Retention and Release of Phosphite and Phosphate in Synthetic Soil Minerals

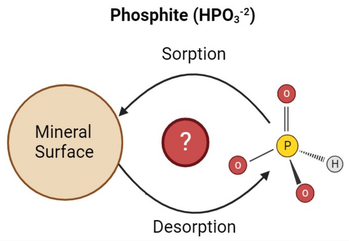
Zenteno, Adrian[1], Doydora, Sarah[2], Duckworth, Owen[2]
NCSU Symposium
[1]California State University Long Beach, CA, [2]North Carolina State University, NC

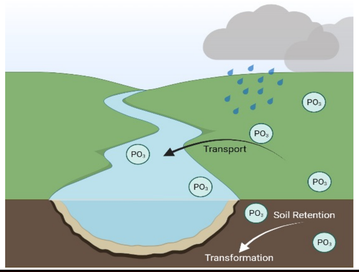
NC STATE UNIVERSITY

Introduction

Phosphorus (P) fertilizers added in the form of phosphate (+5 oxidation state) are often inefficient due to the strong phosphate retention in soil. Phosphite, a reduced form of phosphorus (+3 oxidation state), may be used as an alternative P fertilizer. However, currently there is limited work evaluating phosphite retention and release relative to phosphate in the presence of different soil minerals.

Objective: To evaluate how much of phosphite is adsorbed and desorbed by soil minerals relative to phosphate.

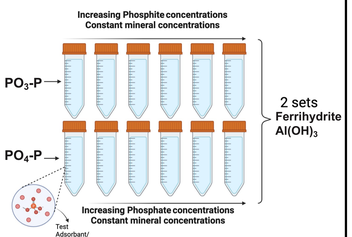




Methods

- Adsorption and desorption isotherm experiments were performed on ferrihydrite and aluminum hydroxide.

- Phosphite and phosphate were reacted to each mineral in a series of increasing concentrations.



- After reacting for 20 hours, samples were centrifuged. The supernatants were filtered and analyzed for total P.

- Desorption experiments were performed on residual adsorbed phosphite and phosphate samples successively in 1, 2, 4, 6, 12, and 24-hour time intervals.

- After each time interval, the samples were processed and analyzed as before.

Results

Fig. 1a) Ferrihydrite

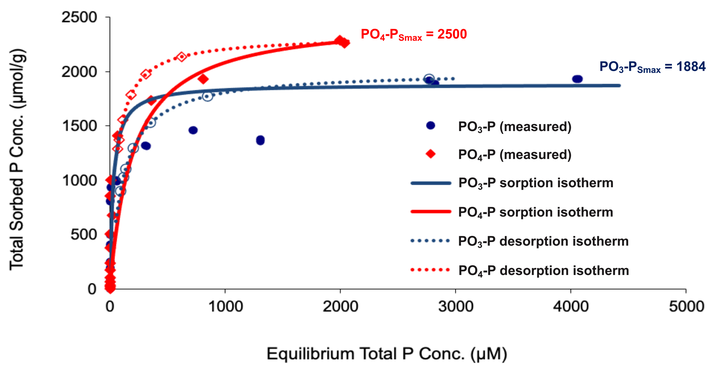


Fig 1b) Poorly crystalline aluminum hydroxide

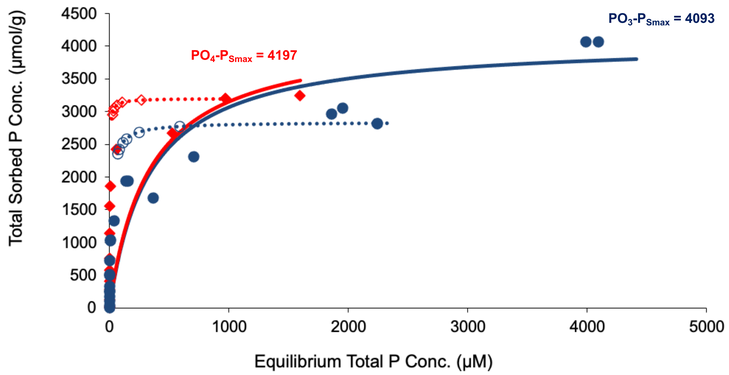
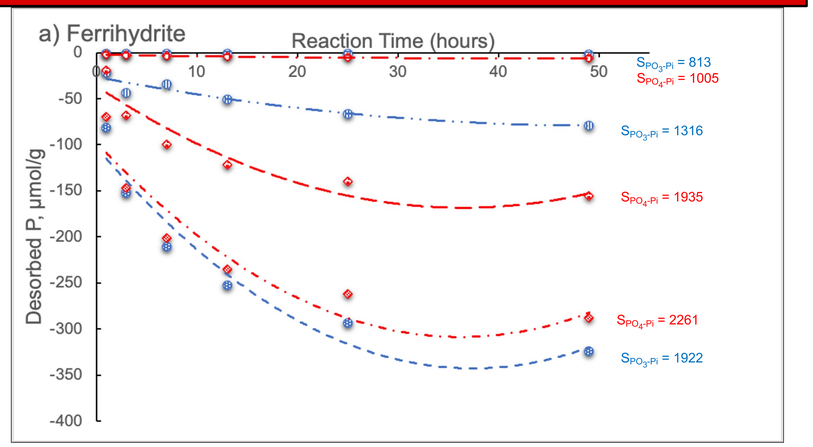


Figure 1. Sorption-desorption isotherm for phosphite (PO_3-P) and phosphate (PO_4-P) measured as total P on a) ferrihydrite and b) poorly crystalline aluminum hydroxide at pH 6 in 0.01 M NaCl background. Isotherms were fitted to Langmuir model $S = \frac{S_{\max} * KC}{1+KC}$, where *S* is the sorbed P concentration, *Smax* is the predicted maximum P sorption capacity, *K* is the Langmuir coefficient and *C* is the solution equilibrium P concentration.



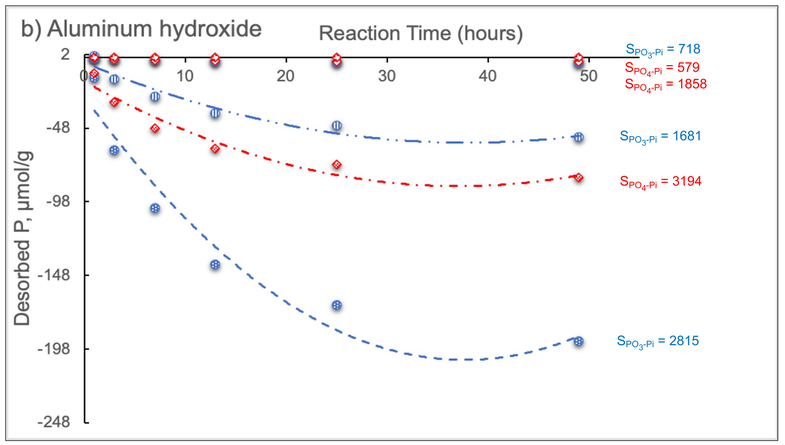


Figure 2. Cumulative concentrations of desorbed phosphite (PO_3-P) and phosphate (PO_4-P) from a) ferrihydrite and b) poorly crystalline aluminum hydroxide over 49 hours of cumulative reaction time from different initial sorbed phosphite ($S_{PO_3\text{-}Pi}$) or phosphate ($S_{PO_4\text{-}Pi}$) concentrations. (Note: Polynomial fittings are only meant to highlight the trends and are not mechanistic desorption models.)

Discussion

- Maximum phosphite sorption is 25% lower in predicted magnitude relative to phosphate on ferrihydrite, but is similar to phosphate on poorly crystalline aluminum hydroxide.

- Phosphite desorbed up to 1.3 and 2.7 times more than phosphate from ferrihydrite and poorly crystalline aluminum hydroxide surfaces, respectively.

Directions for Future Research

- More research should be conducted to understand the chemical transformation of phosphite on the surface of various soil minerals.

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Science and Technologies for Phosphorus Sustainability

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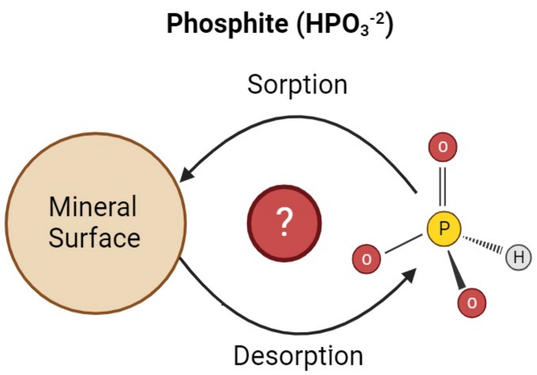

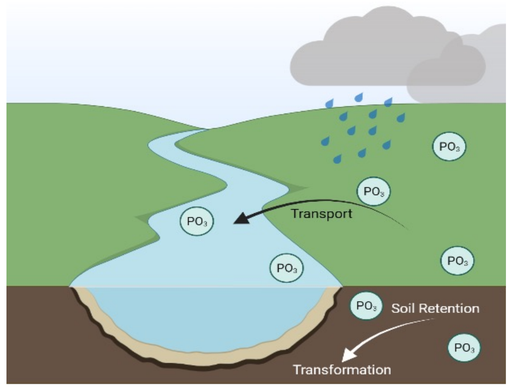

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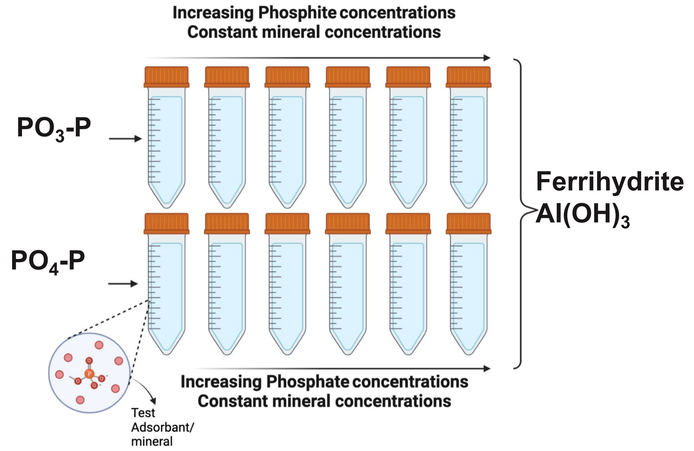

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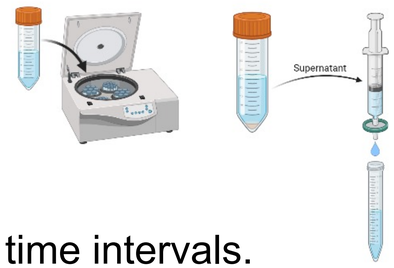

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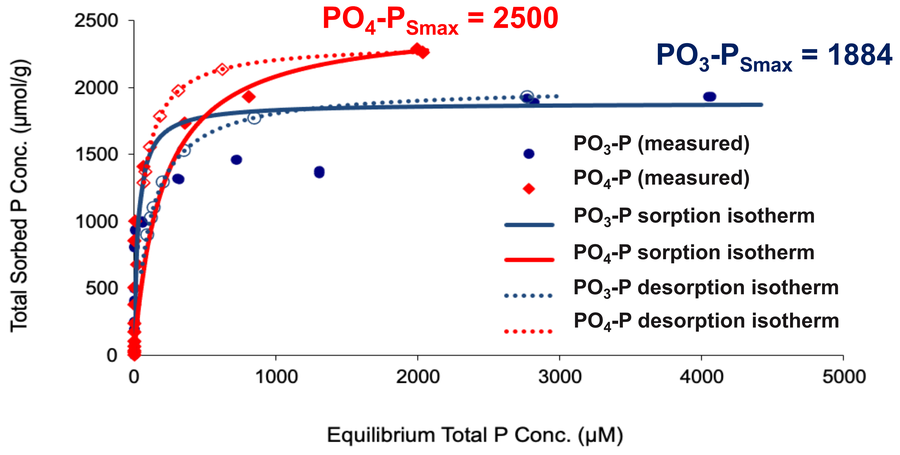

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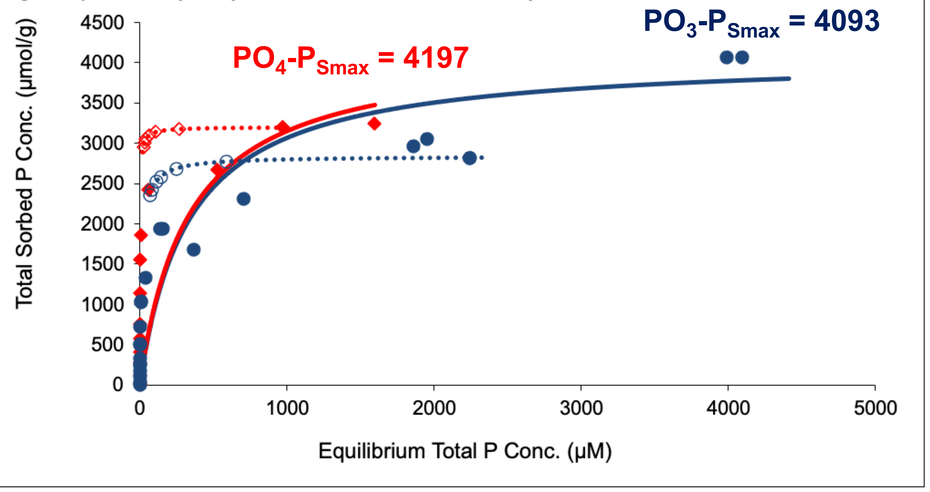

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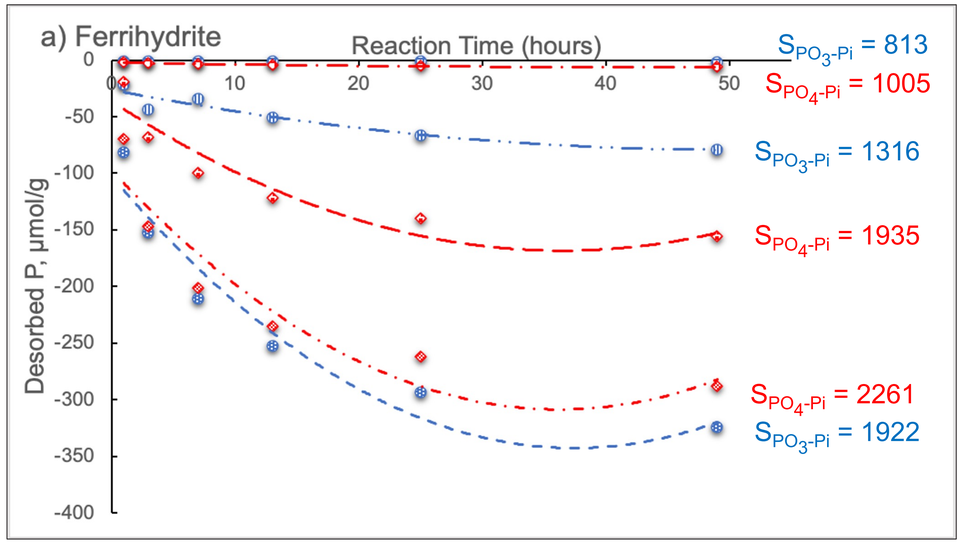

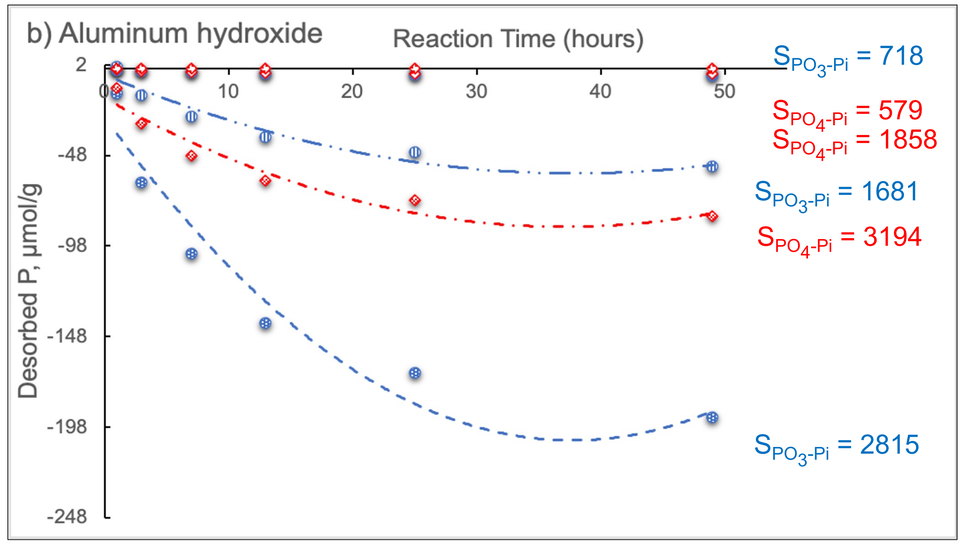

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