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Phosphorus Sorption to Tropical Soils with Relevance to Earth System Model Needs

Melanie Mayes[1*], Wesley Porter[1,2], Julia Brenner[1], Jana Phillips[1], Joanne Childs[1], Xiaojuan Yang[1], Rich Norby[1], and Erika Marín-Spiotta[3]

[1]Environmental Sciences Division and Climate Change Science Institute, Oak Ridge National Laboratory, Oak Ridge, TN;
[2]Department of Geosciences, Middle Tennessee State University, Murfreesboro, TN
[3]Department of Geography, University of Madison-Wisconsin, Madison, WI

Contact: mayesma@ornl.gov

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Many tropical soils are considered phosphorus (P) limited, so the extent to which tropical forests can meet future carbon sink demands is critically influenced by P availability. Mineral soils exert a key control over P availability by forming strong chemical bonds with the orthophosphate (PO_4^{3-}) molecule. Here, we used an existing archive of 24 tropical soils and performed equilibrium batch isotherm experiments involving 0.3 g of soil and 0.03 L of solution in concentrations ranging from 0 to 500 mg PO4-P per L. The prioritization of sorption to higher energy sites before lower energy sites resulted in a nonlinear isotherm that was represented by fitting the data to the Langmuir isotherm. Langmuir parameters consist of Q_{max} which represents the maximum sorption capacity of the soil, and K which represents a binding coefficient. Our Q_{max} values ranged from 734 to 3775 mg $PO4^{-}$P per kg of soil (mg/kg) with a median of 2060 mg/kg. We found significant correlations between Q_{max} values and clay content, total P, and iron and aluminum oxide content. The Langmuir K parameter ranged from 0.015 to 0.285 L/mg with a median of 0.081 L/mg. We did not find correlations between Q_{max} or K with soil order, which likely reflects the small size of our database. In comparing our data with the 12 available literature values for Langmuir parameters, we found that Q_{max} values seemed highly influenced by the initial P concentrations, suggesting that some authors did not add sufficient P to reach the plateau sorption values represented by the Q_{max} parameter. We also identified fitting of the nonlinear equation using linearized equations, which is known to impart significant errors. Thus, we have significant concern about the available sorption data to parameterize Earth system models. Further experiments with soils from Puerto Rico are expanding our database of knowledge to enable more thoroughly-vetted parameters for use in Earth system models.