

## Behavior of Added Phosphorus to Different Soil types in Deir Ezzor Governorate –Syria

Dr. Yaser J. Al-Salama\*

(Received 11 / 5 / 2008. Accepted 10/8/2008)

### □ ABSTRACT □

The purpose of this search was to determine the quantity of phosphate adsorbed in different soil types (calcareous, gypsum, sandy and alluvial) and to study the fitting of Langmuir isotherms equation to describe the P-adsorption process.

The Langmuir equation was non-fitting to describe the P-adsorbed on tested soils when the added-P was more than 80 mg P/L, due to the interference between the adsorption process and precipitation reaction. The statistical correlation coefficients (R) between the amount of P-adsorbed and P-concentrations in solution after equilibration were significant and ranged from 0.927 (for calcareous soil) to 0.973 ( for sandy soil). Calculated Phosphorus adsorption maximum varied widely, ranging from 23.15 mg/Kg soil (for sandy soil) up to 56.50mg/Kg soil (for calcareous soil) mg P/kg soil.

**Keywords:** Soil, phosphorous adsorption /desorption, Langmuir equation.

---

\* Assistant prof, Department of Soil - Faculty of Agriculture – Al-Furat University Deir Ezzor- Syria

## سلوك الفسفور المضاف لنماذج مختلفة من الترب في محافظة دير الزور - سوريا

الدكتور ياسر جمعة السلامة \*

(تاريخ الإيداع 11 / 5 / 2008. قبل للنشر في 10/8/2008)

### □ الملخص □

يهدف هذا البحث إلى تحديد كمية الفسفور المدمصة في نماذج مختلفة من الترب (رسوبية، جبسية ، كلسية ورملية ) في محافظة دير الزور، و معرفة مدى ملائمة معادلة Langmuir لعملية ادمصاص الفسفور في هذه الأراضي، ويهدف أيضاً إلى تقدير الكمية المدمصة العظمى من الفسفور في هذه الأراضي .

بينت النتائج عدم ملائمة معادلة Langmuir لوصف عملية ادمصاص الفسفور في الأراضي المدروسة عندما زاد تركيز الفسفور المضاف عن 80 ملغ/ل وذلك عائداً لعملية التداخل ما بين عملية الادمصاص وتفاعلات الترسيب. كما أظهرت النتائج بأن قيم معامل الارتباط للعلاقة ما بين كمية الفسفور المدمصة والتركيز بعد الاتزان كانت معنوية وتراوح ما بين 0.927 للتربة الكلسية و 0.973 للتربة الرملية. وأن كمية الفسفور المدمصة العظمى والمحسوبة من معادلة Langmuir قد اختلفت كثيراً من 23.15 ملغ/كغ (في التربة الرملية) إلى 56.50 ملغ /كغ (في التربة الكلسية) وبالمقابل فقد أظهرت النتائج وجود علاقة موجبة ما بين ثوابت معادلة Langmuir والنسبة المئوية لكاربونات الكالسيوم ولم تكن هناك علاقة واضحة لباقي خواص التربة

الكلمات المفتاحية : التربة ، ادمصاص وتحرير الفسفور، معادلة Langmuir

\*مدرس - قسم التربة واستصلاح الأراضي - كلية الزراعة- جامعة الفرات- دير الزور- سورية.

## Introduction:

Phosphorus (P) is an essential element for plant growth and the amount of plant-available P in the soil is often inadequate to meet plant requirements. Phosphate reactions and retention in the soil are of paramount importance from the perspective of plant nutrition and fertilizer use efficiency.[1]

Phosphorus is therefore applied to agricultural fields in inorganic and/or organic fertilizers. However, the amount of fertilizer applied often exceeds the plant uptake and this result in a build-up of P in the soil. Most of the excess P is bound to the soil and some of it is transformed to less available forms but there is also a risk of some of the excess P being transported from agricultural fields to surface waters [2].

Many characteristics of the soil phosphate cycle, such as the maximum absorbable, phosphate quantity, the equilibrium quantity of phosphate, the various binding energies and, of course, the phosphate buffering capacity of the soil can all be calculated with the help of phosphate adsorption isotherms. Phosphorus sorption is often described by empirical equations such as the Langmuir equations [2]. In general, the two-term Langmuir isotherm and the Freundlich isotherm models give the best fit to measured data [3]. On the other hand, the understanding of P adsorbed and desorbed by soils is important for safeguarding water quality and for fertilizer management [4].

Several workers investigated the effect of different soil properties on metal reactions (retention and release) in soil. Soil surface, particle size distribution, bulk density, temperature, pH, redox status, ion exchange capacity, organic matter content were reported to significantly control metal retention and release in soil [5]. The relative P sorption, a P-sorption index of the relative P-sorption capacity of sandy soils, has been developed using a one-point isotherm for Florida's soils [6]. However, the P-sorption capacities and desorption potentials of soils in Deir Ezzor governorate have not been reported.

The relationships between P-sorption capacity, P availability and soil components in calcareous soils have been studied in other different countries.[7] Reported that P sorption in soils is related more to their Fe oxide than  $\text{CaCO}_3$  content.[8] Found P-sorption capacity is highly correlated with Fe oxide and clay content, and that  $\text{CaCO}_3$  plays a less important role in P sorption. However, [9] observed that concentrations of labile P in calcareous soils after fertilizer applications are negatively correlated to  $\text{CaCO}_3$  content. [10] Also reported that the ratio of Olsen-P to applied P is negatively correlated to Fe oxides content at low P application rates and to  $\text{CaCO}_3$  content at high P application rates.

The ability of soil to release sorbed P to the environment is dependent on both P-sorption capacity and amount of P sorbed. When the amount of sorbed P increases after P application to soils, soil-P desorption tends to increase, and this in turn, leads to increases in P loss through runoff or leaching. The concept of the degree of P saturation (DPS) has been introduced recently as an environmental index of soil P available to be released through runoff and leaching to surface and subsurface waters. This concept has been applied successfully to different soils in the Netherlands and to some soils in the USA [11]. Moreover, the rate of phosphorus release from solid to solution phase may control the lability of P in soil environments [12].

### The purposes of this work were:

1.To determine the quantity of phosphorus adsorbed in different soil types (in Deir Ezzor governorate ), and to study the fitting of Langmuir isotherms equation to describe the P-adsorption process, and

2.To estimate the correlations between p-adsorption and p-desorption with some properties of tested soils.

### Material and Methods:

Five grams of surface soils samples from four different soils in Deir Ezzor governorate (their proprieties are shown in Table 1) were weighed into a 100-mL centrifuge tube. Fifty milliliters of 0.050 M KCl solution containing 10, 20, 40, 80, 160, 320 and 640 mg P/L was added to each soil sample, respectively. Each tube with suspension was shaken for 24 h at room temperature. After centrifugation at 1800 x g for 15 min, the supernatant was filtered through Whatman No. 41 filter paper. The P concentration in the filtered solution was determined calorimetrically according to [13].

**Table (1): Some physical and chemical properties of experiment soils.**

oil	Samples location	pH	EC EC	OM (%)	Olsen - P (ppm)	Gypsum (%)	CaCO <sub>3</sub> (%)	Particle size distribution (%)			Soil Texture
								Sand	Silt	Clay	
A	Al-kassra village	8.22	2.06	0.55	1.4	3.4	10	69.6	26.0	4.4	Sandy loam
B	Ain bo-Gomaa	8.15	1.20	0.64	3.6	20.8	7.5	38.6	51.6	9.8	Sandy loam
C	Al-Tabny village	7.71	2.07	0.55	2.4	4.4	24.5	63.2	30.4	6.4	Sandy clay loam
D	Al-Masrab village	7.51	2.18	0.91	5.2	6.6	4.4	23.2	44.0	32.8	Clay loam

*Soil A: type for sandy soils*

*Soil C: type for calcareous soils.*

*Soil B: type for gypsum soils.*

*Soil D: type for alluvial soils.*

The amount of P sorbed by soils was calculated from the difference in P-concentration between the initial P solution and equilibrium P concentration in the solution.

After completion of the sorption study, 0.050 M KCl solution was added to each tube that contained soil with sorbed P to reach the total solution volume of 15 mL. The desorption was performed by shaking the suspension for 24 h. The same procedures (centrifugation, and filtration) used for P sorption, were also used for P desorption determination. The P concentration in solution was measured according to [13].

### Adsorption Isotherm:

Adsorption parameters were calculated using Langmuir isotherms equation as follows:

$$\frac{C}{S} = \frac{1}{bS_{\max}} + \frac{C}{S_{\max}}$$

Where:

*S* is the amount of P adsorbed [mg P/kg soil],

*C* is the P-equilibrium concentration [mg P/L]

*S*<sub>max</sub> is the maximum adsorption [mg P/kg soil], and

*b* is a constant related to the bonding energy, or related to the energy of adsorption [L/ mg P].

The percent P desorbed was calculated as follows:

$$\text{Percent desorbed P} = \frac{\text{Amount P released to solution(mg)}}{\text{Total adsorbed P(mg)}} \times 100$$

All the correlations and figures were carried out using the Microsoft office Excel (2003) program.

## Results And Discussion:

The amounts of phosphorus adsorbed on the investigated soils were plotted as a function of equilibrium concentration. Adsorption isotherms obtained for the studied soils were curvilinear, as shown in Fig (1) the ascension degree was the highest for calcareous and gypsum soils, which indicate high affinity of the adsorbed phosphorus. The magnitude of adsorbed-P for different tested soils at used concentrations could be arranged in the following descending order: calcareous soil > gypsum soil > alluvial soil > sandy soil. On the other hand, the gypsum soil has a higher capacity for retention the phosphorus than the alluvial soil, this result maybe referred to high content of CaSO<sub>4</sub> in gypsum soil (table2). Similar results were obtained by [14]. He found that the calcareous and gypsum soils had a high affinity for p-sorption especially at low phosphorus solution concentrations.

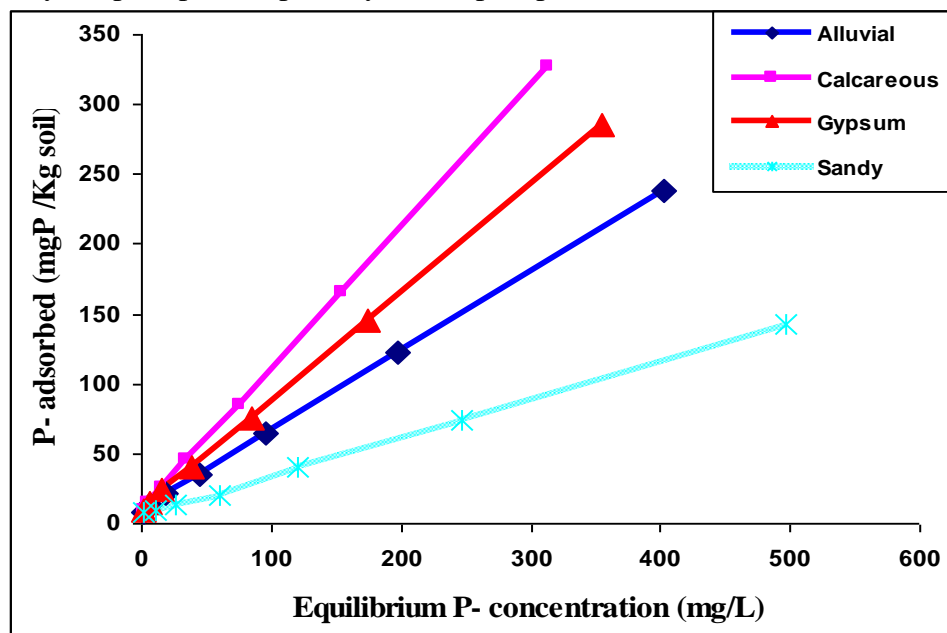


Fig (1): P-adsorption isotherms for the tested soils.

The obtained data agree with those obtained by [15] they demonstrated a surface adsorption phosphate on calcium carbonate particles at low p-concentration and precipitation reaction at higher concentration. Moreover, the different soluble salts in the calcareous and gypsum soils compared to that in alluvial maybe another factor that influence the results in both soils. Phosphate retention, solubility and its availability to the growing plants depend to a great extent on soil content of soluble salts.

The adsorption data obtained for the tested soils were fitted to Langmuir adsorption isotherm. Fig (2) showed Langmuir adsorption isotherm for the tested phosphorus concentrations in selected soils. The obtained logarithmic curves were not fitted to Langmuir isotherm, but when we disregard the last three high p-concentration (more than 80 mg P/L) avoid to precipitation reaction we could be obtained a liner equation (from the first four points) and it's fit to Langmuir isotherm curves.

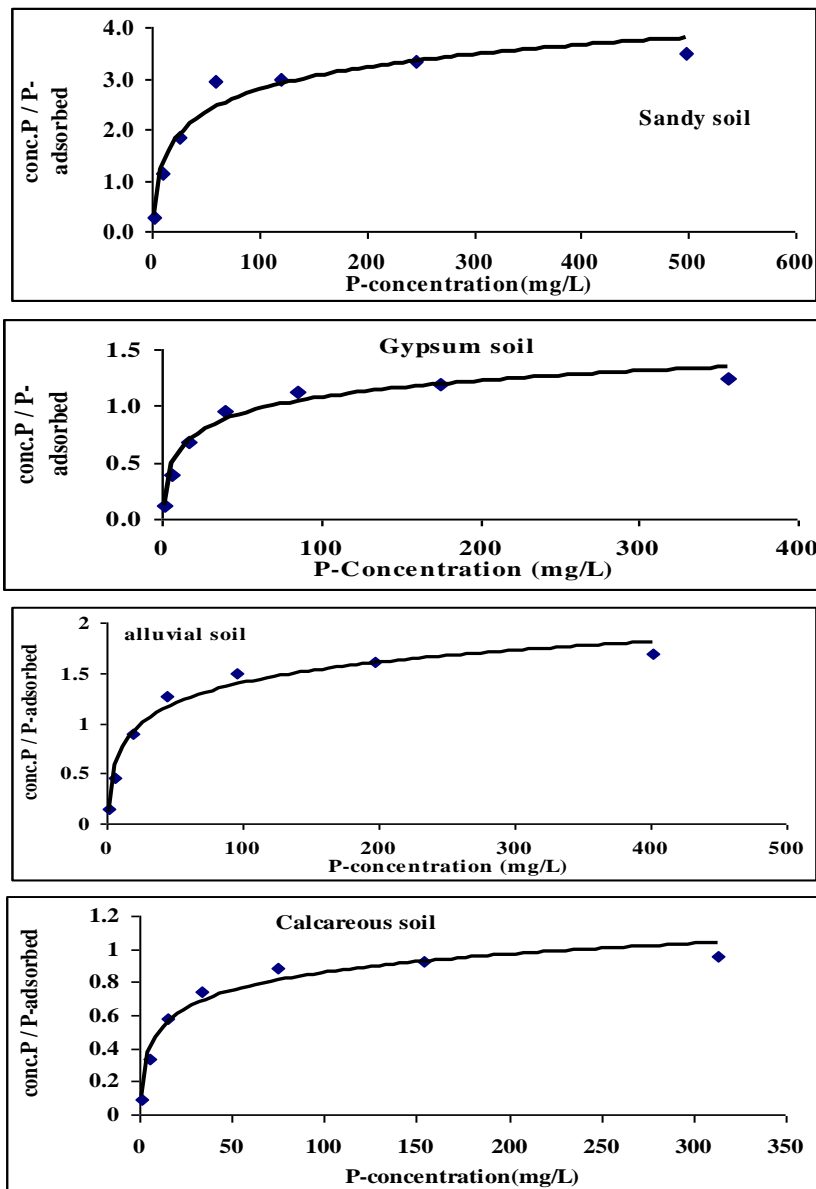


Fig (2): Isotherm curves for tested soils with different phosphorus concentration.

From the liner equations , the statistical correlation coefficients (R) between the amount of adsorbed-P (S/C) and P-equilibrium concentration (C) for any adsorption curve of tested soils were significant and ranged from 0.927 to 0.973 (Table 2).

**Table (2):Langmiur constant and linear equation for phosphorus adsorption by investigated soils.**

Soil	Bonding energy	Maxima adsorption mgP/kg soil	Equation	R
Sandy soil	0.0889	23.15	$C/S = 0.0432C + 0.486$	0.973
Gypsum soil	0.0914	49.26	$C/S = 0.0203C + 0.222$	0.950
Calcareous soil	0.1135	56.50	$C/S = 0.0177C + 0.156$	0.927
Alluvial soil	0.0938	41.15	$C/S = 0.0243C + 0.259$	0.960

Phosphorus adsorption maximum and equilibrium solution concentration of phosphorus are important parameters when studying soil phosphorus levels needed for optimum growth. Determining these parameters for available P could be quite helpful in explaining differences between soils. With the use of these values it would be possible to group up soils which require the same level of available P for maximum growth.

Calculated Phosphorus adsorption maximum varied widely, ranging from 23.15 up to 56.50 mg P/kg soil. The highest value was reported for the calcareous soil, while the lowest ones were reported for sandy soil. Dependence on this result, we could explain the high value of adsorbed phosphorus is returned to precipitation reaction that happened with adsorption process at high concentration of added-P.

The bounding energy coefficients of adsorbed phosphorus are listed in table (2). In general, the lowest value was reported for the sandy soil, while the calcareous soil had the highest bonding energy coefficient. These results agreed with that obtained by [16].They found that the  $CaCO_3$  is the most active sorbent of P in soil.

In order to explain the mechanism of phosphate adsorption and description two general approaches may be made: the detailed study of simple system like clay minerals iron, and aluminum oxides and an empirical approach using statistical correlation between phosphate sorption and other soil properties. The relationship between adsorption parameter and soil properties were evaluated by simple correlation coefficients. The correlation coefficients, Table (3) are used as a guide to establish relationship between Langmuir adsorption parameters and some soil properties.

**Table (3): Simple correlations between some soil properties and Langmuir parameters for phosphorus retention after a 24-h equilibration period.**

R	Gypsum %	$CaCO_3$ %	Clay%	pH
Bonding energy	-0.325	0.905	-0.190	-0.506
Maxima adsorption	0.364	0.505	0.045	-0.465

As shown in Table (3), the positive relationships were observed between Langmuir parameters and soil  $CaCO_3$ %, while there were non-significant relationships between Langmuir parameters and other soil properties. The similar results were obtained by [12] they found positive significant relationships with active calcium carbonate.

**Release experiment:**

The release of phosphorus from investigated soils is shown in Fig (3).The highest phosphorus released values were obtained in the alluvial soil than the calcareous and gypsum soils, while the sandy soil showed the lowest value of phosphorus release.

As shown in Table (4), the CaCO<sub>3</sub> % had a negative significant correlation with the desorbed-p from tested soils, which maybe referred to the reaction of P with CaCO<sub>3</sub> and formation a non-soluble calcium carbonate in calcareous soil especially at high P-concentration. This result is agreed with that obtained by [4]. On the other hand, the pH had a positive significant correlation with the p-desorbed from tested soils; similar result was obtained by [17].

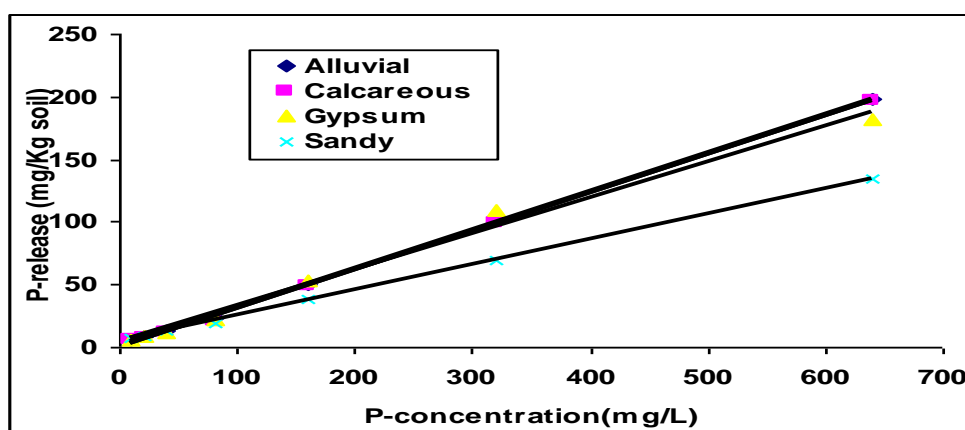


Fig.(3): The release phosphorus with different applied p- concentrations in tested soils.

Table (4): Simple correlation between some soil properties and phosphorus release from tested soils.

R	Gypsum %	CaCO <sub>3</sub> %	Clay%	pH
P-desorbed	-0.365	-0.602	-0.049	0.467

The percent phosphorus desorbed values of the studied soils as presented in Table (5), the means of different applied concentrations, ranged from 54.38 % ( for calcareous soil) to 95.44% (for sandy soil). This result referred to high CaCO<sub>3</sub>% in calcareous soil.

Table (5):The percent phosphorus desorbed from tested soils at different applied concentrations.

P-Conc. mg/L	Sandy soil	Gypsum soil	Calcareous soil	Alluvial soil
10	95.18	68.16	59.21	71.02
20	98.92	59.23	52.63	66.42
40	95.04	52.30	46.17	63.21
80	95.07	53.43	45.53	65.63
160	95.51	70.48	57.81	78.44
320	94.22	75.18	59.27	83.68
640	94.13	63.70	60.06	83.37
Mean	95.44	63.21	54.38	73.11



## Conclusions and Recommendations:

- The Langmuir equation was non-fitting to describe the P-adsorbed on tested soils when the added-P was more than 80 mg P/L, due to the interference between the adsorption process and precipitation reaction.
- The total amounts of the phosphorus recovered through release did not equal to the amount of phosphorus retained by the soils, which may suggest that at least one of the retention reactions was irreversible.

## References:

- [1] HOSSEINPUR A. R. and BIABANAKI. F. S. *Impact of fertilizer phosphorus application on phosphorus release kinetics in some calcareous soils*, Environmental Geology. J. (10), 2008,1207-1212.
- [2] BÖRLING K. ., *Phosphorus Sorption, Accumulation and Leaching*. Ph.D Thesis, Swedish University of Agricultural Sciences, Uppsala. 2003
- [3] FÜLEKY G. and TOLNER L. *Determination of the phosphate content originally adsorbed on the soil by fitting an Adsorption isotherm model*. Applied ecology and environmental research. 4(2), 2006.39-45.
- [4] MEIFANG Z. and YUNCON L. *Phosphorus-Sorption Characteristics of Calcareous Soils and Limestone from the Southern Everglades and Adjacent Farmlands*. Soil Sci. Soc. Am. J. (65), 2001,1404-1412.
- [5] LIVENS, F.R. and RIMMER, D.L.. *Phhsico – chemical controls on artificial radionuclides in soil*. Soil use and Management. Vol. 4, 1988,63-69.
- [6] HARRIS, W.G., RHUE, R.D. KIDDER, G. BROWN, R.D. and LITTELL. R. *Phosphorus retention as related to morphology and taxonomy of sandy coastal plain soil materials*. Soil Sci. Soc. Am. J. 60: 1996, 1513–1521.
- [7] RYAN, J., CURTIN, D. and CHEEMA. M.A. *Significance of iron oxides and calcium carbonate particle size in phosphate sorption by calcareous soils*. Soil Sci. Soc. Am. J. 49: 1985, 74–76.
- [8] SOLIS, P., and TORRENT. J. *Phosphate sorption by calcareous vertisols and inceptisols of Spain*. Soils. Soil Sci. Soc. Am. J.,53: 1989,456–459.
- [9] SHARPLEY, A.N., and SMITH. S.J. *Fractionation of inorganic and organic phosphorus in virgin and cultivated soils*. Soil Sci. Soc. Am. J. 49: 1985, 127–136.
- [10] AFIF, E., MATAR, A. and TORRENT. J. *Availability of phosphate applied to calcareous soils of west Asia and North Africa*. Soil Sci. Soc. Am. J. 57: 1993, 756–760.
- [11] SHARPLEY, A.N. *Dependence of runoff phosphorus on extractable soil phosphorus*. J. Environ. Qual. 24: 1995,920–926.
- [12] SHARIATMADARI, H., SHIRVANI M. and JAFARI. A. *Phosphorus release kinetics and availability in calcareous soils of selected arid and semiarid top sequences*. Geoderma. J. 132 (3-4): 2006 ,261-272.
- [13] OLSEN, S.R., and SOMMERS. L.E. *Phosphorus .P. 403-430. In A.L. Page (ed) , Methods of soil analysis, Agron. No . 9 , part 2: Chemical and microbiological properties, 2<sup>nd</sup> ed., Am. Soc. Agron., Madison , WI, USA. 1982 ,*
- [14] HAWS, I.A.M. . *The adsorption of phosphate by soils rich in palygorskite in the oasis of Alhassa Saudi Arabia*. Scientific. J. King Faisal Univ. 4(2): 2003, 140-153.
- [15] ABDOU, F.M. and EL-NENNAH.. M. *A tracer technique for measuring the reaction of phosphate with calcium carbonate*. Nuclear Science and application Journal. 1975.
- [16] LOPEZ-PINEIRO, A. and NAVARRO, A. GARCIA. *Phosphate Sorption in Vertisols of Southwestern Spain*. Soil Sci. 162 (1): 1997, 69-77.
- [17] BAYOUMI , N.A. and REHAN, M.R. *Phosphate adsorption and desorption as affected by soil properties*. Egypt. J. Soil Sci. 24: 1984,53 –66.

