Adsorption study component magnesium in some Soil The different districts Baiji

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Abstract

This experiment was conducted to determine the behavior of magnesium in five selected soils from Baiji district, which differ in their chemical and physical properties, namely surface sandy soils. (S1) Subsurface sandy soils (S1e), clayey and surface soils (S2e), subsurface clayey soils (S2e), surface gypsum soils (S3e), subsurface gypsum soils (S3e), surface calcareous soils (S4e), subsurface calcareous soils (S4e), surface riverbank soils (S5e), and subsurface riverbank soils (S5e) were subjected to a magnesium adsorption experiment. The three ion exchange equations (Langmeier, Freundlich, and others) were used to study some constants that indicate the behavior of this element in these soils. The coefficient of determination (R^2) was adopted to determine the best equation to describe the magnesium adsorption process in the five soils of Baiji District. The values of the coefficient of determination showed the superiority of the Langmeier equation by an average of 81.9% over the other equations. It was found that the soils studied were ranked according to the constants calculated in the Langmeier equation, ranking the soils according to the values of maximum adsorption. The values from highest to lowest are as follows: (S1, S1e, S3e, S3, S4e, S4, S5e, S2, S2e, S5). The highest value was recorded in surface riverbank soils (1428 mg kg^{-1}), and the lowest value was in surface sandy soils (76 mg kg^{-1}). As for binding energy, surface calcareous soils (S4) recorded the highest value at 0.8982 mg L^{-1}, while the lowest value for this constant was recorded in surface horizon clay soils (0.00187 mg L^{-1}). The order of these soils according to binding energy values is as follows: (S2, S2e, S5e, S5, S3e, S1, S3, S1e, S4e, S4). This order is influenced by the soil's clay and organic matter content or by the occurrence of chemical adsorption processes. The results show a correlation between Q Max values and increasing soil content of separated clay and organic matter. Binding energy values were affected. The values of the separated clay, in addition to its calcium carbonate content.

Keywords; Baiji district.Adsorption .Magnesium Different soil types. Ion exchange equations.

1.Introduction

The district of Baiji is located north of the center of Salah al-Din Governorate and is approximately Located 40 kilometers from the provincial capital, Baiji District has a population of approximately 180,000. The district is characterized by its diverse soils. Water sources are divided into groundwater and freshwater, primarily from the Tigris River, which flows through the northeastern part of the district. This river contributes to the formation of one of the soil types found there: riverbank soils. These soils are characterized by a good organic matter content and a loamy texture. They are well-drained and fertile due to the mineral deposits carried by the river [1]. Gypsum soils also cover large areas of Baiji District. These soils are formed from the weathering of gypsum rocks and cover a significant portion of the district and Iraq, reaching up to 20% of the total area. These

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soils generally suffer from numerous physical, chemical, and fertility problems. The severity of these problems varies depending on the soil's content of hydrated calcium sulfate, to which gypsum soils are attributed [2]. Calcareous soils are also found in the northern parts of the district. After the Al-Zawiya intersection towards Nineveh Governorate, which took its name from its high content of calcium carbonate, it has many problems that hinder its agricultural exploitation. These soils are a result of the weathering of limestone rocks, which cover large areas of global and Iraqi soils. [3] describes sandy soils as poorly structured, predominantly composed of sand (which constitutes more than 85%). These soils cover vast areas of Baiji district and are the result of aeolian deposition. They are characterized by primary minerals and present numerous challenges in their agricultural use [4]. Clay soils also cover limited areas of Baiji. They are among the most important agricultural soils, distinguished by their physical and chemical properties, which give them a high water retention capacity and good nutrient content [5]. The five soil types are used for agriculture: part is used for cultivating all field crops (wheat, barley, sesame, corn, sunflowers), part is used for vegetable crops (tomatoes, cucumbers, melons, watermelons, eggplants, peppers), or for various fruits, and part is used as livestock grazing. In general, these soils suffer from a range of fertility, chemical, and physical problems. Many chemical processes occur in these soils, the most important being adsorption, a process through which minerals accumulate or The fixation of ions, molecules, or atoms from solutions of a substance onto the solid surfaces of the soil, such that these substances are concentrated on the surface more than their concentration in the solution, is one of the most important phenomena that affect soil properties, especially its ability to retain nutrients and exchange them with the soil solution. Soils suffer from variations in their fertility level, which is related to the adsorption and release of elements in them, which mainly affects the availability of elements and their fertility level. One of the most important elements is magnesium, which is a chemical element that is one of the most important basic nutrients necessary for the life of humans, plants, and animals. It exists in nature as a positive ion Mg^{+2} and is one of the alkaline earth elements. It ranks eighth in terms of abundance in the Earth's crust, where its percentage in the Earth's crust reaches 3%, [6] In a previous study of soils in the Baiji district, the magnesium content in the sandy soils was as follows:(2.10) mmol L^{-1} and clay soil, (0.15) mmol L^{-1} and gypsum soil, (3.24) mmol L^{-1} and calcareous soil, (4.9) mmol L^{-1} and riverbank soil, (0.15) mmol L^{-1}. [4], [7[8] [9] Magnesium forms the center of the chlorophyll molecule and helps activate most enzymes. It contributes to sugar formation, starch translocation, oil formation, and seed formation, and is essential for cell division and protein synthesis. Phosphorus cannot be absorbed without magnesium, and vice versa. Therefore, magnesium is necessary for phosphate metabolism and plant respiration. [10].[11] Magnesium is a "mobile" element within the plant; it moves from older leaves to newer leaves when a deficiency occurs. Therefore, symptoms first appear in the lower (older) leaves: paleness between the veins; yellow areas appear between the leaf veins while the veins themselves remain green.Interveinal Chlorosis). Color changes in some crops such as grapes; leaves may turn purple or reddish. Fruit weakening; fruits become pale, less sweet, and smaller[12] Among the most famous equations used to describe the adsorption of elements by soils and minerals is the Freundlich equation [13] and [14]. The Freundlich equation is an empirical equation developed by Freundlich to describe the adsorption of gases on solid surfaces. The general formula of this equation gained widespread use after being further developed by Irving Langmuir in 1918 to describe the adsorption of gas molecules on a flat, solid surface. Langmuir assumed that adsorption occurs only in a single molecular layer on the surface of the adsorbent, thus ruling out interactions between adsorbed

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particles in a thin surface coating. Thus, the amount of adsorbed material increases rapidly at the beginning of adsorption and then gradually stabilizes due to the adsorption process. As for the equation of Temmin, it was widely used in adsorption after its development by Temmin and Bezef in 1940 to describe adsorption involving interactions between the adsorbent and the absorbent, which leads to a linear decrease in adsorption energy with increasing surface coverage. It is used to describe adsorption in aqueous solutions and takes into account the interactions between the adsorbed molecules at the surface. [15]Given the importance of this element in soils, our The importance of research in understanding the kinetics of magnesium (Mg^{2+}) lies in the different soils of Baiji County to improve composting efficiency and increase agricultural production for crops grown there. The aim of the study is to diagnose the physical and chemical properties of these troughs, evaluate the adsorption and release behavior of magnesium through the application of mathematical equations (Langmuir, Freundlich and Temkin) in order to determine the model most efficient at describing the kinetic mechanics and plant readiness of an element.

2- Materials and working Methods

1.2 - Sample Collection Phase

Five different types of soil were collected, and two samples were collected for each site: one surface sample and one subsurface sample. After the samples arrived at the laboratory, they were air-dried and smoothed using a plastic hammer, and passed through a sieve with a diameter of 2 mm. They were then stored in airtight plastic containers, with the information for each soil type affixed to the soil storage containers

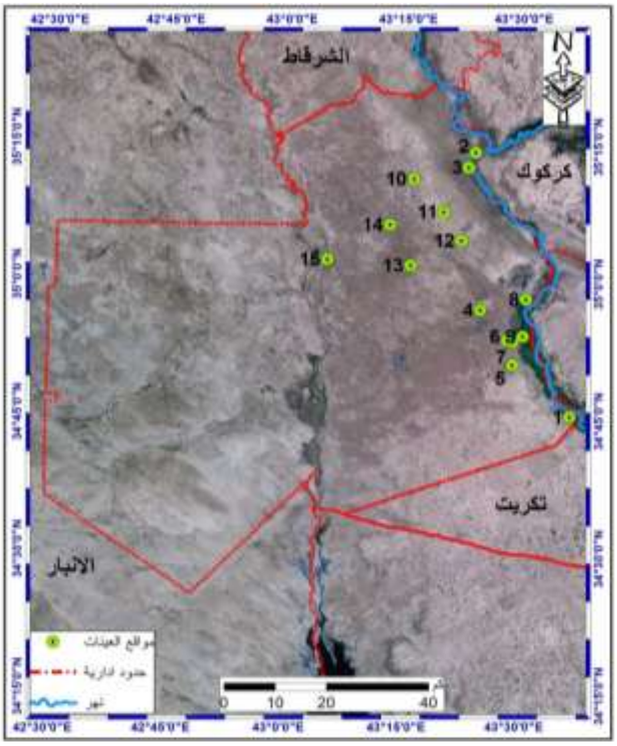

Fig Soil Sampling Sites of the Study Area

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2.2 - Laboratory Analysis of soil

Some physical and chemical tests were carried out on the study soils, where measurements were taken

Soil acidity(pH) According to [16].

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Measuring electrical conductivity(Ec) According to [17]

The organic matter was estimated according to Walkley and Black's Wet Digestion, included in [18]

Calcium carbonate and calcium sulfate were estimated according [25]

Soil texture according to the absorbent method [18]

Magnesium images: Total magnesium content is estimated by digesting soil samples with a mixture of sulfuric, perchloric and chloric acids according to [18]

.Exchangeable magnesium: Extracted by the DTPA method [19]

Soluble magnesium: The soluble magnesium in the soil extract with water was estimated at a 1:1 ratio as reported by [20]

The magnesium adsorption experiment involved preparing standard solutions at seven levels.(500, 250, 100, 50, 25, 10, 5) for each of the ten agricultural soils, and the number of treatments was 70 treatments with a dilution ratio of 20:1, 5 g of soil to 100 ml of solutions containing magnesium ions. The samples were shaken and then left for 24 hours to settle and were separated by centrifugation. Magnesium was measured using an atomic absorption spectrometry (AAS). The data were processed using the three Langmuir-Frendelch ion exchange equations, and a set of constants was calculated for the purpose of achieving the goal of agriculture.

A/ Langmuir equation in describing magnesium adsorption

Its general formula is written as follows:

$$1/X_m = 1/K_{cb} + 1/b \qquad (2)$$

Since:

1X = Amount of magnesium adsorbed (mg/kg)

1C = Magnesium concentration in equilibrium solution (mg/L) K = Binding energy per liter mg^{-1}

b = Maximum adsorption of ions $(mg/kg)^{-1}$

$$x = \frac{1 + KC}{Kbc} \qquad (1)$$

The Langmuir equation can be written in the following form[21]

X =The amount of the adsorbed element on the adsorbent surface is measured in milligrams per kilogram.

C= Concentration of the element in the equilibrium solution (mg/L)

b= Constant related to maximum adsorption liter mg^{-1}

k = Constant related to the binding energy of mg/L^{-1}

Freundlich equation /B describing magnesium adsorption

$$X = kC^b \qquad (3)$$

The linear form of this equation[21]

$$\log X = \log K + b \log C \qquad (4)$$

Since:

Temkin's equation for describing magnesium adsorption /C [21]

$$q_e = B \ln AT + B \ln C \qquad (5)$$

$$B = R_T/b_T \qquad (6)$$

q_e= Amount of element adsorbed in mg/kg^{-1}

B= Adsorption capacity mg kg^{-1}

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C= Magnesium concentration in equilibrium solution (L) mg^{-1}

AT= Constant representing binding energy L/kg^{-1}

RGas constant = (0.00821) mol·K

T= Temperature at 298 Kelvin

b_T= A constant related to the heat of reaction

Table 1. Some chemical and physical properties of study soils

Soil Type	Ph	Ec	O M	Coco3	Caso4	Magnesium Images			soil Texture		
			g Kg^{-1}	g kg^{-1}	g kg^{-1}	ToTal	Mutual	Melted	Sand	Silt	Clay
Sandy	S1	0.47	6.67	182.5	117.3	49.487	14.38	3.3384	831	64	80
	S1e	0.127	5.1	200	200	45.44	8.04	4.2019	822	67	83
Clay	S2	3.4	12.3	188	194.5	90.254	14.802	2.898	100	320	580
	S2e	6	5.5	170	288	81.501	17.49	12.937	100	325	575
Gypsum	S3	2.71	10.17	288.7	218.6	66.75	35.92	5.79	645	196	159
	S3e	2.5	5	228	288	50.904	13.4	3.363	710	335	55
Calcaseous	S4	2.37	10.12	318.75	144	67.393	49.83	15.191	558	311	132
	S4e	3	5.5	275	180	47.317	13.68	0.77	505	370	125
Shoulders	S5	1.7	15.6	252.5	208	84.499	39.624	6.95	265	460	275
	S5e	2.2	13.1	242	320	60	18.8438	10.01	280	460	260

3. Results and Discussion

Table (2) indicates some of the constants calculated from the Langmuir equation as values of the coefficient of determination, which ranged between(97-73) with an average of 81.9%. Maximum adsorption values ranged between (76.33 – 1471) mg kg^{-1}. The highest values were recorded in riverbank soils at the surface horizon (1471) mg kg^{-1}, while the lowest values were recorded in sandy soils at the surface horizon (76.33) mg kg^{-1}. The soils are ranked according to maximum adsorption as follows: (S1, S1e, S3e, S3, S4e, S4, S5e, S2, S2e, S5). This ranking is not accidental but is related to the clay and organic matter content of the soils, which increase their adsorption capacity. The presence of calcium sulfate and calcium carbonate may also contribute to the precipitation of magnesium as magnesium sulfate and magnesium carbonate. The table also shows KL values, which ranged between (0.08982 – The KL value was 0.00187 mg-1 per liter. Calcareous soils recorded the highest values at the surface horizon, while clay soils recorded the lowest. The ranking of the ten soils studied according to their KL values is as follows: (S2, S2e, S5e, S5, Se3, S1, S3, S1e, S4e, S4). The high KL

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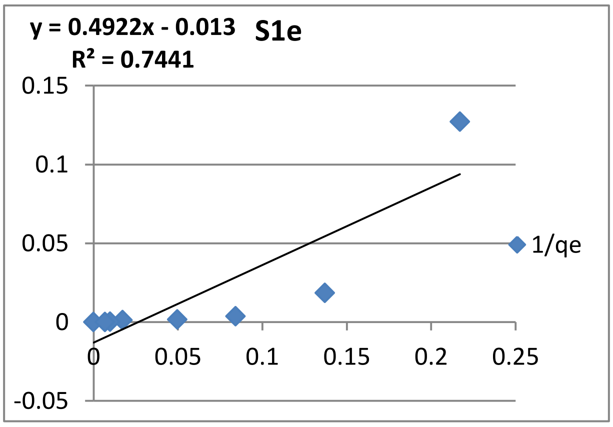
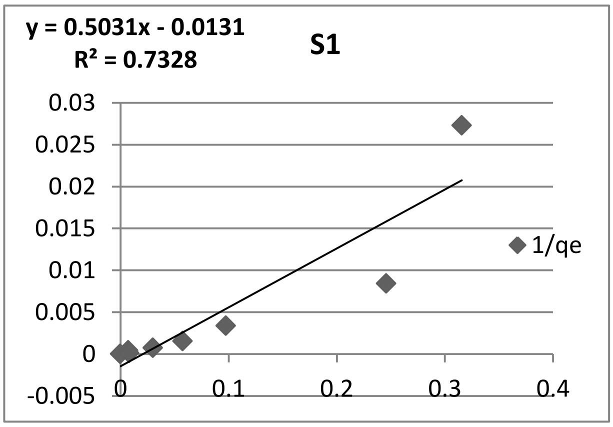
values of some of the studied soils may be due to adsorption at specialized sites, which increases the soil's ability to retain magnesium ions. Alternatively, it may be due to magnesium binding to organic matter or to chemical adsorption. The low KL values of S2 soil, despite its high clay content, may be related to multi-layered adsorption and weak bonding forces [22][23][24]. The values of the mbc constant ranged between 59.879 and 1.87, with calcareous soils recording the highest values at the surface horizon and sandy soils recording the lowest. The ranking of the soils according to their values is as follows: Mbc values, and their order (S1, S2, S1e, S3e, S3, S2e, S5e, S5, S4e, S4), reflect the soil's ability to provide the element over the long term. From these values, it is observed that most soils have the ability to provide the element over long periods, with calcareous soils, riverbank soils, and clay soils leading the way. [25]

Table 2. Maximum adsorption values and binding energy mbc for the Langmuir equation

Standards Soil Type	Equation of a straight iine for the Lagmuir equeation	Coefficient of determination R^2	Q max mg kg^{-1}	KL mg L^{-1}	Mbc
S1	Y = 0.5031x-0.0131	73	76.335	0.026039	1.877
S1e	Y = 0.4922x - 0.013	74	76.923	0.026412	2.031
S2	Y = 0.0534x - 0.001	95	1000	0.00187	1.873
S2e	Y = 0.148x - 0.0008	81	1250	0.005405	6.75
S3	Y = 0.2816x - 0.0071	75	345	0.0252	3.549
S3e	Y = 0.4416x - 0.0106	77	94.339	0.024	2.264
S4	Y = 0.0167x - 0.015	81	666.666	0.08982	59.879
S4e	Y = 0.0238x + 0.0017	81	588.235	0.0714	41.999
S5	Y = 0.032x + 0.0007	97	1423.571	0.0218	31.141
S5e	Y = 0.0727 - 0.0011	85	909.09	0.01513	13,754





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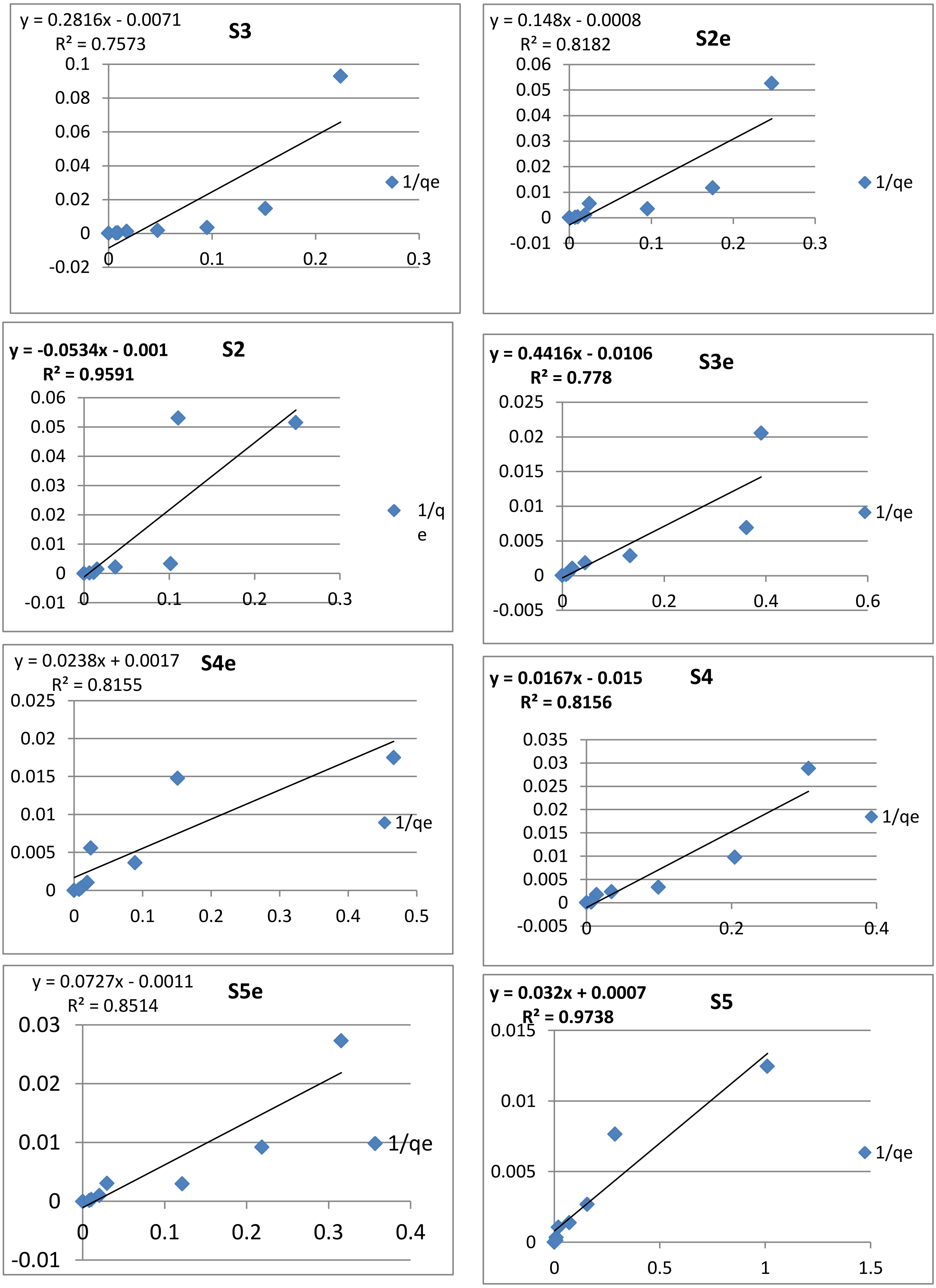

Figure 1. Adsorption curves for the equation Langmuir for study

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Table (3) indicates some of the constants that were calculated from the Freundlich equation as values of the coefficient of determination, which ranged between(65-92%) with an average of 81%, these results indicate the success of the Freundlich equation in characterizing magnesium in the studied soils. 1/n values ranged between (1.5726 - 0.9835) mg kg^{-1}. Riverbank soils recorded the highest surface horizon values (1.5726) mg kg^{-1}, while sandy soils recorded the lowest subsurface horizon values (0.9835) mg kg^{-1}. The soils were ranked based on 1/n values as follows: (S1e, S1, S3e, S4e, S2, S4, S3, S5e, S2e, S5), with soils having a high clay and organic matter content being ranked higher and those with a low sand content and low clay and organic matter content being ranked lower [2]. The reason for this may also be... The effect of calcium sulfate and calcium carbonate, which contribute to the precipitation of magnesium in the form of magnesium sulfate and magnesium carbonate. As for the values of energy Kf, they ranged between 1.762–7.009 ($L.mg^{-1}$). The highest values for this constant were recorded in clay soils with a surface horizon, while gypsum soils with a surface horizon recorded the lowest values. This may be due to the occurrence of adsorption at some active sites, which gives a high holding energy. As for the low binding energy of gypsum soils, it is due to the gypsum covering the exchange surfaces, which weakens the binding energy, in addition to the dominance of the coarse separation in them, especially for gypsum and sandy soils. These soils need fertilization with magnesium. According to the values of Kf, the order is as follows: (S3, S2e, S1, S3e, S4S1e, S4e, S5, S5eS2), [2] and [26].

Table 3. Maximum adsorption values and binding energy for the equation Frindlich for study

Standards / Soil Type	Equation of a straight iine for the Freundlich equeation	Coefficient of determination R^2	1/n mg kg^{-1}	KF mg L^{-1}
S1	Y = 1.0951x + 0.3253	69	1.0951	2.114
S1e	Y = 0.9835x + 0.4382	65	0.9835	2.742
S2	Y = 1.3082x + 0.5457	82	1.3082	7.009
S2e	Y = 1.5244x + 0.3077	86	1.5244	2.0309
S3	Y = 1.4733x + 0.2461	94	1.4733	1.762
S3e	Y = 1.1095x + 0.3323	71	1.1095	2.149
S4	Y = 1.3269x + 0.3612	85	1.3269	2.2972
S4e	Y = 1.2671x + 0.4567	77	1.267	2.862
S5	Y = 1.5726X + 0.5471	92	1.5726	3.524
S5e	Y = 1.5183 + 0.6015	89	1.5183	3.994

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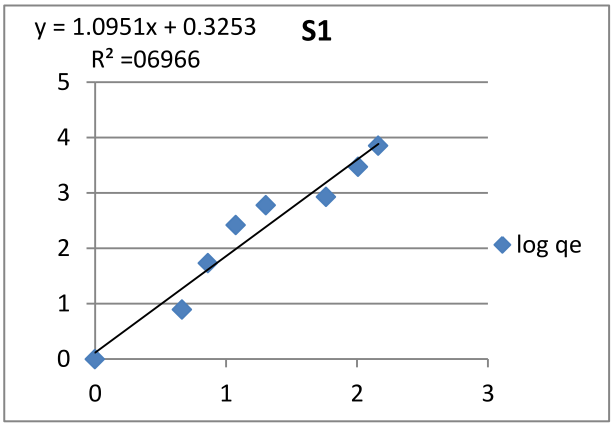
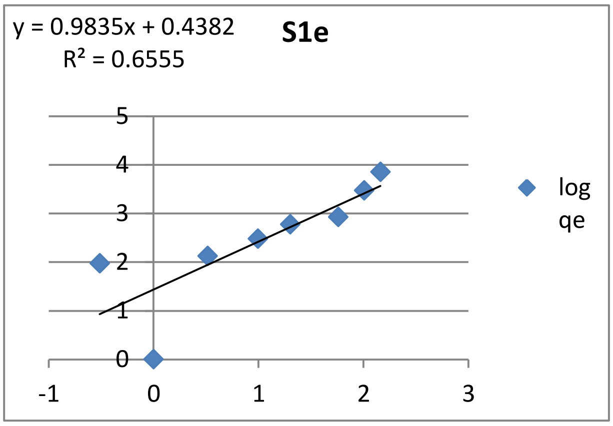
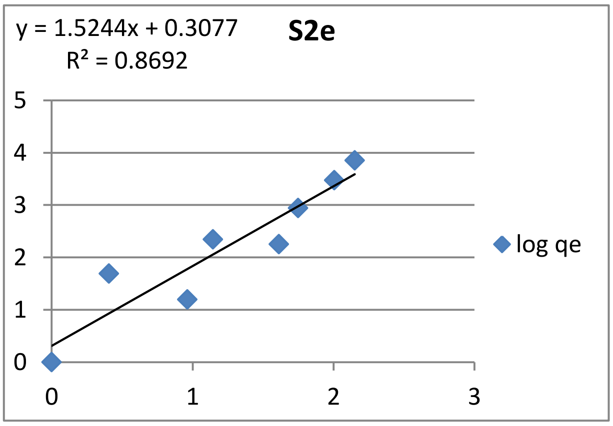
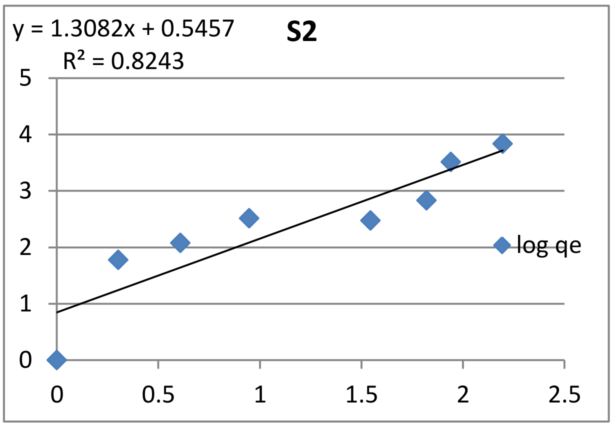
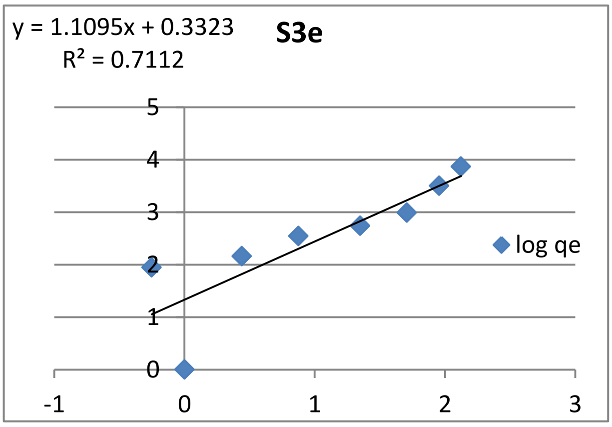
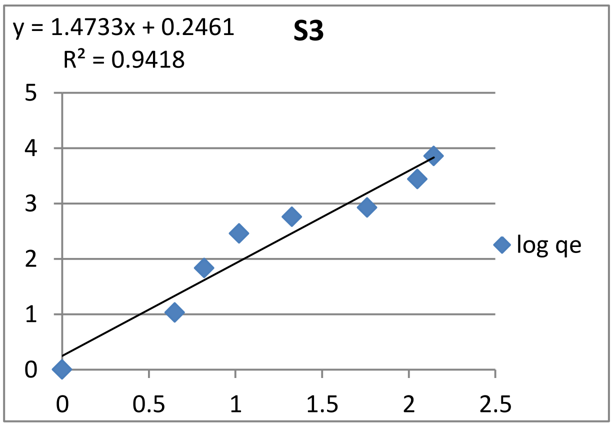

y = 1.0951x + 0.3253
R² =06966
S1
log qe


y = 0.9835x + 0.4382
R² = 0.6555
S1e
log qe


y = 1.5244x + 0.3077
R² = 0.8692
S2e
log qe


y = 1.3082x + 0.5457
R² = 0.8243
S2
log qe


y = 1.1095x + 0.3323
R² = 0.7112
S3e
log qe


y = 1.4733x + 0.2461
R² = 0.9418
S3
log qe

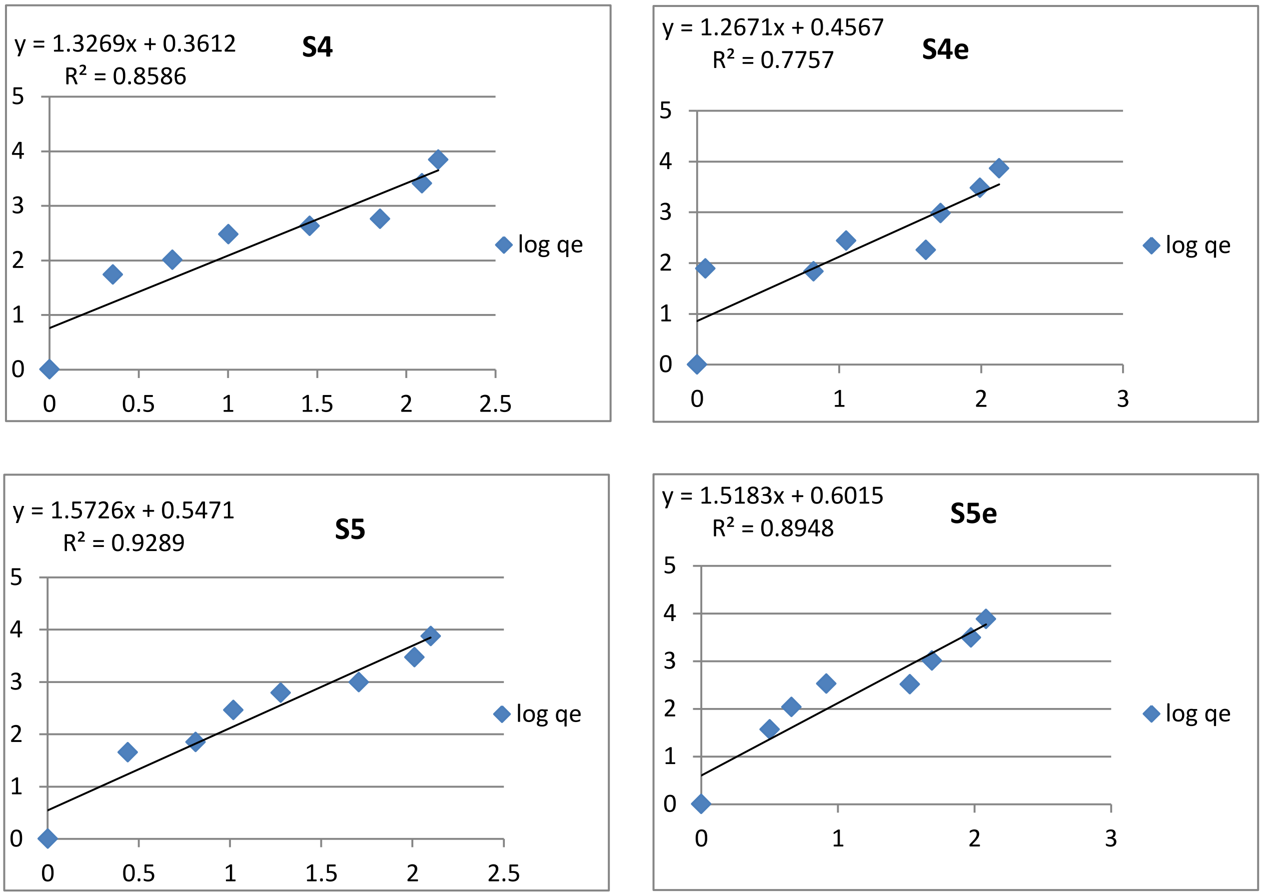


Figure.2 curves adsorption For the Freundlich equation of the study soils

Table.4 contains some constants that were calculated from the equation, represented by the coefficient of determination, whose values ranged, with the highest values in clay soils and surface horizons, while the lowest values were in soils.55.6% and an average of (49-64) between calcareous soils at the surface horizon, and the soils are ranked as follows: (S4, S2e, S5, S5e, S1, S3e, S3, S1e). As for the adsorption energy values, they ranged between 1178-1557.2 mol/J, with the highest values in clay soils at the surface horizon and the lowest values in sandy soils at the surface horizon. These soils are ranked according to adsorption energy values as follows: (S4, S5, S4e, S3e, S1, S5e, S3, S2e). As for the binding energy values, they ranged between (3.6-1.37) mg/L, with clay soils at the surface horizon having the highest values and sandy soils at the surface horizon having the lowest. These soils are ranked according to Kt values as follows. (S4e, S4, S3e, S1e, S5, S5e, S3, S2e) The arrangement of these soils is due to the difference in soil content of organic matter, carbonates and clay separation [23] in addition to the occurrence of an adsorption process in non-specialized sites and through the decrease in the values of adsorption energy it is clear that the adsorption is physical [25].

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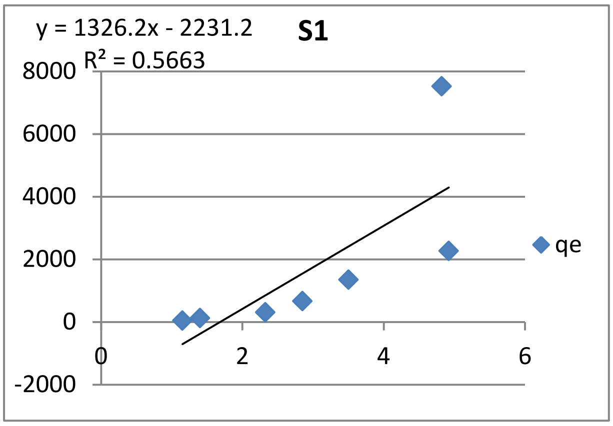
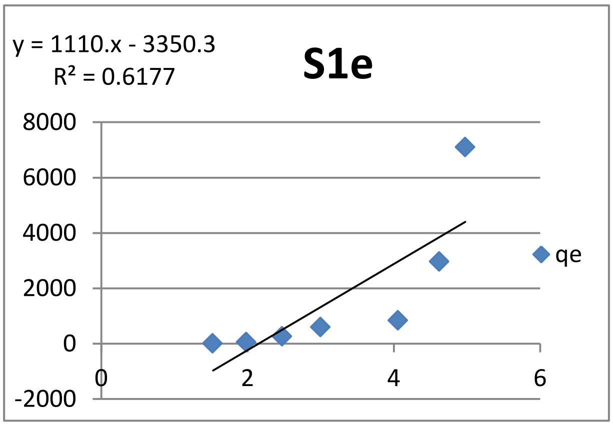
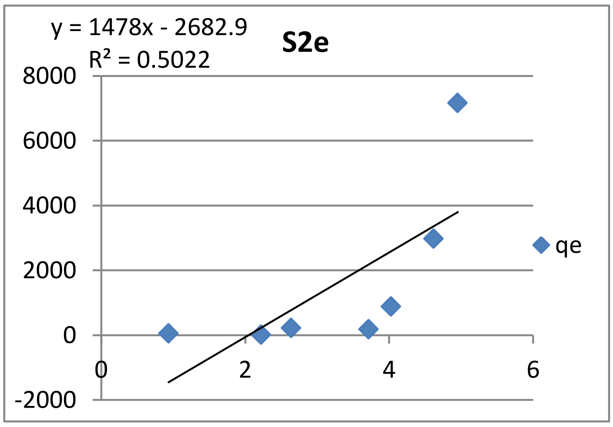
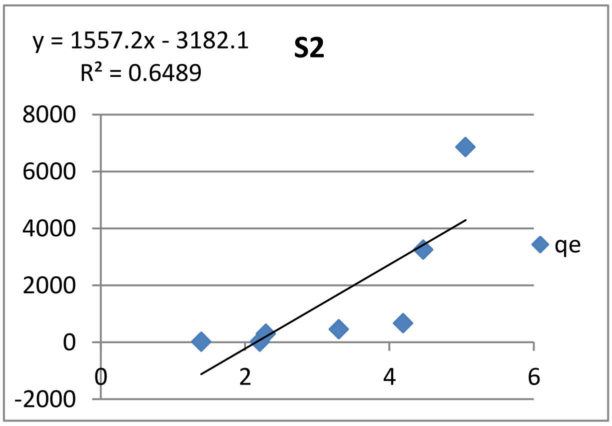
Table. 4 Some papameters of the Temkin equation

Standards Soil Type	Temkin linear equation	Coefficient of determination R^2	B (J mol)	KT (mg L)
S1	Y = 1326.2x - 2231.2	56	1326.2	1.37
S1e	Y = 1110x - 3350.3	61	1110	1.59
S2	Y = 1557.2x - 3182.1	64	1557.2	3.6
S2e	Y = 1478.5x - 2682.9	50	1478.5	2.75
S3	Y=1473.7x - 3056	60	1473.7	1.95
S3e	Y = 1265.3x - 1885.7	59	1265	1.49
S4	Y = 1155.9x + 2153	50	1155.9	1.45
S4e	Y = 1244.4x - 2253.3	49	1244	1.44
S5	Y = 1178.7x + 1140.1	53	1178	1.77
S5e	Y = 1382.2x + 2464	54	1382	1.95









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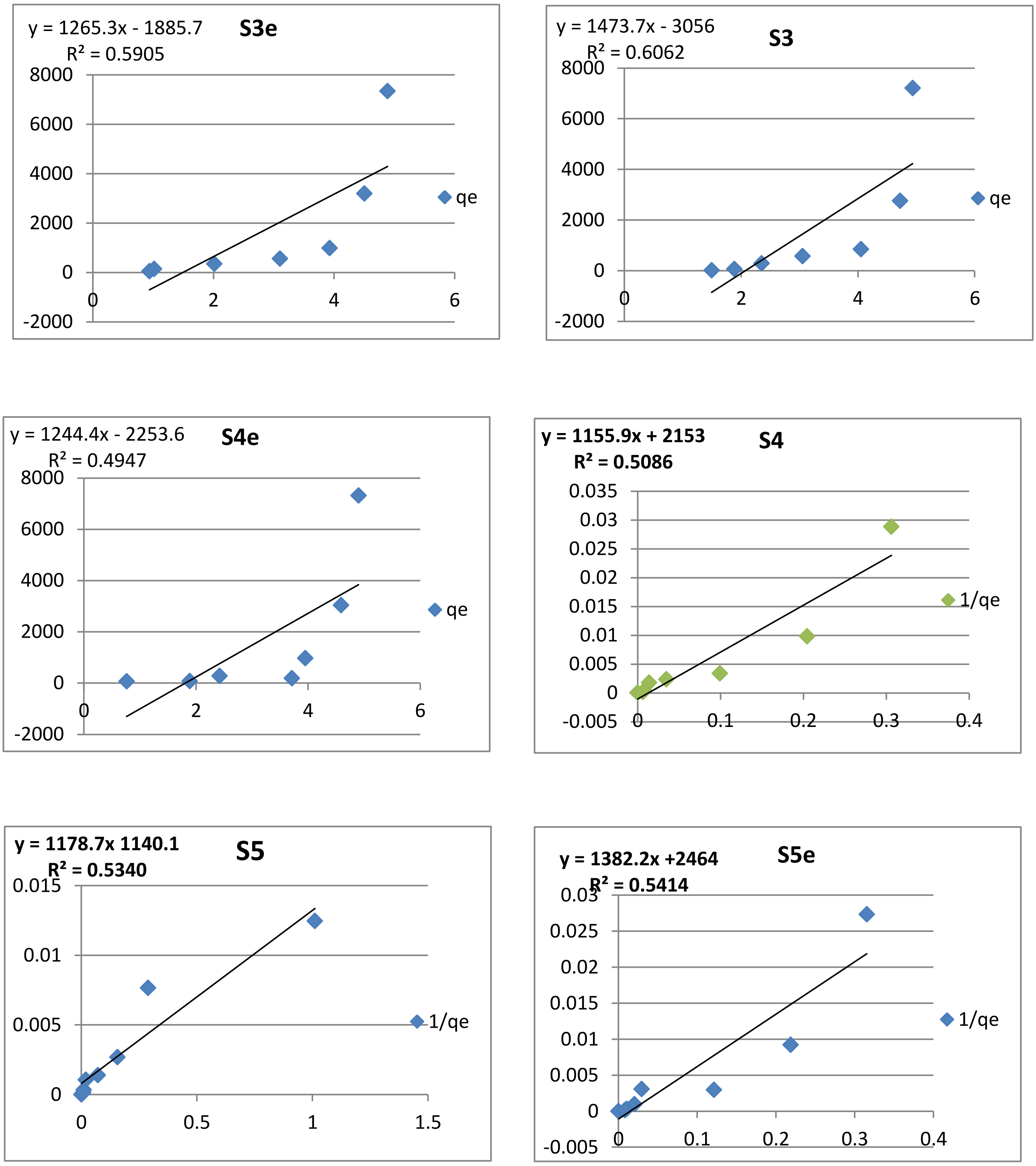

Figure.3curves adsorption To equalize It is possible for soil the study

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Table.5 Coefficient of determination (R^2) for the equations used to describe magnesium

Types of soil	Langmuir equation	Freindlich's equation	Temkin equation
S1	73	69	56
S1e	74	65	61
S2	95	82	64
S2e	81	86	50
S3	75	94	60
S3e	77	71	59
S4	81	85	50
S4e	81	77	49
S5	97	92	53
S5e	85	89	54

Conclusions4.

All equations successfully described the magnesium adsorption process in the studied soils, with the Langmuir equation proving superior. Soils with medium to high clay content exhibited high adsorption capacity, reflecting their ability to provide this element over the long term. High binding coefficient values indicate the soil's capacity to retain magnesium from leaching and reflect the element's release and availability in the soil solution. However, some soils, such as sandy, gypsum, and calcareous soils, require magnesium fertilizer additions. .

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