonate and Fe oxides were removed, and clay was separated by decantation. X-ray diffractograms were obtained with a Philips X-ray diffractometer with Ni-filtered CuKα radiation generated at 40kv and 2θ mA. The semi-quantitative mineralogical composition of the clay fraction treated by Mg-saturation, Mg-plus ethylene glycol-saturation, K-saturation, and K-saturation and heated was determined by X-ray diffraction analyses.

Experimental Method and Procedure

The quantity-intensity of K^+ was determined according to the method of (Beckett, 1964) by adding 50 mL of 0.01M $CaCl_2$ solutions containing (0, 0.1, 0.2, 0.4, 0.6, 0.8, 1, 2, 5, 7, 10 $mmol.L^{-1}$) KCl concentrations to 2.5 g of the soil sample. The soil suspensions were shaken vigorously for (2 h) and left for overnight (24 h) for equilibration and then centrifuged. The suspensions of soil samples were filtered and the supernatants were analyzed for K^+ by a flame photometer and for Ca^{++} and Mg^{++} by titration with versenate (Carter and Gregorich, 2008). The K^+ intensity (I) or the activity ratio of K^+ (AR^K) relative to Ca^{++} Mg^{++} species of each equilibrium solution was calculated. The change in the amount of K in solution gained or lost by the soil (±ΔK) was calculated according to the following equation.

$$(\pm\Delta K) = (ci-cf) \times V/W$$

Where: V=Volume of solution d m^3 and W=Weight of dry soil Kg

The K intensity factor in the liquid phase for soil expressed as activity ratio AR^K, it was computed from the measured concentration of Ca, Mg and K in the supernatant solution after equilibration. The activity ratio of potassium (AR^K) was calculated according to Ratio law (Beckett, 1964) as:

$$AR^K = \frac{a_K}{\sqrt{a_{Ca} + a_{Mg}}}$$

Where: a_i = ionic activity species (Ca, Mg and K). The ionic activity was calculated according to the Lewis equation as described by (Sposito, 2008)

$$a_i = C_i \times \gamma i$$

Where: a_i = ionic activity, C_i =the species concentration of ions in ($mol.L^{-1}$).

The ionic activity coefficients were calculated by the empirical Davies equation given by (Sposito, 2008) as:

$$\log\ \gamma i = -0.512\quad Z_i^2 \left[\frac{\sqrt{I}}{1+\sqrt{I}} - 0.3\ \ I\right]$$

Where: γi= the mean activity coefficient of the electrolyte, Z_i= ion species valence, *I* = ionic strength in ($mol.L^{-1}$).

From a plot of (±ΔK) versus the activity ratio, the Q/I parameters were obtained. The intercept of the Q/I curve on the AR^K_{equ} axis, where K=0, gave the soil K activity ratio at equilibrium (AR^K_0), which mean the soil solution K activity relative to the Ca + Mg at equilibrium. The (PBC^K_0) was calculated as the slope of the linear section of the Q/I curve. Labile potassium (ΔK_0) was obtained from the intercept of the extrapolated linear part of the Q/I isotherm on the quantity axis. The free energy of the K replenishment ($-\Delta G^K_{equ}$) was computed from the following equation as reported by (Beckett, 1964).

$$-\Delta G^K_{equ} = 2.303RT\log AR^K_0$$

Where R and T are gas constant and absolute temperature, respectively.

Gapon constant was calculated according to (Evangelou and Karanthansis, 1986) as follows :

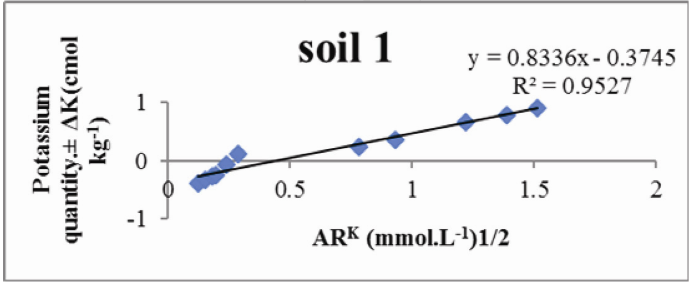
$$k_G = PBC^K / CEC$$

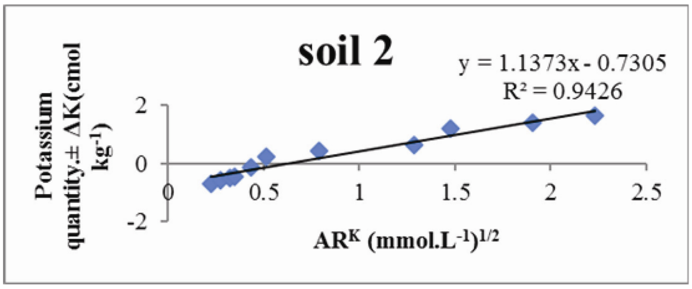
Where:

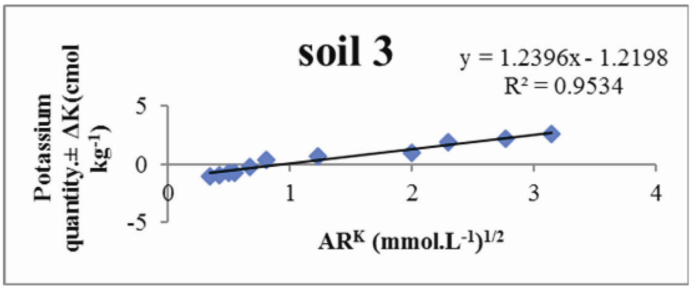
k_G = Gapon constant ,

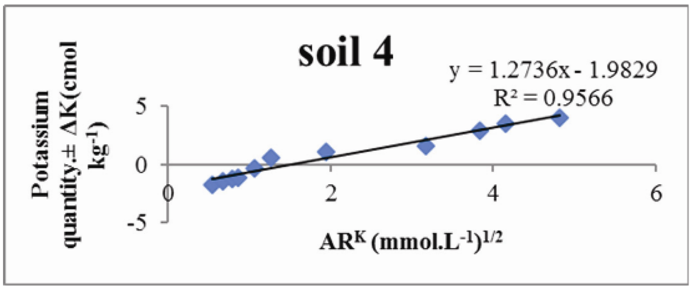
PBC^K= Potassium Potential buffering capacity

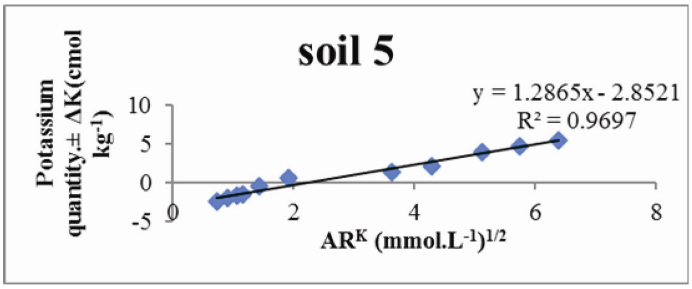
CEC= Cation exchange Capacity

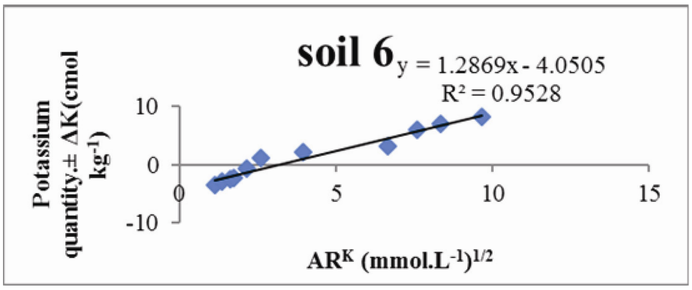


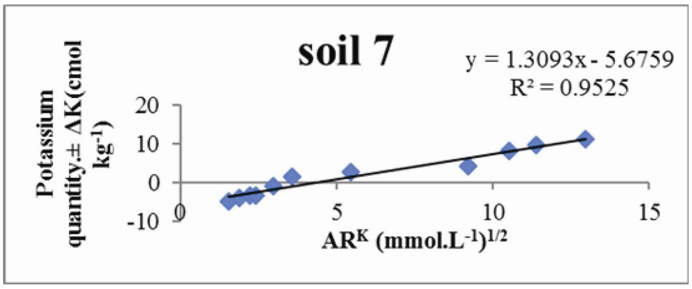


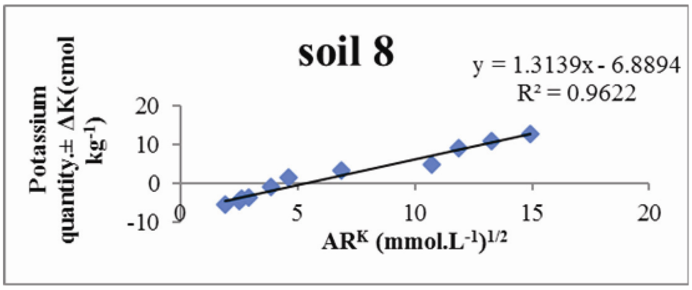


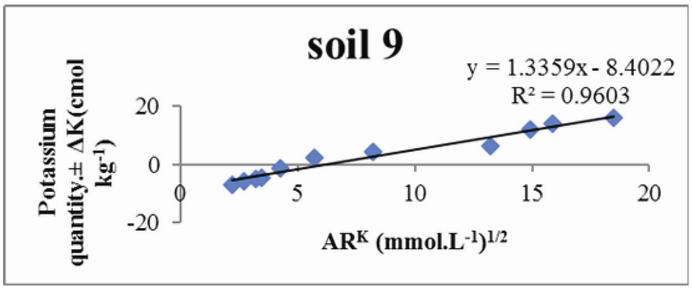


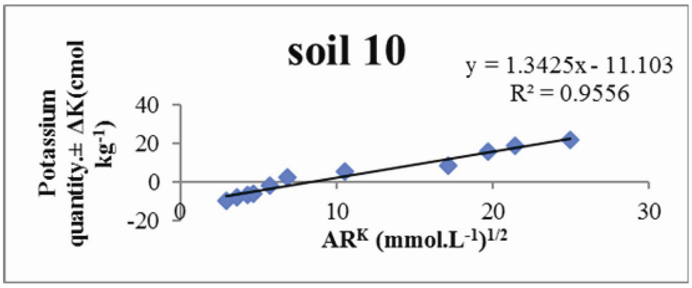


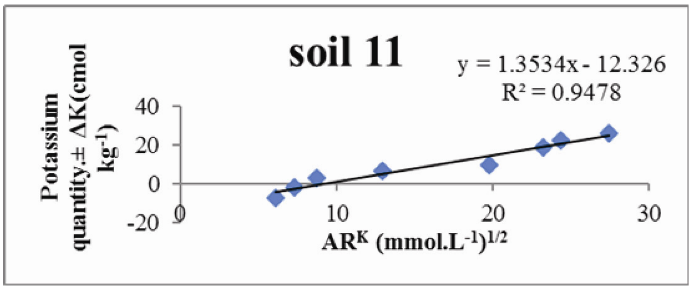












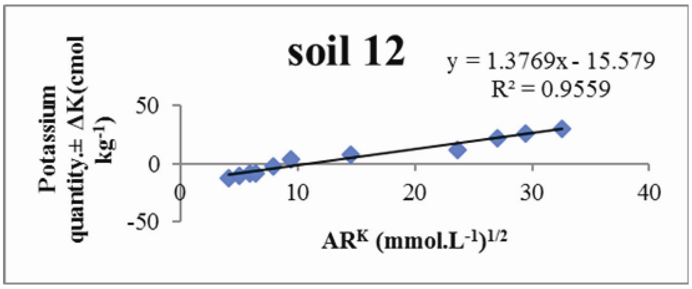


Fig.1 : Quantity-intensity (Q/I) plots for studied soils.

Results and Discussion

Soil Properties

The important physical and chemical characteristics for the soils are presented in Table (1). The Soils pH varied from 7.13 to 7.56. The electrical conductivity (EC) of soils ranged widely from 3.52 to 5.62 dS.m^{-1}. Organic matter (8.12 to 13.3 g.kg^{-1}). The cation exchange capacity (CEC) of soils varied between 18.18 and 28.68 (cmol.kg^{-1}). The results indicate that soil samples have different textures. The clay content in soil 1 is relatively high suggesting its ability to retain K.

Mineralogical properties of the clay fraction

Semi-quantitative analyses using peak- height measurements on X-ray patterns as shown in Table (2) indicates that smectite was the dominant mineral in clay fractions in studied soil. The decrease in diffraction line of 14.55Å with increasing an intensity of diffraction line of 10.70Å in studied soils on K-saturation reflection the collapse in smectite layers and indicates that the smectite in studied soils highly layer charge, this result agrees with the results obtained by (Rasul, 2008), who found that most of the smectite from the Mesopotamian plain was inherited from Mica and is a highly charged layer. The domination of smectite in studied soils is due to the nature of parent materials, and weathering processes during transportation and deposition of materials, or from weathering of ferromagnesium minerals in igneous rocks in the north of Iraq (Al-obaidi *et al.*, 2014). The presence of reflection at 14.55Å in studied soils on K-saturation and heating at 550ºC reveal the presence of chlorite in studied soils and suggesting that the formation of chlorite is may be due to the fixation of magnesium in smectite structure. From the results, we noticed that illite was found in all studied soils during the chlorination process which is identified by its 10.1 Å peak, and it remains stable with all treatment. The obtained results were agreed with previous researches (Rasul, 2008).

Chemistry of Potassium

The K concentration in solution of soil affects the rate of K-diffusion and mass flow towards the root and therefore the absorption of K by plants (Mengel *et al.*, 2001). Amount of water-soluble K ranged widely from 0.002 to 0.06 cmol.L^{-1} as shown in Table (2). The proportion of water-soluble K was 0.05% for the total- Soil containing little or no micaceous mineral has less preferential bonding and selectivity for K, releasing a higher percentage of the exchangeable K^{+}. Exchangeable-K is held by the negative surface charges on organic and clay minerals. It is easily exchanged with other cations and is quite readily available to plants (Sparks, 1985). The data are shown in Table (2) that the values of exchangeable K ranged widely from 0.89 to 1.6 cmol.kg^{-1} for NH4OAc extraction. If we consider samples with exchangeable K < 0.13, 0.13-0.31 and >0.31 cmol.K kg^{-1} soil, respectively from the low, medium, and high-status critical values for soil (Unamba-Oparach, 1985), then all of the samples are high K soils. Non-exchangeable K, can be known as the amount of K–soluble in molar nitric acid minus exchangeable K, is moderate to sparingly available to plants. Table (2) shows that the value of non-exchangeable K ranged widely from 0.55 to 1.80 cmol.kg^{-1}, the high content of non-exchangeable K in all pedons, it may be due to that they have relatively the highest content of K-bearing mineral such as smectite and Illite as shown in Table (2) which are also a potential source of non-exchangeable K. The release of non-exchangeable K is a diffusion controlled process (Rasul, 2008). Amount of total-K in 12 surface soil samples varied from (18.1 to 34.6) cmol.kg^{-1} soil.

Table 1: Relevant physical and chemical characteristics of selected soils.

CaCO$_3$	O.M.	CEC cmol$_c$kg^{-1}	EC$_e$ dSm^{-1} at 25°C	pH	PSD gm kg^{-1}				Locations	No.
gm kg^{-1}					Texture	Clay	Silt	Sand		
350	8.33	18.18	5.62	7.56	L	250	390	360	Taja	1
325	8.12	18.52	3.93	7.27	L	262	368	370	Rashidia	2
339	8.64	19.46	5.38	7.51	CL	290	384	326	Kathemia	3
325	8.92	20.29	5.14	7.46	CL	315	372	313	Rathwania	4
325	8.92	20.29	5.14	7.46	CL	315	372	313	Rathwania	4
267	9.96	22.27	4.26	7.32	CL	367	355	278	Doura	6
295	9.78	21.9	4.15	7.29	CL	370	358	272	Soira	7
284	9.91	21.66	4.48	7.35	CL	375	345	280	Mahmodia	8
295	9.72	22.36	4.76	7.39	CL	377	336	287	Salmanbaak	9
295	9.85	22.04	3.87	7.23	CL	380	380	240	AboGrape	10
296	10.76	23.9	3.74	7.18	SCL	407	395	198	Jaderia	11
210	13.3	28.68	3.52	7.13	C	425	380	195	Amera	12

Table 2: Potassium forms and Clay minerals in Studied soils samples.

Minerals content%				K-forms (cmol.Kg^{-1})				
Chlorid	Kaolinite	Illite	Semctite	Total	Non- Exch	Exch	Soluble	NO.
15	25	8	44	18.1	0.55	0.9	0.003	1
9.5	15.9	11	47.2	18.9	0.65	1	0.002	2
15	32	8	40	26.1	0.93	0.89	0.003	3
12	22	10	50	27.5	0.88	1.1	0.002	4
8.9	17.5	15	51.5	28.2	1.1	1.26	0.01	5
11.3	18.8	12	50.8	28.2	1.1	1.24	0.02	6
8.9	17.5	15	51.5	28.2	1.1	1.26	0.01	7
6	10	20	56	28.1	1.1	1.21	0.01	8
15	12	14	50	28.2	1.2	1.2	0.02	9
4.8	18.4	20	50.1	31.8	1.2	1.2	0.02	10
5.2	8.8	22	57	32	1.3	1.4	0.03	11
4	5.7	25	61.7	34.6	1.8	1.6	0.06	12

Potassium Quantity-Intensity (Q/I) Relationship

Quantity/Intensity relationship of K in soils is often used to determine continues supply of K from soils to plants in quantity and its buffering capacity(Beckett, 1964; Kumar *et al.*, 2007; Lin, 2010). The quantity (Q) indicates to K reserves of non-exchangeable K, intensity factor (I) and indicates the instantly available K. The fit description of buffering capacity is a measure of the resistance to change in K- potential in the soil solution. The activity ratio of K (AR^K) in a solution indicating to the availability of K. This ratio is a measure of the intensity (I) of labile K in the soil and represents the K that is immediately available to crop roots. The change in K quantity is represented by ΔK (Yawson *et al.*, 2011). The Q/I relationships of potassium for the studied soils are illustrated in Figure (1). The Q/I plot for every soil samples showed a linear relationship at high activity ratios and curvilinear at low-intensity levels. Figures (1, 12) as was described previously (Bilias, 2018). The data show that the shape of Q/I plots is the same for all samples, several authors confirm this observation (Al-obaidi *et al.*, 2011; Bilias and Barbayiannis, 2018). The slope of Q/I plot representing a ternary exchange reaction is direct to CEC of the soil (Bar-Yosef *et al.*, 2015) while Bilias and Barbayiannis, (2018) showed that the slope of any Q/I plot representing a soil system is a function of CEC, *kG*, and KAR, hence the magnitude of K-loading. The slopes of the plots not only depended on CEC but also on k_G at low K surface coverage especially, when the slopes are calculated to PBC^K. The absence of curvature in the lower portion of Q/I plots as the major difference found between these calcareous and noncalcareous soils studied by (Evangelou, 1986). It is not clear why this curvature is absent. None the less, the following hypothesize can drown:

1- Since K$^+$ exchange coefficient was found to be independent of calcite solubility (Al-Kanani, 1989), it is probable that the interactions between K$^+$ and sesquioxides may have contributed to the relatively high values of exchange coefficient

2- A masking effect produced by a relatively high concentration of exchangeable K^+.

These are possible factors responsible for the discrepancy between our results and those above-mentioned authors. Since illite and vermiculite constituted between 5-20% of the silica clay content respectively (Al-Kanani, 1991) of these calcareous soils, the K^+-sesquioxides interactions may indeed be contributing factors for these linear graphs. These plots also show the relation between quantity factor as a function of intensity factor (KAR) (chemical potential) for labile K comparing to the chemical potential of Ca^{2+} and Mg^{2+} ions that move to soil solution (Al-obaidi *et al.*, 2015) The plots in Fig. (1) refer clearly to the variation of values of slopes and intercept these variations due to the variation in chemical, physical and mineralogical properties of soils (Al-obaidi *et al.*, 2011; Pal, 1999). The upper parts of these plots are linear and also allow determining ARK_o and soil buffering for K saturation. Also, linear parts of plots refer to exchange K that will be released from readily available sites while curve part of these plots will be from sites that hold extremely (specific locations) (Wang *et al.*, 2004). (Q/I) Though its curve is a relatively permanent characteristic of soil, its parameters can be changed with replenishment of soil solution K, soil clay mineralogy, soil texture, CEC, cropping systems, etc. The reason for Linear shape of Q/I plot is due to the presence of nonspecific K sites in the planar surface of clay minerals. These obtained results were in agreement with the previous researchers (Islam *et al.*, 2017; Rupa *et al.*, 2003; Samadi, 2006).

Q/I parameters Equilibrium activity ratio of K (AR_e^K)

The (AR_e^K) in some solutions gave a satisfactory estimate of K^+ availability in soil. These differences in those parameters in soils could be attributed to the differences in the K^+ concentrations of equilibrating solutions, equilibration period, the Ca^{++} and/or Mg^{++} contents, and probably due to the differences in the mineralogical makeup of the soils (Yawson *et al.*, 2011). the lowest AR_e^K value was observed in soil number S1(0.44)x10^{-3} and the highest by soil number S12(11.39)x10^{-3} $(mol.L^{-1})^{1/2}$ as shown in Table (3). Reason for these variations could be due to differences in the concentration of equilibrating solutions, equilibration time, the Ca and/or Mg content and the differences in the mineralogy of the soils. indicating the high release of K into soil solution (Lin, 2010). The AR_e^K values are the status of immediately available K (Lalitha and Dhakshinamoorthy, 2015; Taiwo *et al.*, 2010), the values obtained increased with increasing K^+ concentrations of the solutions for all the soils At zero level of applied K^+, On this basis, most soils in our study before K-exhaustion experiment would be classified as adequate regarding their ability to supply K ($AR_e^K \geq 0.001M1/2$).

The Labile Pool of K(K_L)

The amount of K which is capable of ion exchange during the period of equilibration between soil solids and soil solution (Lin, 2010; Rupa *et al.*, 2003). Potassium can be capable of ion exchange during the equilibrium between soil solids and solution (Hamed, 2017; Lalitha and Dhakshinamoorthy, 2015). It has to maintain a balance between K on the soil colloids and K in soil solution by ionic exchange. the lowest KL value was observed in soil number S1 (0.37cmolc kg^{-1}) and the highest by soil number S12(15.57), This high value of labile K may be attributed to the high CEC values and amount of loosely bound K^+ ions present in exchangeable site (Hamed, 2017; Samadi, 2012). Also, the high values of labile K due to a greater K release into the soil solution resulted in an increase in the availability of K. Also, K fertilizer may increase the labile K in the soil (Hamed, 2017; Yawson *et al.*, 2011). On the other hand, the lowest labile K value of soil1 (0.37 $cmol.kg^{-1}$) was due to the more retention of K because of the presence of montmorillonite clay mineral (Hamed, 2017; Lalitha and Dhakshinamoorthy, 2015). In general, most of the added potassium either came from mineral fertilizer or released from organic amendments are work with two directions, the first direction with the calcareous soils such as (soil no. 12 in our research) that the amount of potassium is (15.57) because its ability to maintain a great amount of potassium on the clay exchange sites, the second direction with the soil solution that is make the values of CEC and clay contents lower than that their values in (soil no. 12 in our research) on the basis of clay particles. The results appeared that strong correlation between KL and % Illite as shown in Figure (2).

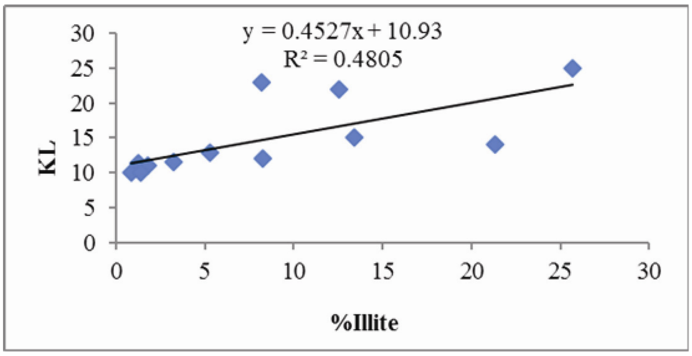


Fig. 2: showed a correlation between KL and %Illite in studied soils

Potential Buffering Capacity (PBC^K)

It is a measure of the ability of soil to maintain a given potassium, and the soils would be able to maintain relatively higher activity ratio of the soil K at potassium stress is present, whereas the lower value would be susceptible to rapid changes in the AR_e^K, signifying frequent K fertilization (Bilias and Barbayiannis, 2018; Lalitha and Dhakshinamoorthy, 2015; Sharma *et al.*, 2012). The PB_C^K values of selected soil samples varied from 0.83 to 1.37 $cmol.kg^{-1}$. All soil samples had low values of PB_C^K as shown in Table (3). The PB_C^k values are divided into very low (20 $cmol.kg^{-1}$ $(mol.L^{-1})$½) and high (> 200 $cmol.kg^{-1}$ $(mol.L^{-1})^{½}$) (Hamed, 2017; Zharikova, 2004). The PBC^K values of the studied soils prove to be of much help in explaining the limiting validity of the equilibrated ratio values in describing the potassium status of many of the studied soils. The high PBC^K values of the soils indicate a greater capacity for maintaining K concentration, but they enable a low K intensity. However, soil 3 which had a low PBC^K value would not maintain a given supply of potassium (Yawson *et al.*, 2011). It may be due to the content of mica is high and K saturation (Bahmani and Arefi, 2013; Rasul, 2008). Figure (3) showed a high correlation between PB_C^K and %Illite. The low values of PBC^K are caused by the few sites of soluble Kit is shown in Q/I isotherms of low buffering capacity. Moreover, the low PBC^K values in the soil samples mean that the potassium fertilizers should be added frequently for optimum crop yield (Bar-Yosef *et al.*, 2015; Panda and Patra, 2018). The PBC^K values of the studied soils prove to be of much help in explaining the limiting validity of the equilibrated ratio values in describing the potassium status of many of the studied soils.

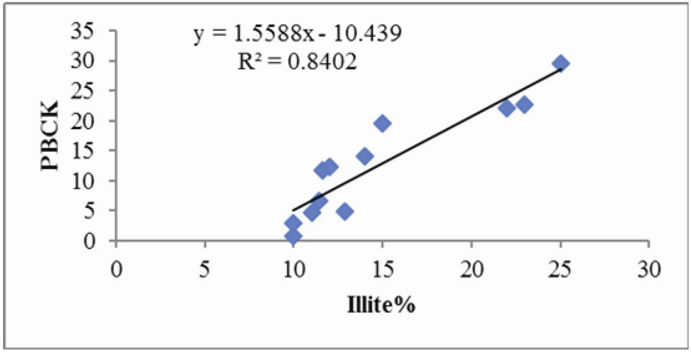


Fig. 3: showed a correlation between PB_C^K and %Illite in studied soils

Free Energies of Exchange of Ca with K (-Δ*G*)

It is related to the chemical equivalent of potassium with the standard state instead of one chemical equivalent of calcium on clay followed by the liberation of certain calories of energy (Rupa *et al.*, 2003). It depends extensively on characteristics of soils (Yawson *et al.*, 2011). The characterization of the exchange equilibria on clay, soil surface was studied with the previous approach. The thermodynamic functions of soils have been used in recent years to describe the K availability. Most of the thermodynamic studies on soils have involved the calculation of the free energy of exchange from equilibrium the lowest (-ΔG) value was observed in soil number S1(-1.09 kJ.mol^{-1}) and the highest by soil number S12 (-0.63 kJ.mol^{-1}) at 298K$^{\circ}$.(Bilias and Barbayiannis, 2018; Woodruff, 1955) predicted the ΔG value -0.48 or less as sufficient amount of available K,(-0.60 to -0.71) kJ.mol^{-1} as a medium amount of available K and (-0.84 to -0.96) kJ.mol^{-1} as deficient in available K. According to the standard for -ΔG Ke reported by (Woodruff, 1955), the K supply for all soils is optimum amount of available K. This relationship is indicative of the fact that either the greater intensity of K ion in solution or a greater amount of exchangeable K would render the K –(Ca+Mg) exchange less spontaneous. In other words, because of the common ion effect, preference of the exchange for K will be less as compared with that for Ca and Mg. The positive and significant relation of free energy of exchange with KG and KG·CEC confirms that when selectivity for K increases the amount of free energy required for the exchange reaction increases. The As–ΔG is more negative, the preference of K^+ adsorption in soil greater than Ca^{2+} and Mg^{2+}(Sparks, 1985).

Table 3: Some thermodynamic parameters of potassium in soil samples

k_G (L mol^{-1})$^{1/2}$	-ΔG k.J mol^{-1}	PBC^K cmol$_c$ kg^{-1} (mol L^{-1})$^{-1/2}$	K_L cmol$_c$ kg^{-1}	AR^K_e*10^{-3} (mol L^{-1})$^{1/2}$	NO.
0.02	-1.09	0.83	0.37	0.44	1
0.04	-1.04	1.13	0.73	0.64	2
0.05	-0.98	1.23	1.21	0.97	3
0.06	-0.91	1.27	1.98	1.55	4
0.05	-0.86	1.28	2.85	2.21	5
0.05	-0.81	1.28	4.05	3.14	6
0.06	-0.77	1.30	5.67	4.33	7
0.05	-0.74	1.31	6.88	5.24	8
0.06	-0.71	1.33	8.40	6.29	9
0.06	-0.67	1.34	11.10	8.24	10
0.06	-0.66	1.35	12.32	9.11	11
0.07	-0.63	1.37	15.57	11.39	12

Gapon Selectivity Coefficient (k_G)

It indicates the relative affinity of soils for potassium in the presence of Ca or Mg under both in the soil solid phase and soil solution under equilibrium conditions. (Bernard *et al.*, 2006; Samadi, 2012). Exchangeable potassium (K_{ex}), calcium (Ca_{ex}) and magnesium (Mg_{ex}) in the soil solid phase are considered to settle a dynamic equilibrium state with the concentration of the same cations in the soil solution. This state was outlined by(Evangelou and Karanthansis, 1986). The lowest (k_G) value was observed in soil number (S1) 0.02 (mol.L^{-1})$^{1/2}$ and the highest by soil number (S12)at the maximum level of applied 0.07 (mol.L^{-1})$^{1/2}$ as shown in Table (3). The changes in kG values are attributable to the levels of exchangeable Ca and Mg(Bernard JD, Kociałkowski ZW, 2006). Soil selective behavior for K in comparison with dominant Ca and Mg may also be attributed to the preferential attraction of K ions over Ca and Mg(Poonia and Niederbudde, 1990). at some planar sites of soil colloids, if $Ca_{ex} + Mg_{ex} \approx CEC$ is assumed. This statement agrees with our findings as shown in Figs (4,5).

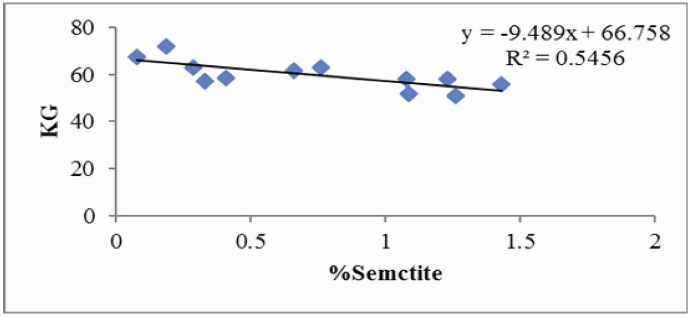


Fig. 4: showed a correlation between KG and % Smectite in studied soils

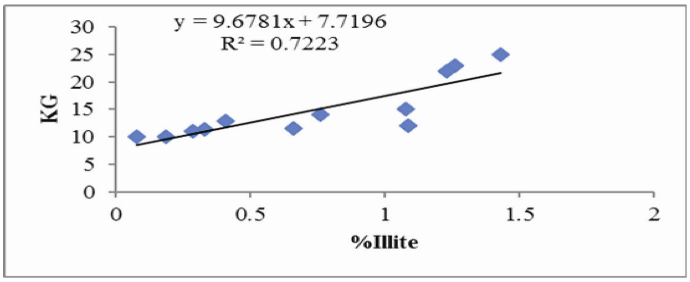


Fig. 5: showed a correlation between KG and %Illite in studied soils

Table 4: Correlation Coefficients between potassium parameters and some properties of soils

R^2					**Soil property**
k_G $(L\ mol^{-1})^{1/2}$	**$-\Delta G$ k.J mol^{-1}**	**PBC^K $cmol_c\ kg^{-1}$ $(mol\ L^{-1})^{-1/2}$**	**K_L $cmol_c\ kg^{-1}$**	**AR^K_e $(mol\ L^{-1})^{1/2}$**	
0.67	0.95	0.63	0.94	0.94	pH
0.57	0.92	0.54	0.97	0.97	EC
0.88	0.51	0.83	0.36	0.36	O.M.
0.77	0.47	0.69	0.48	0.47	$CaCO_3$
0.89	0.49	0.78	0.39	0.38	CEC
0.73	0.55	0.55	0.45	0.44	Sand
0.02	0.08	0.07	0.0016	0.0008	Silt
0.61	0.39	0.39	0.45	0.44	Clay
0.58	0.49	0.58	0.47	0.46	Semctite
0.42	0.43	0.43	0.41	0.40	Illite
0.47	0.50	0.47	0.54	0.53	Kaolinite
0.23	0.43	0.30	0.43	0.43	Chlorid
0.91	0.57	0.88	0.37	0.37	Soluble
0.80	0.56	0.67	0.50	0.53	Exch
0.88	0.49	0.70	0.25	0.41	Non- Exch
0.56	0.29	0.36	0.29	0.28	Total

Conclusions

In order to understand the K supply status, one has to know the basic characteristics of soils, From the physical and chemical properties, especially, texture, pH, organic matter, EC, CEC, $CaCO_3$, the soil samples showed wide variation in K release. The quantity-intensity approach for evaluating K dynamics in these soils has given a tool to predict K+ availability to plants. The Q/I parameters such as (AR_e^K, K_L, PBC_K, $-\Delta G$, k_G) effort suitable parameters to evaluate K kinetics. Soil clay Minerals such as Illite and Smectite were Related with (PBC_K, k_G, and K_L). It can be concluded all study soils are characterized by good potassium reserve but have low rate release, therefore these soils require particular management necessary to prevent degradation of soils and also improves its management.

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