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USING THE DIFFUSION EQUATION AND THE FORCE FUNCTION EQUATION TO DESCRIBE THE LIBERATION OF CHLORIDE ionsWHEN WASHING SALT SOILS USING WATER QUALITIES OF DIFFERENT IONIC STRENGTHS

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Abstract

A continuous washing experiment was carried out using water types with different ionic strengths, as the electrical conductivity of river water is 2.05 siemens M-1 and the tap water is 5.71 siemens M-1W. And two sites in Al-Kifl (and each site has two depths) (0-20 and (20-40) cm to know the speed of salt movement collectively depending on the time factor. The statistical program Statistical was used to know the effect of water of different ionic strengths on the content of soils of different salinities and textures. the results of the continuous washing experiment using two types of water of different ionic strengths show that the highest concentration of liberated chloride was accumulated in the sample of the Kifl site (second site) Ct2 A G2 amounting to 98.152 centimos kg-1 treated with tap water and the lowest concentration was in the Mouradian site of 9.835 centimos kg 1- Treatment with river water. The kinetic equations (force function equation, diffusion equation) were applied to describe the kinetic behavior of chloride ion liberation from the soil using the Statistical program.

Keywords: kinetics, diffusion equation, force function equation, saline soils.

Introduction

The use of chemical kinetics approach is one of the best methods used to study the liberation as a function of time and the adsorption of ions in the soil. Many kinetic equations and models have been used to describe the kinetic interactions of a number of ions, as they can provide a good description of the liberation of the elements through the values of the coefficient of determination and the introduction of the time factor with the amount liberated He described it quantitatively with mathematical equations, and that these equations are based on the foundations of kinetic chemistry, such as the zero-order equation, And the first-order equation and the diffusion equation, and the constants of these equations were used to explain the ions liberated from the soil, or the equations are of an experimental nature, such as the Eluvig equation and the power function equation (exponential function) (Hundal and Pasricha, 1993),among the studies that were conducted to know the liberation and adsorption of soil ions, including what Al-Hassani (2007) did, where he indicated that the diffusion equation was the best in describing the kinetics of chloride liberation when washing saline soils of different textures in Baghdad governorate. Using the concept of chemical kinetics, and the theoretical basis for studying the liberation of ions from the soil is by applying the laws of velocity, the aim of which is to calculate the liberation coefficient, where the time factor is entered with the amount liberated and quantitatively put into mathematical equations, where the equation is determined best in describing the adsorption and liberation of the elements through comparison between the values of the coefficient of determination R2 and the experimental error values SE as a measure to prefer between them (Barboush, 2017). The power function equation outperformed the rest of the equations in describing the liberation of ions and chlorides upon continuous washing of the two sabkha soils (Al-Hashimi, 2020).

A theoretical overview of research
MATERIALS AND METHODS

A continuous washing experiment was carried out using water types with different ionic strengths, as the electrical conductivity of river water is 2.05 d Siemens M-1 and the tap water is 5.71 siemens M-1W. And two sites in Al-Kifl (and each site has two depths) (0-20 and (20-40) cm to know the speed of salt movement collectively depending on the time factor. The statistical program Statistical was used to know the effect of water of different ionic strengths on the content of soils of different salinity and texture, and the method of washing Inefficient intermittent when time is the criterion for determining washing efficiency, and the intermittent washing method is inefficient when time is the criterion for determining the efficiency of washing, so the continuous washing method was used on the selected study soil samples, as washing columns with a diameter of 5 cm and a length of 30 cm were used and filled with soil weighing 500 grams of dry and crushed soil and sifted through a sieve 2 mm, depending on the size of the column, and a filter paper was placed at the bottom of the soil to ensure that the soil was not lost during washing. The soil was also rotated when adding it to the inside of the washing columns, and a filter paper was also placed on top of the surface of the soil in the column to ensure that the soil surface does not become agitated when adding washing water, The columns were hammered quietly to obtain a homogeneous bulk density, and the soil column models were washed with two types of water of different ionic strength and based on the pore size of the soil particles inside each column. Until the required level is reached, the porous volume of each soil column was calculated from the following Jensen (1983) equation:

$$\mathbf{Pv_w = Ws - \Delta s}$$

As if:

:Pv w: stands for pore volume measured from the difference in mass of water (cm3)

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WS: means the mass of column soil after saturation (g)
S: means the mass of the soil of the kiln-dry column (g)Δ
The equilibrium filter was received from each column and at regular intervals, as the period for completion of the filter was calculated by calculating the time taken from the start of the first drop of the wash filter to the end time of the wash filter in the column (the time of the descent of the last drop of the wash filter) at each Porous size assembled. The electrical conductivity (EC), the soil reaction (pH), and the aggregate concentration of the element were measured. The following symbols indicate:
Ct1 Washing with river water
Ct2 - washing with tap water
)20-0(A - Depth
)20-20(B- Depth
M - Mouradia site
G1- Al-Kifl site (the first site)
G2 - Al-Kifl site (the second site)

Kinetics equations to describe the release of chloride
Estimating the amount of sodium and chloride released from the soil samples on which the washing process was carried out, and to find the best equation that describes the mechanism of sodium and chloride liberation, and finding out the liberation rate K, the following kinetic equations were used by Sparks (b, a, 1985):
: **Power function equation**

$$InC_t = InC_0 + K_d Int$$

The symbols mean the following:
Co = concentration of the element at time zero.
Ct = concentration of the element at time t (extraction time).
Kd = slope of the straight line and equal to the coefficient of liberation velocity of the element expressed in units of mol kg-1 hour-1 or mmol kg-1 hour-1 or centimoles kg-1 hour-1 or mg kg-1 min-1
t = time in a minute, hour, or day.

Parabolic diffusion equation:

$$C_t = C_0 + K_d \sqrt{t}$$

Determine the best math equation
To determine the best mathematical equation that describes the process of liberating the element and the speed of its liberation from the soil is done by calculating the coefficient of determination (R2) between the amount of element liberated and the time and calculating the error the standard (SE) represents the difference between the experimental results and the results calculated from the linear kinetic equation (Simard et al., 1992).

$$SE = \left[\frac{\Sigma(C_t - C_t*)^2}{n-2} \right]^{\wedge 0.5}$$

Where: the symbols stand for

Ct - the concentration of the measured component of the solution at time t

Ct* - the concentration of the element calculated from the equation at time t

n - the number of measurements in the experiment

Results and Discussion

Continuous washing experiment to measure chloride displacement using water of different ionic strengths

Table 1 shows some chemical properties of water of different ionic strengths used in the continuous washing experiment represented by 0.02 mol L-1 river water and 0.07 mol L-1 tap water, respectively. The highest SAR value was 4.554 for tap water and 1.480 for river water. This indicates the difference in the ability of this water in ion exchange reactions and the liberation of exchanged ions, including sodium and chloride (Al-Kiki, 2013 Al-Badrani, 2014). The aggregate concentration values of each of the sodium and chloride ions mentioned in Table 11 for the studied soil samples were used in the mathematical description of the amount of these ions released as a function of the aggregate time, to identify the best equation that describes the release of these ions. from exchange sites, and that the purpose of applying these kinetic criteria is to obtain the coefficient of the speed of liberation of ions in the concept of kinetic chemistry, that is, the speed of the reactions that take place inside the soil and the accompanying transport processes, depending on the time factor (Sparks, 1999). (1998)

Table 1 shows the chemical properties of water with different ionic strengths used in the continuous washing experiment:

SAR (mmol l^{-1})$^{1/2}$	soluble negative ions (mmol l^{-1})				dissolved positive ions (mmol l^{-1})				pH	ionic strength (mmol l^{-1})	EC decisions m^{-1}	water type
	SO_4^{2-}	Cl^{1-}	HCO_3^{1-}	CO_3^{2-}	K^{1+}	Na^{1+}	Mg^{2+}	Ca^{2+}				
1.389	3.32	4.12	2.13	Nil	0.03	3.11	3.00	2.01	7.56	0.02	1.35	River water
4.554	12.32	25.92	4.50	Nil	0.53	19.41	8.34	9.83	7.23	0.07	5.71	Trocar water

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Mathematical description of chloride ion release based on chemical kinetics

The results of continuous washing of soil columns affected by salts were applied in the chemical kinetics equations (diffusion equation, power function equation), which are the best means to predict the liberation of ions from the studied soils using the STATISTICA program to obtain the values of Kd, R2 and SE to determine the best equation that describes the kinetics of the chloride ion This is based on the highest coefficient of determination R2 and the lowest standard error SE. The purpose of applying these kinetic criteria is to obtain the coefficient of the liberation speed of ions in the concept of kinetic chemistry, that is, the speed of the reactions that take place inside the soil and the accompanying transport processes, depending on the time factor. And the best equation to describe the liberation of chloride from the soil mathematically based on the values of the coefficient of determination by taking the highest value of the coefficient of determination R2 from Table 2 and taking the lowest value of the standard error SE from Table 3 (Sparks, (1989). Through the results of the study, it was found that the force function equation is superior to the diffusion equation In describing the liberation of chloride ion, as in Tables 2 and 3, it gave the highest value for the determining factor of 0.968 and the lowest value for the standard error of 0.156 in the Al-Kifl site treated with Ct2CL BG1 puncture water. These results agreed with what was reached (Al-Hashemi, 2020).

Table 2 Coefficient of determination of chloride release according to the diffusion equation and the power function equation when using water qualities with different ionic strength:

According to the diffusion equation R2				**According to the diffusion equation R2**			**the symbol**	**Location**
ionic strength				**ionic strength**				
Trocar water **)0.07 (**	**the symbol**	River water **)0.02(**	**the symbol**	Trocar water **)0.07(**	**the symbol**	River water **)0.02(**		
0.905	**Ct2CLA M**	0.853	**Ct1 CL A M**	0.952	**Ct2CLA M**	0.915	**Ct1CLA M**	**Mouradia**
0.937	**Ct2CLBM**	0.872	**Ct1CLB M**	0.960	**Ct2CLBM**	0.930	**Ct1CLB M**	
0.929	**Ct2 CL A G1**	0.766	**Ct1 CL A G1**	0.965	**Ct2 CL A G1**	0.852	**Ct1 CL A G1**	**Al-Kifl**
0.968	**Ct2CL B G1**	0.889	**Ct1 CL B G1**	0.952	**Ct2CL B G1**	0.948	**Ct1 CLB G1**	
0.852	**Ct2 CL A G2**	0.780	**Ct1CL A G2**	0.925	**Ct2 CL A G2**	0.864	**Ct1 CL A G2**	
0.903	**Ct2 CL B G2**	0.864	**Ct1 CL B G2**	0.962	**Ct2 CL B G2**	0.936	**Ct1CL B G2**	

Table 3 Determination of the least standard error of chloride release according to the diffusion equation and the force function equation when using water qualities with different ionic strengths:

According to the diffusion equation SE				According to the diffusion equation SE			the symbol	Location
ionic strength				ionic strength				
Trocar water)0.07 (	the symbol	River water)0.02(		Trocar water)0.07(	the symbol	River water)0.02(		
0.271	Ct2CLA M	0.309	Mouradia	4.231	Ct2CLA M	3.348	Ct1CLA M	Mouradia
0.203	Ct2CLBM	0.641		2.842	Ct2CLBM	4.329	Ct1CLB M	
0.238	Ct2 CL A G1	0.544	Al-Kifl	3.386	Ct2 CL A G1	4.301	Ct1 CL A G1	Al-Kifl
0.156	Ct2CL B G1	0.158	Ct1 CL B G1	1.715	Ct2CL B G1	1.827	Ct1 CLB G1	
0.335	Ct2 CL A G2	0.279	Ct1CL A G2	6.461	Ct2 CL A G2	4.282	Ct1 CL A G2	
0.257	Ct2 CL B G2	0.249	Ct1 CL B G2	4.355	Ct2 CL B G2	3.334	Ct1CL B G2	

Effect of ionic strength of water on chloride release rate coefficient in soil

The ionic strength of water affects the coefficient of chloride liberation speed in the study soils, where the chloride ion liberation velocity coefficient calculated by the force function was adopted, due to its preference in describing the chloride ion liberation of the diffusion equation. We notice from the results of Table 4 that the highest value of the chloride release velocity coefficient is found in the column of the Al-Kifl site, Ct2Cl AG2, treated with tap water with an ionic strength of 0.07 mol L-1, as it was 2.135, according to the power function equation, and the lowest value of the sodium liberation velocity coefficient is 0.777, as shown in the results of the study It is found in the column of Mouradia site Ct1 Cl BG1 treated with river water with an ionic strength of 0.02 mol L-1 when applying the power function equation. From this, we conclude that an increase in the ionic strength of water leads to an increase in the speed coefficient of chloride liberation. The reason for this may be due to the role of the electrolytic concentration of water, which is expressed by the ionic strength, as it represents the sum of the charges affecting the diffusion layer, which has an important role in this stage of washing (Al-Hashemi, 2020):

Table 4 Coefficient of chloride release rate according to the diffusion equation and the power function equation when using water qualities with different ionic strength

According to the force function equation Kd				According to the diffusion equation Kd			the symbol	Location
ionic strength				ionic strength				
Trocar water)0.07 (	the symbol	River water)0.02(		Trocar water)0.07(	the symbol	River water)0.02(		
2.061	Ct2CLA M	1.058	Ct1 CL A M	14.353	Ct2CLA M	5.693	Ct1CLA M	Mouradia
1.927	Ct2CLBM	2.132	Ct1CLB M	13.306	Ct2CLBM	11.994	Ct1CLB M	
2.127	Ct2 CL A G1	1.708	Ct1 CL A G1	14.720	Ct2 CL A G1	10.144	Ct1 CL A G1	Al-Kifl
1.921	Ct2CL B G1	0.777	Ct1 CL B G1	13.176	Ct2CL B G1	4.517	Ct1 CLB G1	
2.135	Ct2 CL A G2	1.052	Ct1CL A G2	15.606	Ct2 CL A G2	6.680	Ct1 CL A G2	
2.077	Ct2 CL B G2	1.260	Ct1 CL B G2	15.055	Ct2 CL B G2	7.905	Ct1CL B G2	

Conclusions:

The soils of the study were characterized by a high ability to release chloride, and the ability increased with increasing the period and the ionic strength of the water used for washing, and the force function equation was superior to the diffusion equation because it had the highest coefficient of determination and the lowest standard error.

Recommendations:

We need other studies in the field of research and the possibility of applying it the field in small experimental units.

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