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Adsorption of Phosphate in Different Soil Environment of Western India

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Abstract: Adsorption of Phosphate on soil has been studied using batch adsorption technique. This study is carried out to examine adsorption capacity of Phosphate on different soil. Results revealed that adsorption rate initially increases and equilibrium reached about one hour. Further increase in contact time did not show significant change in equilibrium concentration. The Langmuir , Freundlich and Temkin isotherm were used to describe the adsorption equilibrium studies. Langmuir isotherm is best fitted.
Keywords: Phosphate, soil, batch method, adsorption, isotherm.

I. INTRODUCTION

Phosphorus is an essential element for plant and animal growth. All living plants and animals require phosphorus .It is the second most important nutrient ,next to nitrogen that has often been found limiting biological productivity in terrestrial environments and as well as in surface water environments. Phosphorus containing compounds are essential for photosynthesis in plants, for energy transformations and for the activity of some hormones in both plants and animals. Plants obtain their phosphorus from the soil in which they grow and, if no fertilizer has been used the phosphorus in the soil is derived from the parent material from which the soil was formed.

Management of phosphate fertilization is essential for maintaining the concentration of biologically available soil- P at a value adequate for plant growth, while minimizing the movement of dissolved -Phosphorus and particulate -Phosphorus to surface water and shallow ground water .Soils also have a defined capacity to adsorb phosphorus and there will be a great possibility to release excess Phosphorus into the surface of ground water when a critical Phosphorus sorption saturation level is attained [1]

Phosphorus has its slow diffusion and high fixation in soils and, therefore it is imperative to apply Phosphorus fertilizers for improving crop growth and yield. In order to understand the complex behavior of Phosphorus in soil, several workers have emphasized the importance of Phosphorus fertilizer management based upon chemical extraction methods (soil-test methods) and phosphate adsorption isotherms. But, Phosphorus sorption method has an edge over chemical extraction methods as it also defines the efficiency of the crops to utilize the Phosphorus available from soil [2]. Excessive Phosphorus export from agricultural landscapes can lead to eutrophication of surface water[3].Phosphate adsorption is the process in which phosphate ions are held on active sites of soil particle surfaces [4].Phosphorus is a critical element in natural and agricultural ecosystems throughout the world [5] as its limited availability is often the main constraint for plant growth in highly weathered soils of the tropics [6].Phosphorus deficiency problems are common in well-weathered oxisols and ultisols because of strong acidic reactions and abundance of Al and Fe ions [7] and the situation can be worsened with inappropriate Phosphorus management [8].In acid soils of India, liming and application of phosphate fertilizers as organic or inorganic sources have been suggested for controlling Phosphorus deficiency. However, low availability of soil Phosphorus due to adsorption reactions by the soil constituent's results in only a small fraction coming to soil solution for crop utilization. Thus the concentration of soluble reactive Phosphorus in soil and drainage water is controlled by rapid adsorption reactions [9]. The Phosphorus deficiency in Indian soil varies from region to region according to soil texture especially clay content, Al and Fe oxides, $CaCO_3$, organic C content, pH etc. Different forms of soil phosphorus have different solubilities and consequent availability in soils.

II. MATERIAL & METHOD

The Batch tests were carried out in 250 ml flask using a natural soil as a sorbent. The soil samples were collected from the process house, IV phase, RIICO industrial area, Bhilwara and agriculture area Kaithun from Kota. The soil samples were dried in air for about three weeks. After drying the soil was sieved in order to obtain different particle size distribution (100-300 BSS). Phosphate samples were prepared by dissolving a 0.220g of solid potassium dihydrogen phosphate (KH_2Po_4) in double-distilled water this

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will give 300 ppm solution and used as a stock solution and diluted to the required initial concentration. A 2g natural soil was mixed with 100ml of the aqueous solutions of various initial concentration (0.5mg/L, 1mg/L, 2mg/L, 3mg/L and 4 mg/L) of Phosphate in each flask. The stirring speed was kept constant at 120 rpm. The flasks were shaken at a constant rate, allowing sufficient time for adsorption equilibrium. It was assumed that the applied shaking speed allows all the surface area to come in contact with ions to be adsorbed over the course of the experiments. The study was performed at room temperature to be representative of environmentally relevant condition. The pH of the solution was measured with a HACH-pH meter. The effects of various parameters on the rate of adsorption process were observed by varying contact time, adsorbent concentration, initial P Concentration, and pH of the solution. The solution volume was kept constant. The measurements were made at the wavelength λ=650nm, which corresponds to maximum absorbance [13]. Using a mass balance, the concentrations of Phosphate at different time adsorbed in soil solids was calculated,

$$qt= (C_o - C_t) V/ M \quad (1)$$

where qt is the amount of Phosphate adsorbed onto the natural soil at time t C_o is the initial concentration of Phosphate , C_t is aqueous phase concentration of Phosphate at time t,V is the volume of the aqueous phase, M is the weight of natural soil.The Phosphate adsorbed in soil is estimated by ascorbic acid and Ammonium Molybdate method (colorimetric) at 650 nm wave length.
This method uses a complexation reaction to produce a coloured complex of molybdate and phosphorus. This complex is formed when phosphate (sample) is heated with ammonium molybdate in the presence of acid and excess ascorbate ions (which are to prevent the colour degrading as the molybdate oxidizes slowly). The coloured complex formed is dependent on the initial phosphate concentration in the sample.The amount of phosphate present is determined by comparison of the blue colour with known standards of phosphate, subjected to the same reaction with molybdate reagent. The amount of Phosphate sorbed was calculated as the difference between the amount of Phosphate added and that remaining in solution [10].

III. RESULT AND DISCUSSION

A. Influence of Variation of Amount of Soil.

In the experiment the amount of soil were taken 2gm ,4gm,6gm and 8 gm and the results reveals that the % adsorption increases and at a certain point it becomes constant . There is a significant correlation between maximal Phosphorus adsorption and clay content, and the total amount of phosphorous adsorbed into the soil can be attributed to presence of sorptive sites. This could be related to the relatively large number of positive charges that can react and strongly bind the negatively charged phosphate ions in the solution. It is also reported that maximal adsorption value increases with increasing values of clay content and phosphorus of soil [11,12]

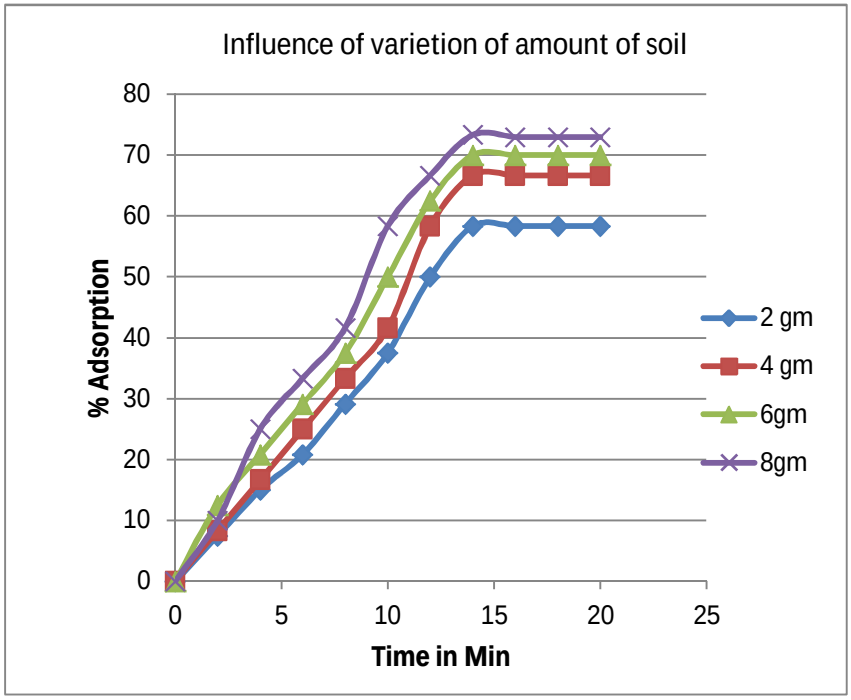


Fig:1 Influence of variation of amount of soil.

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B. Influence of Variation of Initial Phosphate Concentration

In the experiment the amount of Phosphorus were taken 0.06mg,0.12mg,0.18mg and 0.24 mg and the results reveals that the % adsorption increases and at a certain point it becomes constant .The linearity between equilibrium Phosphorus concentrations versus rate of Phosphorus sorbed was due to large intermolecular distance between Phosphorus ions resulting in negligible mutual repulsion and the deviation from linearity indicated that the binding affinity of soil to Phosphorus decreased with increase in surface saturation with Phosphorus. [13]

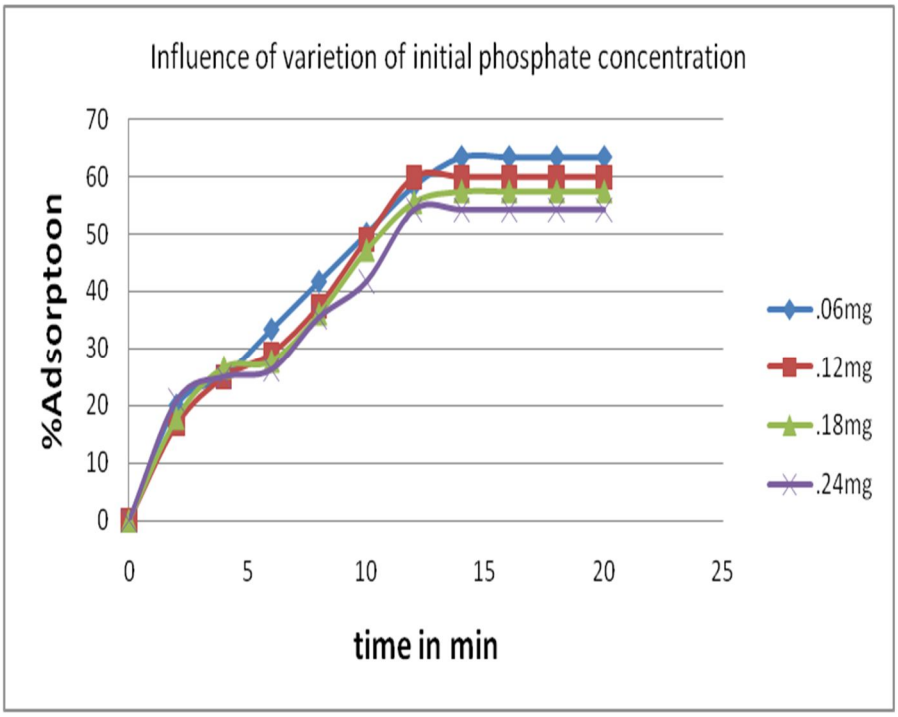


Fig:2 Influence of variation of initial phosphate concentration

C. Adsorption Isotherms

Adsorption is usually described through isotherms, that is, functions which connect the amount of adsorbate on the adsorbent. Distribution of Phosphate ions between the liquid phase and the solid phase can be described by several isotherm models such as Langmuir and Freundlich [14].The Langmuir model assumes that uptake of sorbate occurs on a homogenous surface by monolayer sorption without any interaction between the sorbed ions. Also, all the binding sites of surface have equal energy of sorption. The linear form of the Langmuir equation can be given as:

$$Ce/qe = 1/bqe + Ce/qe \qquad (2)$$

where qe; is the monolayer adsorption capacity (mg/g), b; is the Langmuir constant (L/mg), Ce; is equilibrium concentration of sorbate. The plot of Ce/qe versus Ce was employed to calculate the intercept value of 1/bqe and slope of 1/qe .

One of the essential characteristics of this model can be expressed in terms of the dimensionless constant separation factor for equilibrium parameter, RL,defined as:

$$RL= 1/1+bCo \qquad (3)$$

The value of RL indicates the type of isotherm to be irreversible (RL=0), favourable (0<RL<1), linear RL=1 or unfavorable RL>1.

The Freundlich isotherm, on the other hand, assumes o heterogeneous sorption surface with sites that have different energies of sorption. This model can be presented as:

$$lnKf= lnKf+ 1/nf*Ce \qquad (4)$$

Where Kf; is the relative sorption capacity of sorbent, and nf; is a constant related to sorption intensity. The plot of lnqe versus lnCe should give a straight line with a slope of 1/nf and intercept of lnKf . To evaluate the applicability of Langmuir and Freundlich isotherm models for the adsorption of P ions by soil.

For Langmuir isotherm the value of R^2 is 0.995 s because the interaction with molecules already it is also favorable because The binding energy of the soils for P sorption decreased with increase in surface coverage.

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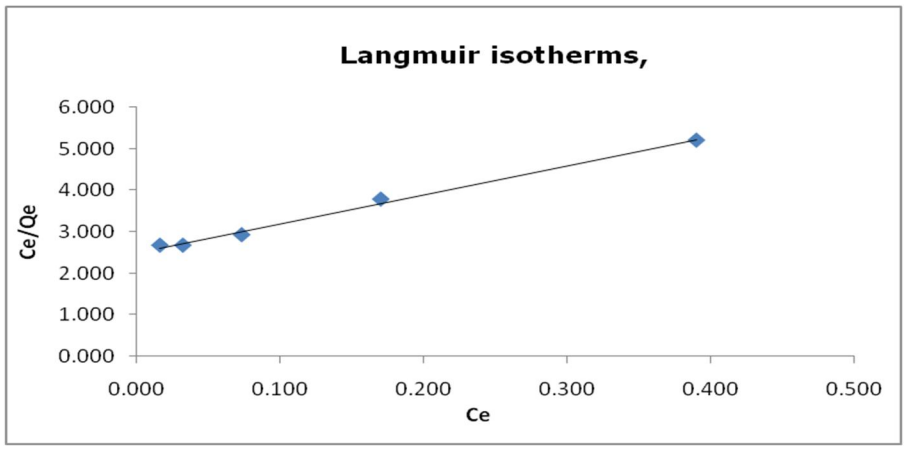


Fig:3 Langmuir Adsorption isotherm

For Freundlich isotherms the value of R^2 is 0.990. The Freundlich Equation is fit because the energy of adsorption decreased exponentially with increasing surface saturation when adsorption fitted in the Freundlich equation [15]

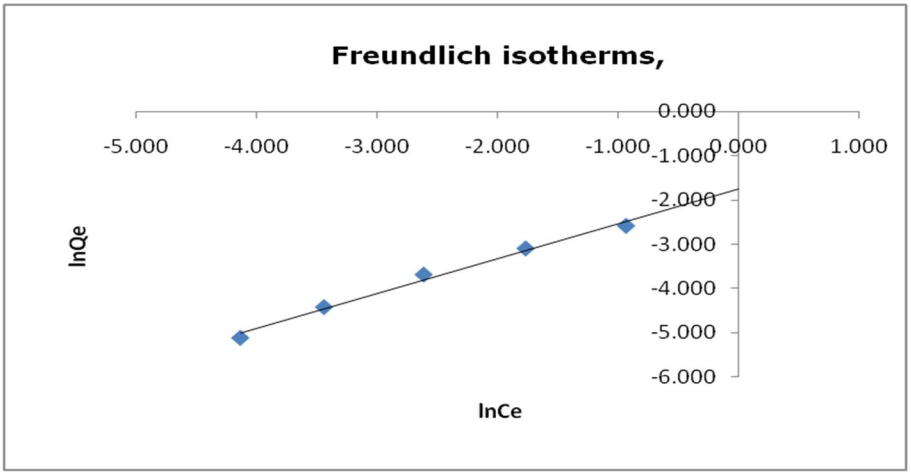


Fig:4 Freundlich Adsorption isotherm

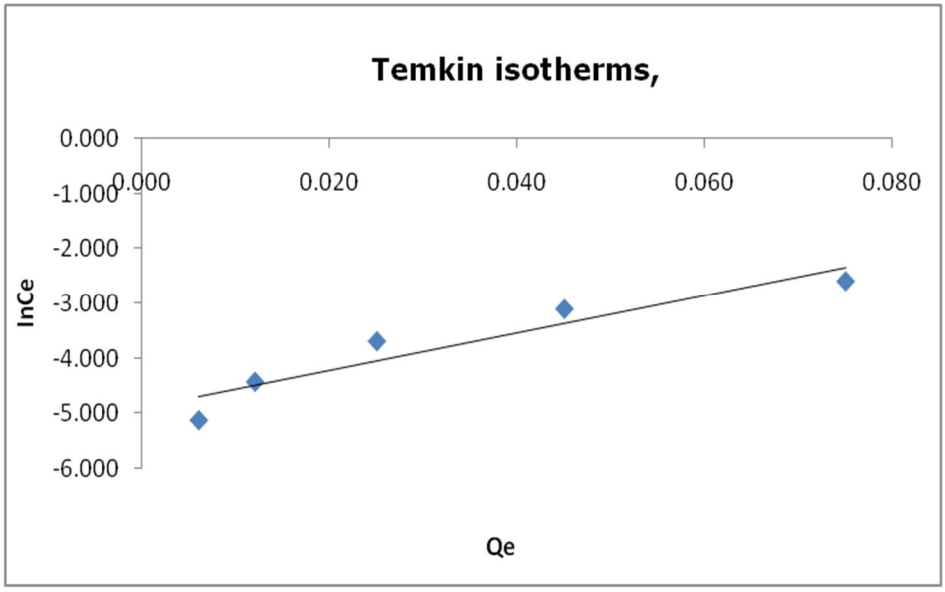


Fig:5 Temkin Adsorption isotherm

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For Temkin isotherms the value of R^2 is 0.892. The Temkin Equation is not suitable for explaining the Adsorption isotherm.

Table:1 Adsorption Parameters

Isotherm	Equation	R^2
Langmuir	y = 7.005x + 2.492	0.995
Freundlich	y = 0.788x - 1.747	0.990
Temkin	y = 34.05x - 4.893	0.892

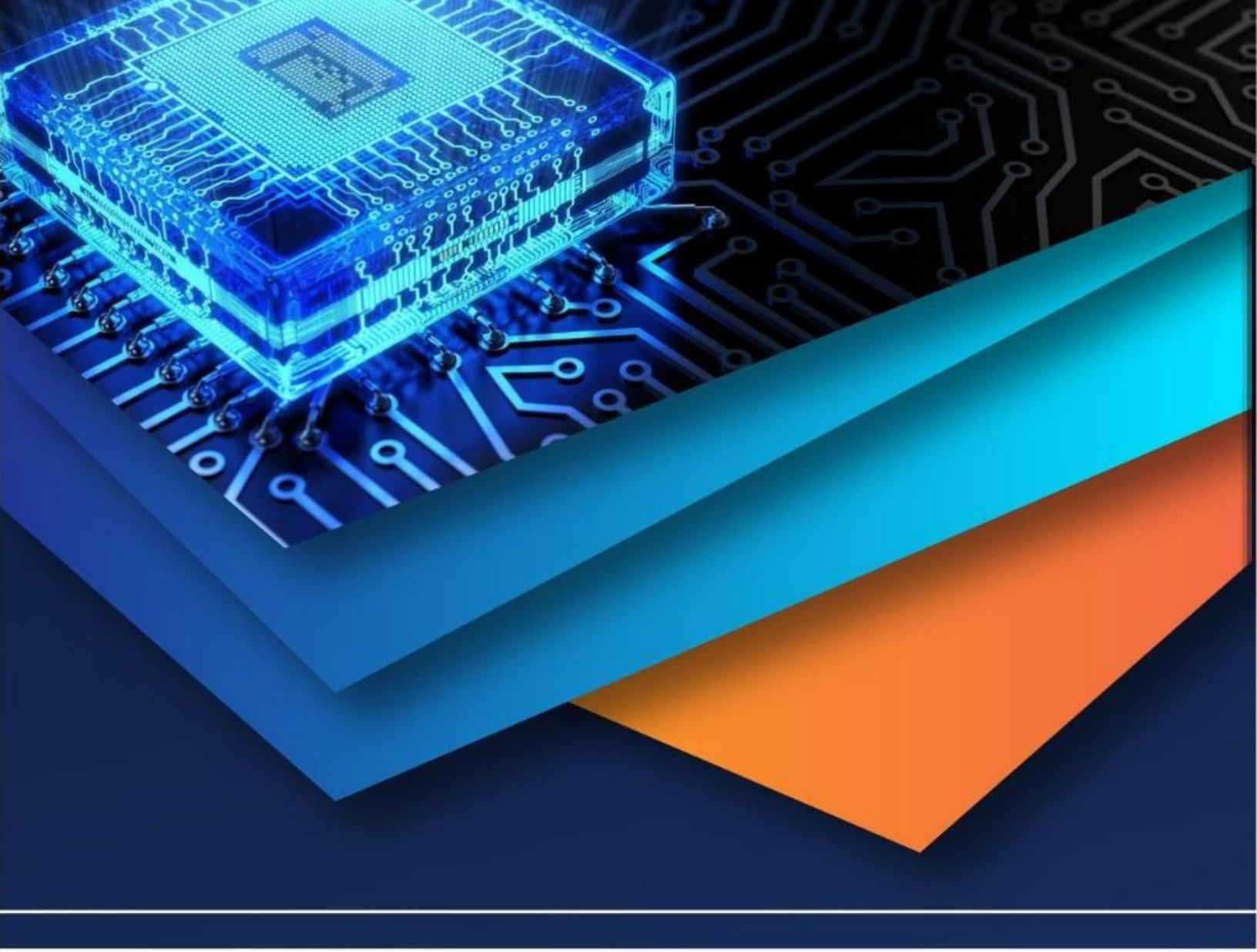
IV. CONCLUSION

In the laboratory a series of batch experiments have been performed for adsorption of phosphate in soil. The results reveals that Freundlich adsorption isotherm and Langmuir adsorption isotherm are in favor and the equilibrium data fitted best with the Langmuir isotherm than Freundlich and Temkin isotherm . The aim of this work was to study adsorption of Phosphorus in soil. This adsorption process is a function of particle size, amount of adsorbent, initial phosphate concentration of solution. The result indicate that the adsorption increases with decreasing particle size, with increasing amount of soil and initial phosphate concentration. A contact time of 60 min. was found to be optimum. The equilibrium data fitted best with the Langmuir isotherm .

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