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Phosphorus Sorption Parameters for Vertisol and Inceptisol of India

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Abstract: **Phosphate fertilizers applied to the soils under goes transformations in soil- plant system. After phosphorus (P) application to soil, it reacts immediately with soil particles and calcium compounds, and converts to less available form by the processes of adsorption and precipitation. Phosphorus fertilizer is an expensive input and its use efficiency by crops may range from 10-25%. The soils from Barrackpore and Nagpur representing soil order Inceptisol and Vertisol were collected for the study. The P sorption isotherm was determined by equilibrating (at 30±1^{o}C) 3 g soil samples with 30 ml of 0.01 M $CaCl_2$ containing 0, 5, 10, 25, 50, 75 and 100 mg P L^{-1}. The soils were analysed for initial soil properties like pH, organic C, clay content which varied between soils. All the adsorption isotherms or models describe the quantity- intensity relationship between solution and solid phosphorus phases for a given soil. The soils from Barrackpore and Nagpur representing soil order Inceptisol and Vertisol were collected for the study.**

1. INTRODUCTION

Phosphorus is the critical element in natural and agricultural ecosystems of the world. Phosphorus availability in soil is controlled by two important mechanisms, one is fixation with soil colloids and other is precipitation of P to form sparingly soluble products [1] depending upon its concentration in soil solution. In soil, P availability is largely governed by sorption–desorption reactions. Sorption of P takes place on the surface of soil colloids. Phosphorus sorption isotherm has been used widely as it governs the supply of labile inorganic P (fertilizer P) and helps in predicting the efficiency of crops to utilize that labile P.

Phosphorus sorption model integrates two aspects one is quantity and other is intensity where the former describes the capacity of soil to supply the P to soil solution once replenished by plant roots or micro organism, lost from soil, and the later indicates the soil solution P concentration or labile P. Thus P sorption model plays an important role in controlling the P supply to crops. Adsorption isotherm equations like Langmuir have been used worldwide to characterize the P status of soils.The problem of P deficiency gets accentuated with improper P management and crops differ in phosphorus uptake in different soil. The soils from Barrackpore and Nagpur representing soil order Inceptisol and Vertisol was undertaken to investigate the phosphorus sorption characteristics for P nutrient management.

2. MATERIAL AND METHODS

2.1 Phosphorus Sorption experiment

The soil samples from Vertisol and Inceptisol were collected from field with medium P status air dried and processed through 2 mm sieve and used for laboratory analysis. The P sorption isotherm was determined by equilibrating (at 30±1^{0}C) 3 g soil samples with 30 ml of 0.01 M $CaCl_2$ containing 0, 5, 10, 25, 50, 75 and 100 mg P L^{-1}. Two drops of toluene were added to arrest microbial growth. After six days of equilibration, the suspension was centrifuged at 3500 rpm for 10 min and the solution P content in the clear supernatant solution was determined by depletion technique. The amount of P sorbed was calculated by subtracting the amount of P in the extract from amount of P initially added [2]. Phosphorus sorbed (mg kg^{-1}) versus P remaining in solution (mg L^{-1}) was plotted to determine the sorption isotherm. The sorption values of each soil were plotted according to the Langmuir isotherm.

(i) The Langmuir equation described in its linear form is as
$C/X = 1/ Kb + C/b$[3]

Where, C is equilibrium P concentration (mg L^{-1}); X (x/m) is the amount of sorbed P (mg kg^{-1});

b is the constant related to P sorption maximum (mg kg^{-1}) and K is the bonding energy (L mg^{-1}), respectively.

3. RESULTS AND DISCUSSION

The soil pH ofVertisol and Inceptisol were 7.5 and 7.9 respectively. The soils varied in texture depending upon the clay, silt and sand content and Vertisol was clayey and Inceptisol was sandy loam in texture with low to medium available soil P status.

The graphical representation of equilibrium P concentration versus rate of P adsorbed on unit mass of soil colloid were used to calculate the maximum sorption capacity of the soils and the affinity of the soil to hold P. In all the four soils the equilibrium P solution and per unit P adsorption by soil colloids increased with increasing P addition [4]. The phosphorus sorption maxima was determined by fitting the solution P concentration and adsorbed P values in Langmuir equations. The equilibrium P concentrations and P adsorbed of two soils varied among each other at different levels of P is given in table1. All the adsorption isotherms or models describe the quantity- intensity relationship between solution and solid phosphorus phases for a given soil. The phosphate adsorption isotherm gave good fit in sorption isotherm by Langmuir (r^2 = 0.98 for vertisol and r^2=0.90 for inceptisol) table 2. The graphical representation of equilibrium P solution concentration versus per unit adsorption gave linear isotherm in all the cases (Fig: 1).

The Langmuir constants like sorption maxima for Vertisol and Inceptisol was 469.57 and 183.33 µg g^{-1}, affinity constant was 0.25 and 0.26 ml μg^{-1} respectively. The high sorption was observed in Vertisol is due to high clay content of the soils increased the surface area for more P adsorption. However higher the amount of P adsorbed by the soil and its constituents less will be available for plant uptake. The maximumP buffering capacity (MBC) of soil is the characteristic property of soil changes significantly depending upon the amount added and taken up by plant roots. The maximum phosphorus buffering capacity (MPBC) (table 2) of the soils was computed by multiplying Langmuir 'b' and bonding energy constant 'k' [5].The maximum P buffering capacity of Vertisol and Inceptisolwas 119.71 and 46.96ml g^{-1} indicating high P adsorption in the former onto soil colloids and very little in soil solution for exploitation for plant roots and consequently less phosphate mobility. The variations in the buffering capacity of soils different soil orders were due to variation in clay percent and Fe and Al oxides [4]. Buffering capacity values are determined by measuring P quantity and intensity produced by cropping, i.e., the ratio between change in labile P and change in the solution P concentration [6].Vertisol with high P sorption capacity require more P application compared to inceptisol. The study revealed that P sorption maxima, buffering capacity help in planning better P management strategies for sustaining crop productivity in these soils.

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Table 1: Equilibrium P concentration and amount of P sorbed by Vertisol and Inceptisol

P doses (mg kg^{-1})	Vertisol		Inceptisol	
	Equilibrium P concentration in soil solution (µg ml^{-1})	Amount of P sorbed (µg g^{-1})	Equilibrium P concentration in soil solution (µg ml^{-1})	Amount of P sorbed (µg g^{-1})
0	0	0	0	
2	0.12	18.76	0.13	18.04
5	0.41	45.86	0.81	41.87
10	1.01	89.94	4.13	58.50
25	3.93	210.70	14.39	106.10
50	13.31	366.90	31.87	181.27

Table2: Phosphorus sorption parameters of experimental soils

	Vertisol	Inceptisol
P sorption maxima 'b' (µg g^{-1})	469.57	183.33
Affinity constant 'k'(ml µg^{-1})	0.25	0.26
Correlation coefficient (r^2)	0.98	0.90
Maximum Buffering Capacity (ml g^{-1})	119.71	46.96

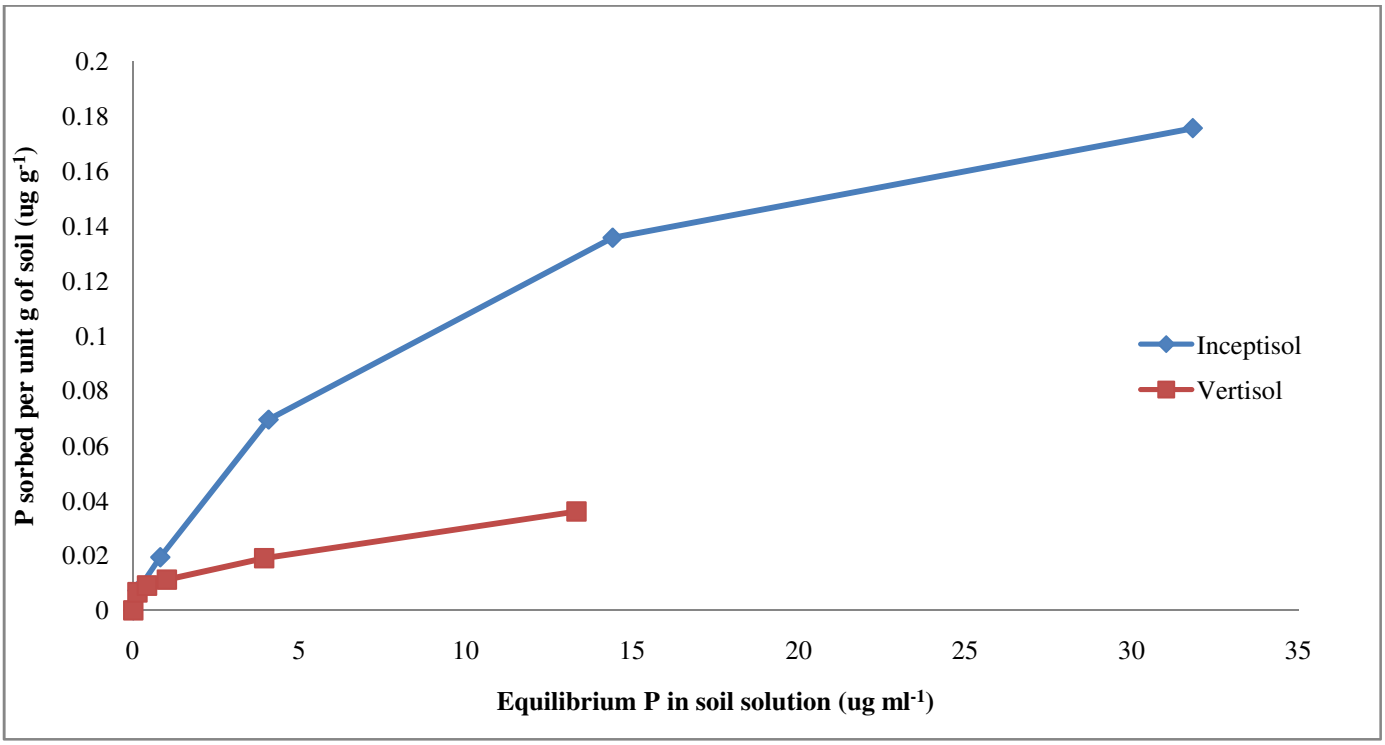

Fig. 1.: Langmuir adsorption isotherm curve for Vertisol and Inceptisol