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A Study on Relationship between Soil and P Adsorption Parameters

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A B S T R A C T

P adsorption maximum was significantly and positively correlated with pH (r = 0.85**), clay (r = 0.96**) and silt + clay (r = 0.94**), however, the binding energy showed a significant and positive correlationship with organic carbon (r = 0.68*) only. In case of Freundlich Isotherm there was no significant relationship between Freundlich adsorption parameters and soil properties except between the empirical constant 'K' and soil pH. Clay content dominated the P adsorption of these soils as indicated by its significant regression coefficient. Soil pH, organic carbon, clay, clay + silt, available P and total P together accounted for 98% of Langmuir 'b', 52% of Langmuir 'K', and 78%of Freundlich 'n' and 56% of Freundlich 'K' respectively. The values of buffering capacity for Vertisol, Alfisol and Inceptisol were 1.90, 0.86 and 0.22 and the P sorption at 0.2 ppm solution concentration was found to be 61.40, 49.27 and 30.19 for Vertisol, Alfisol and Inceptisol respectively.

Keywords

Freundlich, Correlation, P adsorption parameters.

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Introduction

It is now well establish that adsorption parameter can utilized as an index for predicting the availability of phosphorus to crops (Vig *et al.*, 1978a; Singh and Sarkar, 1985). The magnitude and rate of P sorption mainly depend upon the properties of soils and phosphate sources. Soils differ widely in their chemical and physical makeup according to geological and geographical location.

Organic matter, clay (Jalali and Sharma 1987) and hydrous oxides of Fe and Al (Tekchand and Tomar 1993) in acid soils and calcite and Ca^{2+} (Holford *et al.*, 1990) in calcareous soils, play a major role in phosphate sorption. Various other factors that affect the amount of phosphate retained by the soil through adsorption process are pH (Tekchand and Tomar, 1995), temperature and time of contact of phosphorus with the soil.

Soil pH is a critical factor in phosphate sorption P usually decreases with increases in soil pH. It has been suggested that organic matter increase the availability of P by chelating the P fixing cations and (Al^{3+}, Fe^{3+}, Ca^{2+}), exchange of adsorbed PO_4^{3-} by organic anions, protective action and decrease in pH and Eh of the soils (Stevenson, 1982; khanna *et al.*, 1984).

Addition of different P fertilizers of varying solubilities along with organic manure in soil retained higher amounts of saloid P and available P for longer period due to their reduced fixation as calcium phosphate

(Tomar. 200). The clay fraction, P dominantly containing kaolinite and accessory oxides and hydrous oxides are of Fe and Al, played an active role in P sorption. Hydrous oxide of Fe and Al has been found to occur as fine coatings on surface of clay minerals in soil, these coating characterized by large surfaces area, hold an appreciable quantity of phosphate, there by implying a secondary role of crystalline aluminosilicate in phosphate sorption (Ryden and Pratt, 1975b).

Materials and Methods

Bulk soil samples from 0-15 cm were collected four soil soil samples each from different sites belonging to three soil orders – Inceptisol, Alfisol and Vertisol were collected from the experimental farm so as to have large variation in their properties and analyzed for different soil properties by following different standard procedure.

The Inceptisols are fine, mixed, hyperthermic, udic ustochrept and shallow in depth, yellow in colour having small quantities of $CaCO_3$, and iron concretion which increases with depth. They are locally known as ‘‘Matasi’’. These soil drain much more rapidly than Vertisols and are leached to a greater extent. The Vertisols are fine montmorillonite, hyperthermic, udic chromustert, locally called as Kanhar and identified as Arang ‖ series. They are usually deep, heavy and clayey (50-55 %). Dark brown to black in colour and neutral to alkaline in reaction due to presence of lime concretions. The Alfisol are classified as fine, loamy, mixed hyperthermic, udic Rhodustalfs, udic haplustalfs. Haplustalfs is locally known as ‘‘Dorsa’’ and have line and numerous iron concretions. The soils have moderate depth and are brownish grey in colour.

The pH was measured with pH meter using 1:2.5 soil water suspensions (piper, 1967). The clear suspension extract obtained from pH was also utilized for EC measurement using conductivity bridge (Black, 1965). Organic carbon was determind by Walkley and Black’s rapid titration method as determind by Black (1965). Soil texture was determined by International Pipette Method as described by Piper (1967). Available P was determined by Olsen method using 0.5 M sodium bicarbonate (pH 8.5) as an extractant using charcoal free from soluble phosphorus was used to absorb the dispersed organic matter and make the filtrate colourless for further colorimetric analysis (Jackson, 1978). Total Phosphorus was determined by using $HClO_4$ – 60% solution as suggested by Olsen and Sommers, (1982).

Results and Discussion

The P adsorption study was conducted on three soils namely Inceptisol, Alfisol and Vertisol. The characteristics physico-chemical properties of these soils are presented in Table – 1. Table shows that there was a wide variation in the texture of these soils and the pH ranged from slightly acidic (Inceptisol) to slightly alkaline (Vertisol). Alfisol showed almost natural reaction.

The organic carbon ranged from 0.47% to 0.50 %. The P status of the soils showed marked variation owing probably to the differential P fertilization in the past.

Correlation coefficient between soil properties and adsorption parameters

The relevant simple correlation coefficient values are presented in Table – 3. Correlation of Adsorption parameters of Langmuir and Freundlich Isotherms were worked out taking all soil types together with pH, clay, silt + clay, organic carbon, available P and total P. For the Lamgmuir equation, value of ‘r’ indicated that P adsorption maxima was significantly and positively correlated with pH (r=0.85**), clay (r=0.96**) and silt + clay (r=0.94**). Similar positive correlations were also observed by Saha *et al.*, (1999) between clay and ‘b’. The binding energy a significant positive correlationship with organic carbon (r=0.68*) only. The result shows that these soil properties influenced P adsorption strongly for all three soil types. The high and significant positive correlation of silt + clay with P adsorption maxima implies that a considerable portion of silt along with clay is also active in P adsorption. Das *et al.*, (1983) also found a highly significant positive correlation of some Alfisol of Orissa with their clay content. Singh *et al.*, (1996) found that P adsorption by Alfisol was closely related with soil clay and organic matter.

Table.1 Physico-chemical properties of soils under study

Soil	Soil Texture			pH	Organic Carbon (g kg^{-1})	Olsen P (kg ha^{-1})	Total P (kg ha^{-1})
	Sand (%)	Silt (%)	Clay (%)				
Inceptisol							
A	35	26	39	6.7	0.47	38.61	1777
B	43	27	20	6.8	0.51	9.14	1237
C	45	27	28	6.5	0.53	15.32	1215
D	43	27	30	6.4	0.44	16.16	1291
Alfisol							
A	23	29	48	7.3	0.46	26.81	1411
B	27	39	42	7.2	0.50	25.50	1366
C	22	33	45	7.0	0.41	23.80	1344
D	25	34	41	7.2	0.49	23.74	1369
Vertisol							
A	15	29	56	8.1	0.51	10.96	1559
B	21	25	54	8.3	0.53	32.14	1833
C	15	29	56	8.0	0.51	11.83	1569
D	15	30	55	8.5	0.50	36.41	1852

Table.2 Correlation coefficient between soil properties and adsorption parameters

Soil properties	Langmuir		Freundlich	
	‘b’	‘k’	‘n’	‘k’
pH	0.85**	0.41	-0.38	0.75*
Organic carbon	0.96**	0.23	-0.61	0.63
Clay	0.07	0.68*	0.48	0.57
Silt+ clay	0.94**	0.15	-0.61	0.57
Available P	0.04	-0.12	-0.30	-0.02
Total P	0.50	0.14	-0.50	0.35

Table.3 Multiple regression coefficients

Isotherms	Adsorption parameters	pH	Org. carbon	clay	Clay + salt	Av. P	Tot. P	R^2
		B_0	B_1	B_2	B_3	B_4	B_5	
Langmuir	‘b’	18.11	-15.61	8.89**	-7.55	-1.01	-0.06	0.98
	‘k’	-0.19	0.01	0.00	0.41	0.00	0.00	0.52
Freundlich	**‘n’**	-1.34	0.46	-0.05	8.69	0.02	0.00	0.78
	‘k’	0.74	10.30	-0.08	50.64	0.03	-0.01	0.56

Multiple regression coefficients

Multiple regression analysis(Table 3) was carried out to assess the combined effect of soil pH, organic carbon, clay + silt, available P and total P to different adsorption parameters of both Langmuir and Freundlich Adsorption Isotherms. The regression analysis indicated for 98% of 'n' and 56% of the Freundlich 'K'. However, the regression coefficient for clay was only found to be highly significant indicating that the clay content dominated the P adsorption of these soils, Jalali and Sharma (1987) also found 80.5% variation in P adsorption due to clay and organic matter out of which 73% was due to clay content. pH may decrease or increase or have no effect on P sorption depending upon the experimental conditions (Tomar, 2000).Positive and significant correlation between P adsorption and clay content have been reported by several workers Teckchand and Tomar, 1992, Murthy *et al.,* 1996; William *et al.,* 1958, Udo and Uzo, 1972 and Khalid *et al.,* 1977.

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