Determining the Main Physicochemical Properties of Betwain (Rania) Plain Soils

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Abstract: This study was conducted during August 2015 to June 2016, which included studying some physicochemical properties of the soils of 14 locations at Bewain plain. The main results were summarized as follows: The range of soluble, exchangeable, and total potassium were (0.04-0.38 $mmol_c.L^{-1}$), (0.03- 0.11mmol.kg $^{-1}$) and (0.59-1.28 $mmol_c.L^{-1}$) for the studied soils respectively. The values of potassium activity ratio ARK and potassium free energy (ΔG) were (0.001 to 0.002 $mmol.L^{-1})^{0.5}$ and (-5142 to -6411 cal mol^{-1}) respectively. The amount of adsorbed, desorbed, desorption index (DI) and hysteresis of K^+ for the studied soils were ranged between (594.4 - 1081.2), (335 - 738), (0.68 - 0.99) and (344.6 - 156.8) $mg.kg^{-1}$ respectively. The ratio between (initial soluble K^+ concentration, total K^+ , Ca^{2+} , Mg^{2+} , Na^+ , HCO_3^-, Cl^{-1} , SO_4^{2-} , AR^K, Exchange able K^+, adsorbed K^+ , desorbed K^+ , K^+ Hysteresis, DI, pH, CEC, EC, ΔG, $CaCO_3$ and Organic matter) for irrigated soils to non irrigated soils were (2.11, 1.08, 1.51, 1.02, 1.42, 1.14, 1.28, 1.68, 2.00, 1.17, 1.13, 1.09, 1.25, 1.01, 1.01, 1.57, 1.43, 0.92, 0.76 and 1.13) respectively.

Keywords: Potassium Adsorption, Potassium Desorption, Potassium Hysteresis Desorption Index

1. Introduction

A major contributing factor to low agricultural yields in developing countries is low soil fertility, this has mainly led to lack in crop production (Ayaga et al., 2004). Soil potassium is divided into solution, exchangeable, fixed, structural or mineral potassium (Spark & Huang, 1985). Hussien (2007) explained that the amount of soluble K^+ in some soils of ninavah governorate was between 0.03-0.59 $cmol_c.kg^{-1}$ soil. Hashemi and Abbaslou (2016) indicated that the soluble potassium for (13) soil samples in southern Iran was ranged from 1.25 to 27.5 mg kg^{-1}. Hama-Amin (2012) recorded that the exchangeable soil potassium in Erbil plain was ranged from 3.71 to 14.45 mmol kg^{-1}. Akrawi and Esmail (2014) observed the value of non exchangeable potassium from (16) soil samples in Iraqi-Kurdistan region was ranged between (0.619-4.10) $cmol_c$ kg^{-1}.

Hama-Amin (2012) recorded that the non exchangeable potassium in Erbil plain soils was ranged from 3.74 to 51.68 mmol kg^{-1}. Hashemi and Abbaslou (2016) record that the non exchangeable potassium for (13) soil samples in southern Iran was ranged from 3.3 to 69.4. The potassium activity ratio(**AR** ^{k})can be explained as the ratio of activity of potassium to the square root of activities of Ca^{2+} and Mg^{2+} at equilibrium (Lindsay, 1979).

If the negative value of K^+ free energy (ΔG) of soil extract is more than 3000 it means K^+ is deficient (Hama-Amin, 2012). Hama-Amin (2012) recorded that the potassium free energy of (23) soil samples in Erbil plain was ranged from -2534 to -3814 cal mol^{-1}.

Akrawi and Esmail (2014) recorded that the amount of adsorbed, desorbed and desorption index of potassium were ranged from 2.52 to 4.46 Cmolc Kg^{-1} , 1.11 to 2.67 Cmolc Kg^{-1} and 0.26 to 0.58 respectively, for some soil orders in Iraq-Kurdistan region. Since there is little or no studies about physicochemical properties and potassium status in Betwan plain soils, for this reason this study was done, in order to:

1- Determine the amount of adsorbed, desorbed, hysteries and desorption index of potassium for the studied soils.
2- Determining some physiochemical parameters of potassium like concentration, activity, exchangeable, activity ratio and free energy.

2. Materials and Methods

2.1 The study Area

The adequate soil samples were taken during July, 2015 from the soil surface layer (0-30 cm) of (14) locations (Grdjan1, Saruchawa-shkarta, Hajyawa, Grdjan2, Kanemaran1, Chwarqurna, Xwadae-qurabaraza, Saruchawa-grdetle , Darband1, Darband2, Topawa, Kanequlka, Kanemaran2, Qasrok) at Betwan plain (Figure, 1). The samples were air dried, grounded, passed through a 2 mm sieve, and then stored prior to analysis.

2.2 Physical, Chemical and Physicochemical Analysis

Particle size distribution was determined according to Klute (1986). While the main soil chemical properties like (EC, pH, organic matter, Equivalent $CaCO_3$, catain exchange capacity , concentration of soluble Ca ,Mg, Na, K, HCO_3, CO_3, Cl and SO_4, forms of potassium were determined according to Jackson (1973).

2.3 Thermodynamic Measurements and Calculations

Ionic Strength:

The ionic strength was calculated according to the Griffin and Jurinak (1973) equation: I= 0.013 EC ……….(1)

Where: I= Ionic strength. EC= Electrical conductivity (dS m^{-1} at 25 ºC.).

Activity Coefficient:

The ionic activity coefficient was calculated according to Lindsay (1979) as follows:

$$\log \gamma i = -0.512 * Zi^2 \left[\frac{\sqrt{I}}{1+\sqrt{I}} - 0.31\right] \quad \ldots\ldots\ldots\ldots\ldots..\ldots (2)$$

γi = activity coefficient. Zi = Valence of ion. I = Ionic strength in mol L^{-1}-

Ionic Activity(ai):

Ionic activity and potassium activity ratio (AR^k) were determined depending on the following equations (Lindsay, 1979).

ai = Ci * γi ……….......... (3)

Where: Ci = Concentration of ion in mol.L^{-1} .γi = Ionic active coefficient.

Potassium activity ratio were calculated by using the following equation: $AR^K = \frac{aK^+}{\sqrt{aCa^{2+} + aMg^{2+}}}$ ………. (4)

Free Energy (ΔG):

The free energy was calculated by using the Woodruff (1955) equation :

$$-\Delta G = RT \ln AR^K \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots (5)$$

Where: ΔG= Free energy cal mol^{-1} or J mol^{-1} . T= Absolute temperature.
R= Gas constant 1.987 cal K^{-1} mol^{-1} or 8.314 J K^{-1} mol^{-1} .

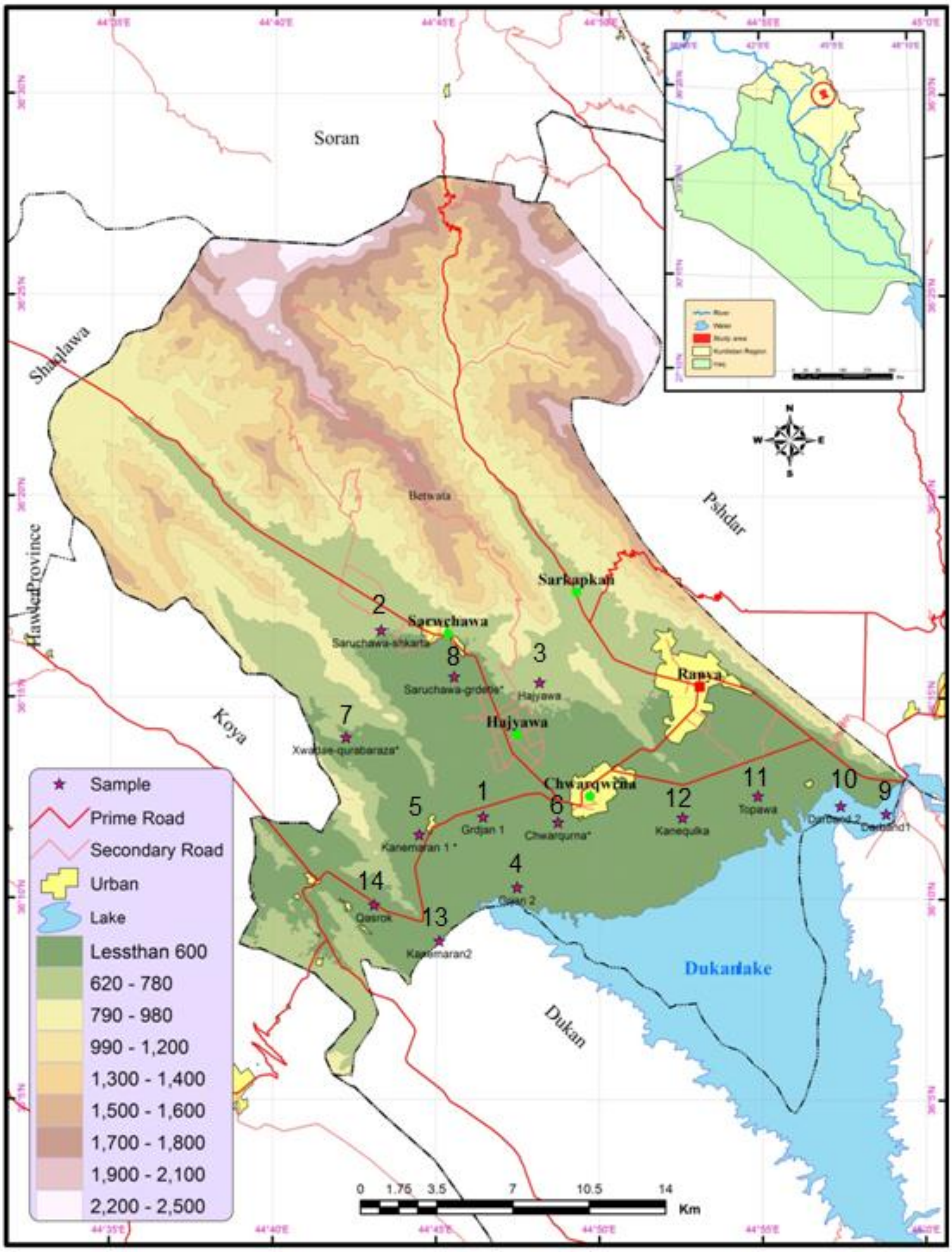

Figure (1): The locations of the studied soils

Laboratory Experiment:

The laboratory experiment included determining amount of adsorbed ,desorbed and desorption index as follow:

Potassium adsorption (K_a)and Potassium desorption (K_d):

They were determined depending on Rowell (1996) method.

Desorption index (DI):

Was calculated according to Marazadori *et al*., (1991) as follows:
DI= (md / ma) *100 ....………..............(6).
Where : Md= Amount of desorbed K^+. Ma = Amount of adsorbed K^+.
-Statistical analysis: The data were analyzed using LSD.01 according to Milton and Jessic, 1995).

3. Results and Discussion

Particle Size Distribution:

Table (1) reveals that the soils included different textures, from the fine textured clayey soil to sandy loam texture ,this may be due to differing in particle size distribution or differing in the ratio between sand ,silt and clay particles of the studied soils (Raweell,1996). The pH of soil samples was ranged between (7.01 to 8.24) it means the soils were located between slightly to moderately alkaline (table,1).

Table (1) shows the significant difference between the (EC) of the soil samples, which was ranged between (0.38 to 1.36) dSm $^{-1}$. It means the soil samples are non-saline because EC of them was less than 4 dS. m $^{-1}$ (Jackson,1973). The locations affected significantly on concentration of the soluble cations (Ca^{2+} , Mg^{2+} , Na^+ , K^+), the range of them were (2.00-640), (1.40-5.60), (0.32-1.57) and (0.04-0.38) $mmol_c.L^{-1}$ respectively, while the range of total and exchangeable K^+ were (0.59-1.28) $mmol_c.L^{-1}$ and (0.03-0.11 $mmole.kg^{-1}$) respectively (Table, 1). It means Ca^{2+} was the dominate cation since the studies soils were extensive calcareous (Marschner, 1995).

The concentration of soluble anions (HCO_3^- , Cl^- and SO_4^{2-}) were ranged between (2.50-3.90),(1.20-4.80) and (0.15-7.55) $mmol_c.L^{-1}$ respectively (table, 2). The dominate anion was HCO_3^- , this may be due to the reason mentioned before. The total $CaCO_3$ was ranged between (98.10- 323 $g.kg^{-1}$)(table,1).It means most of the studied soils were sever calcareous since the $CaCO_3$ was more than 100$mg.kg^{-1}$ soil (Marschner, 1995).

Generally Table (2) shows that the soil samples were various significantly in organic matter content (O.M) which ranged from 9.80 to 19.70 $g.kg^{-1}$. It means 71.40% of the studied soils have high organic matter content, while 28.60% of soil samples are medium organic matter content. It means the soil of 10 locations have high organic matter content, while the soil of 4 locations have medium organic matter content. Since if the organic matter content less than 8.5 $g.kg^{-1}$ it means the soil contains low amount of organic matter, if the organic matter content is between 8.5-12.75 $g.kg^{-1}$ it means the soil is medium in organic matter content but if the organic matter content is more than 12.75 $g.kg^{-1}$ it means the soil contains high amount of organic matter (Baruah & Barthakur, 1999).

The soils or locations were affected significantly on cation exchange capacity (CEC) which was ranged between (14.09 to 34.65 $cmol_c.Kg^{-1}$) (table,2).it means the soils are differing in fertility since increase in CEC means increase in soil fertility (Baruah & Barthakur, 1999).

Potassium Activity Ratio (AR^K):

Table (1) refers to the values of potassium activity ratio; the highest value ($0.17mmol.L^{-1})^{0.5}$ was recorded from soil number (1), while the lowest value ($0.02mmol.L^{-1})^{0.5}$ was recorded from soil number (7). This may be due to the higher values of soluble K^+, Ca^{2+}, Mg^{2+} and EC for the soil number (1) in comparing with other studied soils (Table, 1), while the K^+ concentration of soil number (7) is very low in comparing with other soils, since the ratio between activity of K^+ and square root of Ca^{2+} plus Mg^{2+} is responsible for limiting AR^K (Beckett, 1964).

Free Energy (-ΔG):

Free energy is a measure for potassium supplying power of the soil, the values of ΔG for the studied soils were presented in table (1), the highest value (-5142 cal mol^{-1}) was found from soil number (1), while the lowest value (-6410cal mol^{-1}) was recorded from soil number (7) (table,1). This may be due to the highest value of AR^K. It means all the studied soils having low supplying power since the values of them were low or it means the potassium status in the studied area is low than plant requirements since the negative value of potassium free energy (-ΔG) of the studied soils was more than 3000 or the range of the negative value of potassium free energy (-ΔG) was between (-4410 to -5142), these results agree with those recorded by Hama-Amin (2012).

Amount of Adsorbed, Desorbed, Hysteresis and Desorption Index (DI):

Table, (2) refers to adsorption, desorption, hysteresis and desorption index (DI) values of K^+ for the studied soil samples in the study area. The range of them were between (594.40 to 1081.20, 335.00 to 738.00, 344.60 to 156.80) $mg.kg^{-1}$ and (0.68 to 0.99) respectively. This significant variation in the above physicochemical parameters may be due the variation in physical, chemical, physicochemical and mineralogical properties of the studied soils, (Hussein, 2007, Said-Khalil, 2013; Blumenstein, 2015).

Table (1): Some physical and chemical properties of the studied soils

Soil NO.	Soil texture	pH	EC $dS.m^{-1}$	Ca^{2+}	Mg^{2+}	Na^{+}	K^{+}	AR^{K} $(mmol.L^{-1})^{0.5}$	ΔG Cal mol^{-1}
				$mmol_c.L^{-1}$					
1	Clayey	7.11	1.36	6.40	5.60	1.53	0.38	0.17	-5142
2		7.32	0.41	2.60	2.40	0.56	0.15	0.10	-5456
3		7.35	0.38	2.00	2.80	0.40	0.09	0.06	-5759
4		8.24	0.85	5.20	3.40	0.96	0.25	0.13	-5301
5		7.17	0.42	2.20	2.40	0.65	0.13	0.09	-5519
6	Sandy loam	7.38	0.67	2.00	4.80	1.02	0.13	0.07	-5668
7	Clayey	7.34	0.44	2.80	2.60	0.60	0.04	0.02	-6410
8	Loamy	7.16	0.60	3.40	2.50	0.32	0.06	0.03	-6170
9	Clayey	7.18	0.88	5.10	3.10	1.40	0.13	0.06	-5759
10	Silty loam	7.01	1.16	7.00	4.40	1.57	0.18	0.07	-5668
11	Silty clay	7.23	0.84	4.80	3.20	0.72	0.18	0.09	-5519
12	clayey	7.2	0.81	5.30	3.20	0.76	0.31	0.16	-5178
13		7.23	0.49	2.20	1.70	0.64	0.20	0.15	-5216
14	Loamy	7.25	0.44	2.60	1.40	0.56	0.09	0.05	-5867
LSD.01		0.60	0.24	2.10	2.63	0.30	0.15	0.05	n.s

Table (2): Some chemical and physicochemical properties of the studied soils

Soils	HCO_3	Cl^-	SO_4^{2-}	$CaCO_3$	O.M	CEC $cmol_c.kg^{-1}$	Total K^+ $mmol_c.L^{-1}$	Exch. K^+ $mmol.kg^{-1}$	K^+ Adsorption	K^+ Desorption	K^+ Hysteresis	DI
	$mmol_c.L^{-1}$			$g.kg^{-1}$					$mg.kg^{-1}$			
1	3.80	4.80	5.11	156.30	19.70	34.64	1.03	0.10	1081.20	736.80	344.40	0.81
2	3.10	1.40	1.25	106.00	16.50	33.96	0.89	0.08	1038.40	735.60	302.80	0.77
3	3.90	1.20	0.19	181.40	11.00	32.85	0.78	0.06	92.00	662.20	258.80	0.97
4	3.60	2.40	3.81	168.40	14.20	31.72	0.98	0.08	948.60	650.40	298.20	0.79
5	3.20	1.40	0.78	218.30	14.20	14.09	0.87	0.07	899.80	693.20	206.60	0.89
6	2.80	2.20	2.95	323.00	9.80	13.87	0.64	0.04	594.40	335.00	259.40	0.68
7	3.00	1.40	1.64	98.10	14.30	15.93	0.96	0.08	925.00	701.60	223.40	0.85
8	2.70	1.80	1.78	113.10	12.00	32.16	0.98	0.08	695.40	538.60	156.80	0.94
9	2.50	2.00	5.23	117.30	11.00	24.05	0.59	0.03	859.40	643.40	216.00	0.91
10	3.40	2.20	7.55	108.90	9.90	25.17	0.59	0.03	657.80	465.60	192.20	0.76
11	3.40	2.60	2.9	146.20	15.30	23.36	1.05	0.10	854.20	509.60	344.60	0.73
12	4.00	2.20	3.37	109.80	16.40	31.56	1.28	0.11	1006.80	738.00	268.80	0.96
13	2.70	1.60	0.44	179.30	14.20	32.25	1.23	0.10	728.40	505.80	222.60	0.84
14	3.00	1.50	0.15	159.60	14.20	28.72	0.94	0.08	726.60	526.80	199.80	0.99
LSD.01	1.02	2.03	2.34	21.89	2.90	5.12	0.67	.03	190.70	103.04	49.60	0.24

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