

## Phosphate Desorption from Soil

S.MUSTAFA<sup>\*</sup>, S.Y. HUSSAIN, A.NAEEM, S.MURTAZA AND K.FARINA<sup>2</sup>

<sup>1</sup>N.C.E. in Physical Chemistry, University of Peshawar, Pakistan

<sup>2</sup>PCSIR Labs. Peshawar, Pakistan

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**Summary:** Phosphate desorption from soil as a function of pH and temperature, using electrolyte and ion exchange resin methods, has been studied. The resin method is found to be the most suitable method for the extraction of phosphate from the soil. Low pH values and high temperature was observed to enhance the phosphate desorption which is due to an increase in the solubility of calcium phosphate.

### Introduction

The study of the desorption of phosphate from soil helps in understanding the processes which occur near the root surface when plants take up phosphate from soil. A number of workers [1-6] used anion exchange resin for such studies because the resin method [2] gave better correlation with phosphate uptake by plants, presumably due to the simulation of the desorbing effect of plant roots. The present work deals with the desorption of phosphate from soil, using both the electrolyte and resin methods. Further, using the resin method, phosphate desorption from soils is studied as a function of pH, temperature and counter ion.

### Results and Discussion

The amount of available phosphate extracted by the electrolyte method is given in Table 1. It is clear from these results that the availability of the soil phosphate depends upon the nature of the electrolyte used. The amount of phosphate desorbed is greater in the presence of chlorides than in nitrates. Further, availability also depends upon the cations ( $Mg^{2+} > K^+ > Ca^{2+}$ ). The cation effect is due to the fact that the soil is calcareous in nature, where calcium phosphate is mostly expected to be formed. As such, the addition of calcium salt would decrease the calcium phosphate solubility by the common ion effect while the other cations (magnesium and potassium) would be expected to increase the solubility by lowering the activity of the phosphate and calcium ions. Nevertheless, it is possible that ions such as magnesium or potassium displace calcium effectively for the exchange site in the soil. As a result, the increased calcium concentration in the solution pushes the equilibrium further towards the postulated calcium phosphate complex. Such results have also been reported by Bell and Black [7].

Table 1: Available phosphate in the soil extracted by 0.01 M electrolyte solutions.

Electrolyte solution (0.01M)	$\mu\text{g P.g}^{-1}$ Soil
KCl	3.59
CaCl <sub>2</sub>	2.28
MgCl <sub>2</sub>	4.00
KNO <sub>3</sub>	3.06
Ca(NO <sub>3</sub> ) <sub>2</sub>	1.91
Mg(NO <sub>3</sub> ) <sub>2</sub>	3.20

The amount of phosphate desorbed by the resin method is given in Table 2. The data in table indicate that the OH<sup>-</sup> form of the resin desorbed greater amount of phosphate from the soil than the resin in the Cl<sup>-</sup> form. This effect is due to the higher capacity of the OH<sup>-</sup> form of the resin as compared to Cl<sup>-</sup> form. This kind of behaviour, as reported earlier by us [8] is the result of the predominate role of the anion-water interaction compared to the coulombic interaction between the phosphate ions and the fixed groups of the resin. The smaller ion like OH<sup>-</sup>, having high tendency of solvation, would prefer the aqueous phase. Moreover, more soil phosphate is desorbed at low pH values and at high temperatures, which is due to the increase in the solubility of calcium phosphate with decrease in pH and increase in the temperature of the system. Similar conclusions are also reported in the literature [1, 9, 10]. Further, the greater amount of phosphate desorbed at high temperature may also be due to the increase in selectivity of the resin towards the phosphate anion [11].

It is evident from Tables 1 and 2 that the resin method gives higher value than electrolyte method. Therefore, the resin method is most suitable for the extraction of phosphate from the soils. These findings show the enhancement in the selectivity of the resin toward the soil phosphate, when used in the OH<sup>-</sup> form. As such the ideas put forward by Christensen

\*To whom all correspondence should be addressed.

Table 2: Effect of temperature and pH on the desorption of phosphate from soil by ion exchange resin, Amberlite IRA-400 (Cl<sup>-</sup> and OH<sup>-</sup> form).

pH	Temperature (°C)	Resin IRA-400	
		Cl <sup>-</sup> Form µg P.g <sup>-1</sup> Soil	OH <sup>-</sup> Form µg P.g <sup>-1</sup> Soil
7	25	18.1	37.1
	50	31.5	66.2
8	25	15.8	33.7
	50	28.2	62.7

and Postner [4] regarding the unsuitability of the resin method are untenable.

## Experimental

### Soil Sample

The soil samples were collected from the fields near the Peshawar University campus from a depth of 0 - 15 cm. They were air dried, crushed to pass through 30 mesh sieve and stored in polythene bags for desorption studies. The soils were calcareous and clay loam in nature, having a pH of 7.79 in distilled water. Using the method of Chang and Jackson [12], the inorganic phosphate fractions i.e. calcium phosphate, aluminum phosphate and ferric phosphate were found to be 250, 100 and 25 µg/g, respectively.

### Phosphate Desorption by the Electrolyte Solutions

0.01M electrolyte solutions of KCl, CaCl<sub>2</sub>, MgCl<sub>2</sub>, KNO<sub>3</sub>, Ca(NO<sub>3</sub>)<sub>2</sub> and Mg(NO<sub>3</sub>)<sub>2</sub> were prepared in distilled water.

### Procedure

2.5 gm of the sample was weighed in a series of 250 mL conical flasks. Fifty mL of the electrolyte solution was added to each flask (soil: solution was added to each flask (soil: solution ratio = 1:2). Two drops of chloroform were also added to each flask to control the microbial activity. The flasks were stoppered and then shaken for 24 hours at 25°C. The mixture was centrifuged at 5000 rpm for 15 minutes. The supernatant was filtered and analyzed for phosphate by Murphy and Riley method [13].

### Phosphate Desorption by the Ion Exchange Resin Amberlite IRA-400

#### Materials

The resin, Amberlite IRA-400(20-50 mesh) was washed several times with distilled water in a burette provided with a glass wool plug. The resin

was conditioned by treating several 100 mL portions of each of 1M HCl and 1M NaOH solution. The treatment continued until the concentration of the effluent became equal to 1M. Each system was left standing for 24 hours washed with distilled water until the washings were free of Cl<sup>-</sup> and OH<sup>-</sup> ions. After air drying, each resin was stored for desorption studies.

### Procedure

Two gm of soil was taken in a 250 mL conical flask to which 4 gm of the resin (Cl<sup>-</sup> or OH<sup>-</sup> form) and 100 mL of double distilled water was added. Two drops of chloroform were also added to control the microbial activity. The pH of the mixture was adjusted to the desired value with the help of Precision pH meter type: OP-205/1, Radelkis, Budapest. The mixture was gently shaken for 24 hours at 25 °C and 50 °C in an air thermostat. It was then centrifuged at 5000 rpm for 15 minutes. The supernatant solution was filtered and the filtrate was analyzed for phosphate.

The soil residue and resin were transferred to a terylene fine mesh cloth. The soil was washed through the cloth with double distilled water. The residue (resin as sand) left was transferred to 100 mL beaker. Phosphate was leached from the resin by 10 mL portion of a solution, 1M in NaCl and 0.1M in HCl. Each portion of the solution was allowed to stand for an hour with the resin and then filtered. The leaching was continued until 100 mL of the leachate was collected. The last portion of the leaching solution and the resin were heated to 80 °C for a minute before filtration. The leachate collected was analyzed for phosphate by the methods stated earlier.

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