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THE REACTIONS AND MECHANISMS OF INORGANIC  
PHOSPHATE SORPTION BY SOILS

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John Christopher Ryden

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### Abstract

A review of the literature relating to the reactions and mechanisms involved in the sorption of inorganic phosphate (P) by soils and soil components suggested several topics for further research, the results and interpretations of which are presented in this thesis. Soils which contrasted in components and properties considered to be important in P sorption sorbed between 210 and 3350  $\mu\text{g P/g}$  during 40 hr from 0.1M NaCl at a final P concentration of 10  $\mu\text{g P/ml}$ . Contrasting soils provided a more reliable basis for the interpretation of data obtained in investigations of the reactions and mechanisms of P sorption by soils. Sorption of P was described by four first-order reactions for each soil. The rate constant for a particular reaction was also similar for each soil, implying that the same series of reactions were involved in P sorption. The decrease in extractability and isotopic exchangeability of sorbed P with increasing time, following P addition, coupled with increased recovery of P by citrate-dithionite-bicarbonate extraction indicated that adsorption was followed by absorption. Elimination of the differences between the amounts of P sorbed from various support media during 40 hr, when an estimate of the equilibrium condition was made, pointed to the implications of time-dependent sorption in the interpretation of P sorption data. Virtually complete replaceability by K of Ca removed from solution in response to P sorption was obtained. Retention of Ca to balance the increased negative charge arising from P sorption, and not the precipitation of a calcium phosphate, is indicated. Time-dependent sorption affected significantly the interpretation of P sorption data using the Langmuir equation. For equilibrium data, the P sorption isotherm for each soil was described by three distinct Langmuir equations, each corresponding to a particular P concentration range or region ( 0 to 0.02, 0.08 to 0.80, and 1.0 to  $> 20 \mu\text{g P/ml}$  ). The sorption energy constant of a Langmuir equation corresponding to a particular region was very similar for each soil and suggested similar sorption mechanisms for each soil. Charge and pH relationships of P sorption by two soils and Fe gel demonstrated that three distinct P sorption mechanisms caused the deviation of P sorption data from a single Langmuir equation. The same mechanisms

were involved in P sorption by soils and Fe gel. Data suggested that the mechanisms involved the ligand exchange reactions  $-\text{OH}_2^+$ ;  $\text{H}_2\text{PO}_4^-$ ,  $-\text{OH}$ ;  $\text{H}_2\text{PO}_4^{--}$ , and  $-\text{OH}$ ;  $\text{HPO}_4^{2-}$  at the hydrous-oxide surface. These mechanisms are in accord with the three Langmuir sorption energy constants obtained for each soil. The reactions and mechanisms of P sorption established have important implications to the plant availability of soil and fertilizer P, and provide a basis for the interpretation of other P sorption data.

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