

PREDICTION OF PHOSPHATE LOSS FROM P-LOADED SOIL PARTICLES IN AQUEOUS SYSTEMS

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ABSTRACT

Phosphate ions of the incorporated phosphorous-fertilizer will be more or less strongly bounded on the surface of soil particles. The rate and reversibility of the sorption depend on the dose of phosphorous fertilizer and the time passed after fertilizer application.

Water erosion can carry away the fertilized upper soil layer and deposit it in rivers and lakes. Some part of sorbed phosphate ions will release into the water and causes environmental pollution and eutrophication of surface waters.

How phosphate ions will be desorbed from the soil particles - sooner or later - fertilized with phosphorous - will be discussed in this paper.

A calcareous loamy soil of pH_{H_2O} 7.9 was used in the model experiment. The soil was incubated with 0, 80 and 320 mg kg⁻¹ phosphorus than equilibrated with different rates of phosphorus. After shaking and centrifugation the solid phase was 12 times shaken with distilled water and the desorbed quantity of phosphorous was calculated.

Using the equation used for adsorption, a new model was constructed for description the one and multistep desorption. Parameters of the model help to calculate the reversible and irreversible part of sorbed phosphorous.

Higher fertilizer phosphorus dose produces higher rate of desorbable phosphorus. The model used in this work, developed with the combination of modified Freundlich equation and the mass balance equation, makes it possible the description of multistep desorption and the calculation of potentially desorbable phosphorus amount (Q). The desorbable phosphate quantity nearly increase with the sum of added fertilizer phosphate, 40% of the added P at 0 and 80 mg.kg⁻¹ at previously fertilizer application level and 55% at 320 mg.kg⁻¹ P level.

INTRODUCTION

Studies in the quasi-equilibrium state of soil solution, when the volume of this is increased, an additional amount of solute must be released from the solid phase in order to satisfy the new equilibrium condition. This is the so-called desorption whereas, ions are thought to be in the double layer when the soil is dry, and are capable of moving out to the capillary water through negative adsorption when wet (*Anas, 1988*).

So, when soil suspension is prepared with distilled water, a certain part of labile phosphorous content of the soil will go into the solvent. Since both the phosphorous content remaining in the soil (P_S) and the phosphorous content solved in water (P_L) derive from reserve of the soil (Q) thus relationship can be described with the general balance equation (*Tolner and Fuleky, 1987*):

$$Q = P_S + P_L$$

The relationship for 1 g soil and 100 cm³ water solvent can be described by the Freundlich isotherm (Tolner and Fuleky, 1995):

$$Q = k \cdot c^{1/3}$$

In the present paper, studies are to investigate how fertilizer phosphate will release from soil particles into the water during successive desorption steps, equilibrating the soil always with new water.

MATERIAL AND METHODS

The phosphorous experiment was carried out on a calcareous loamy soil of pH_{H₂O} 7.9 and 0 CaCO₃ content, from Keszthely, Hungary. The soil samples were incubated for one month with different rates of phosphorous (0, 80 and 320 mg.kg⁻¹ P) at room temperature and field water capacity.

The incubated samples with 0 and 320 mg.kg⁻¹ P were equilibrated with 0, 80 and 160 mg.kg⁻¹ P, whereas the sample which had 80 mg.kg⁻¹ P was shaken with 0, 80, 160 and 240 mg.kg⁻¹ P using KH₂PO₄ in aqueous system and 1 g soil with 10 ml solution for 24 hours.

In centrifuged solutions P was measured and the solid phase was 12 times shaken with distilled water for 24 hours and the desorbed quantity of phosphorous was calculated.

The phosphorous concentration in the solutions was measured spectrophotometrically.

MODELING

There is an assumption that the P in the solution transferred from the aqueous phase to the solid phase will be divided two parts. One part will tightly held to the surface, so difficult to release, called irreversible part (fixed form), whereas the other part will be able to release, called reversible part (sorbed form).

When we try to describe the adsorption and we add P to the solution (original P concentration). If all this P should go to the soil, it can form surface-bond P (fixed+sorbed), this is indicated by the mass balance, line Figure (1). Equilibrating the concentration decreases from **c_{original}** to **c_{equilibrium}**.

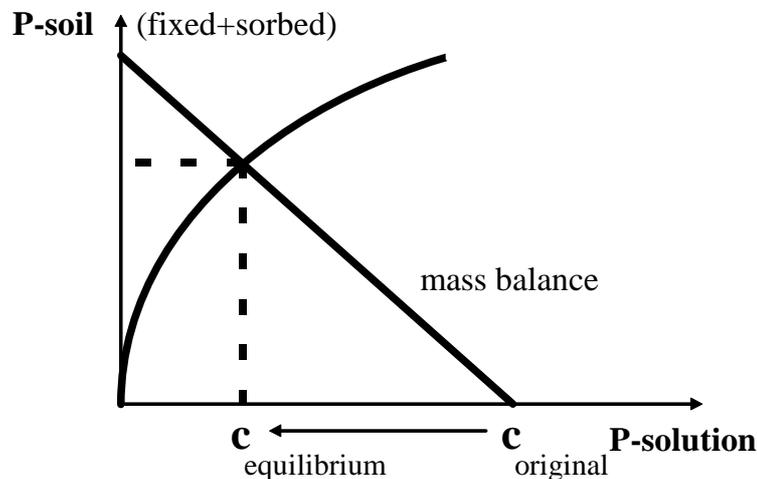


Figure Hiba! A kapcsoló argumentuma érvénytelen.. Theoretical adsorption equilibrium

On the other hand, it is worth to mention that during desorption process, we have to consider only the sorbed-P form (Q). With the assumption that all this amount is able to release into the solution, so, this relationship represented by the P-solution mass balance line Fig.(2).

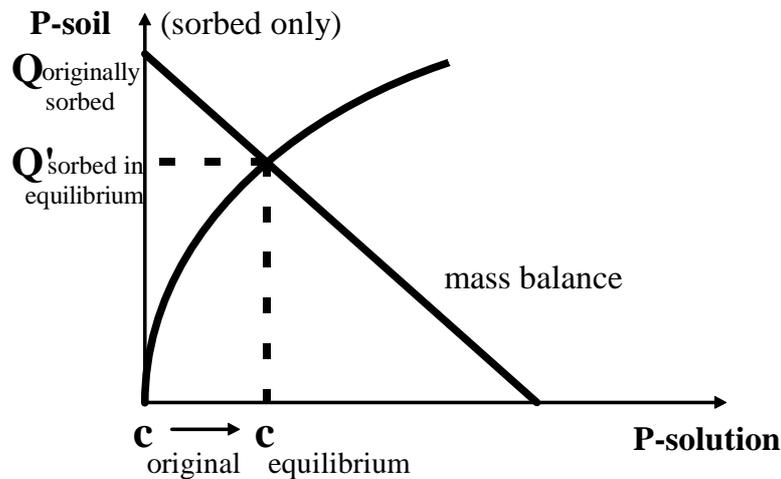


Figure Hiba! A kapcsoló argumentuma érvénytelen.. Theoretical desorption equilibrium

When adding distilled water (0 P concentration) a part of sorbed-P releases into the solution causing depletion of sorbed-P from Q_{original} to $Q'_{\text{equilibrium}}$ and arising the concentration in the solution from c_{original} to $c_{\text{equilibrium}}$.

This process could be repeated some times after each other. A series of decreasing Q and c values are the results of the succeeding equilibrium which are shown in Figure 3. The parameters could be calculated by the next consideration. After the first equilibrium step the P remaining on the solid phase Q_1 . The difference between the original amount of sorbed P (Q) and remaining sorbed P (Q_1), the volume of P solution c_1/S , where S is the soil:solution ratio and the equation will be in the form:

$$Q_1 = Q - \frac{c_1}{S}$$

The second step is carried out by adding new volume of distilled water to the solid phase, in this case Q_1 represents the original sorbed-P and decreases to Q_2 whereas the P concentration in solution arises from $c_{\text{original}}=0$ to c_2 , so the equation will be as:

$$Q_2 = Q_1 - \frac{c_2}{S} = Q - \frac{c_1 + c_2}{S}$$

by repeating the filtration and adding distilled water to the solid phase the original sorbed-P is Q_2 and decreases to Q_3 while the $c_{\text{original}}=0$ in the solution arises to c_3 , the expressed equation is :

$$Q_3 = Q - \frac{c_1 + c_2 + c_3}{S}$$

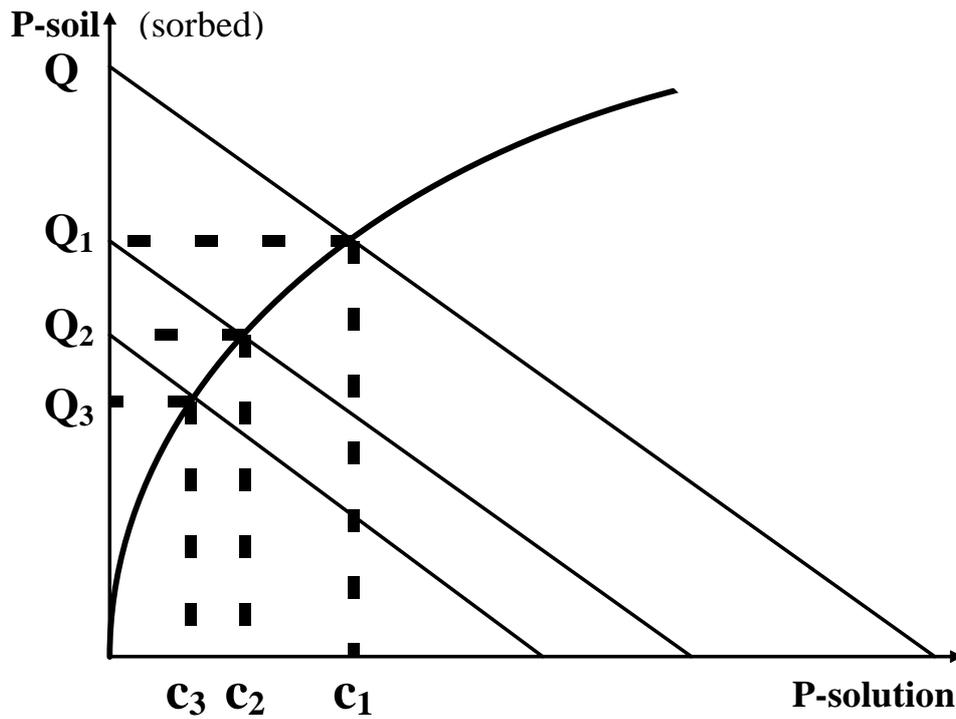


Figure Hiba! A kapcsoló argumentuma érvénytelen.. Equilibrium succeeding multistep desorptions.

Adding new and new water the multistep desorption process can be described by the general formula is:

$$Q_n = Q - \frac{\sum_{i=1}^n c_i}{S}$$

substituting the modified Freundlich equation:

$$Q_n = k \cdot c_n^{1/3}$$

Combining the two equation, we get the model which used in this presentation:

$$Q - \frac{\sum_{i=1}^n c_i}{S} = k \cdot c_n^{1/3}$$

This equation of the stepwise-desorption has two parameters **k** and **Q**, which can be calculate after measuring the P concentration in the solution.

RESULTS AND DISCUSSION

The last general equation was applied to represent the data by plotting $Q - \sum c/S$ vs c , Figure 4. It can be shown that this model gives a good fitting of desorption data of soils incubated with 0, 80 and 320 mg kg⁻¹ P.

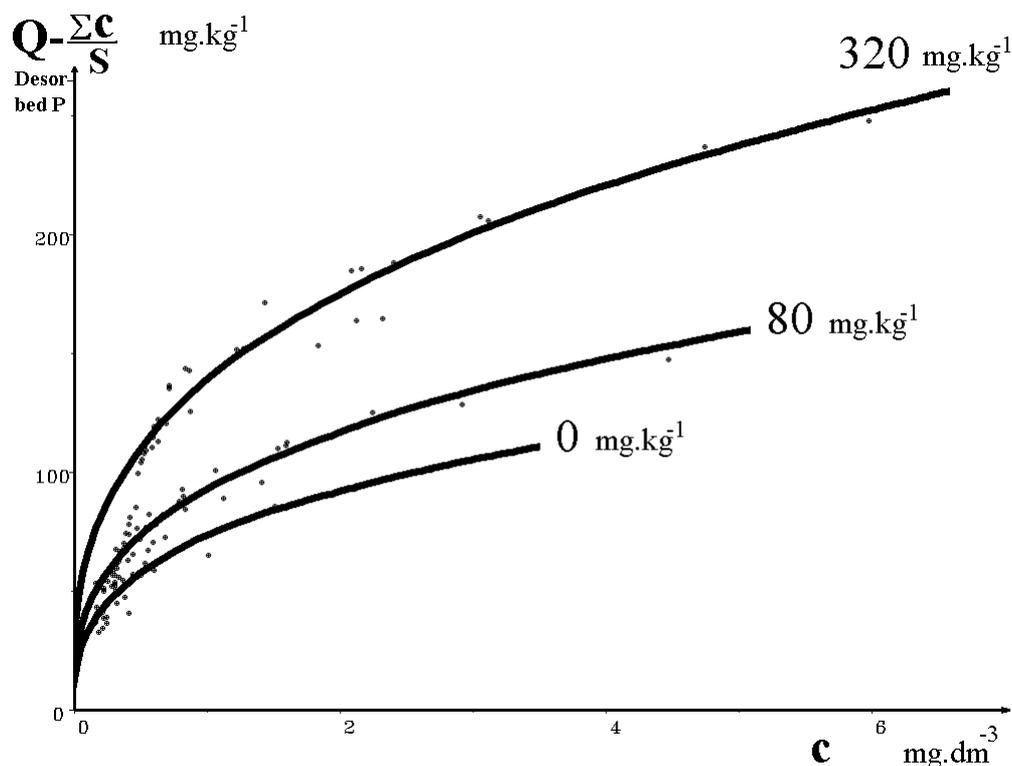


Figure Hiba! A kapcsoló argumentuma érvénytelen.. Desorbed phosphorus amount as the function of the previously added P

Phosphate desorption could be described well with the modified Freundlich equation. Higher phosphate fertilization results higher desorbable phosphate amount. These data could be calculated well by the help of the model.

For easier comparison the Q values obtained are demonstrated in Table 1. Table 1. contains 10 values of the desorbable P.

Table Hiba! A kapcsoló argumentuma érvénytelen.. Calculated desorbable phosphate quantities mg kg⁻¹

PREVIOUSLY ADDED P mg kg ⁻¹	RECENTLY ADDED PHOSPHATE mg kg ⁻¹			
	0	80	160	240
0	62	92	128	
80	98	127	158	192
320	238	284	308	

Table 2. summarizes the results as percentage of the sum of P-added, taking in consideration that the desorbable P amount (62 mg kg⁻¹) at 0 P-loading (mg kg⁻¹) as the reference point of the calculations.

Table Hiba! A kapcsoló argumentuma érvénytelen.. Desorbable phosphate amount, percent of the sum of added P

PREVIOUSLY	RECENTLY ADDED PHOSPHATE mg kg ⁻¹
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ADDED P mg kg⁻¹	0	80	160	240
0	-	38	41	
80	45	41	40	41
320	55	55	53	

The desorbable phosphate quantity nearly increase with the sum of added fertilizer phosphate, 40% of the added P at 0 and 80 mg kg⁻¹ at previous fertilizer application level and 55% at 320 mg kg⁻¹ P level.

CONCLUSIONS

Fertilizer phosphorus added to the soil could be divided two inorganic parts: fixed form and desorbable form. The rate of the two bounding depends on the soil properties, the dose of fertilizer phosphorus and time after fertilization. From point of view of environment the magnitude of potentially desorbable phosphorus is important. That is the form which can release into solution sooner or later. In this soil the maximum of desorbable phosphate was 30-60 percent of the phosphorus bounded to the soil solid phase in the model experiment. Both the phosphorus added sooner or later increased nearly the same rate the amount of desorbable phosphorus. Higher fertilizer phosphorus dose produces higher rate of desorbable phosphorus. The model used in this work, developed with the combination of modified Freundlich equation and the mass balance equation, makes it possible the description of multistep desorption and the calculation of potentially desorbable phosphorus amount (Q).

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