Reviewer #1 (Dr. Eric Roy)

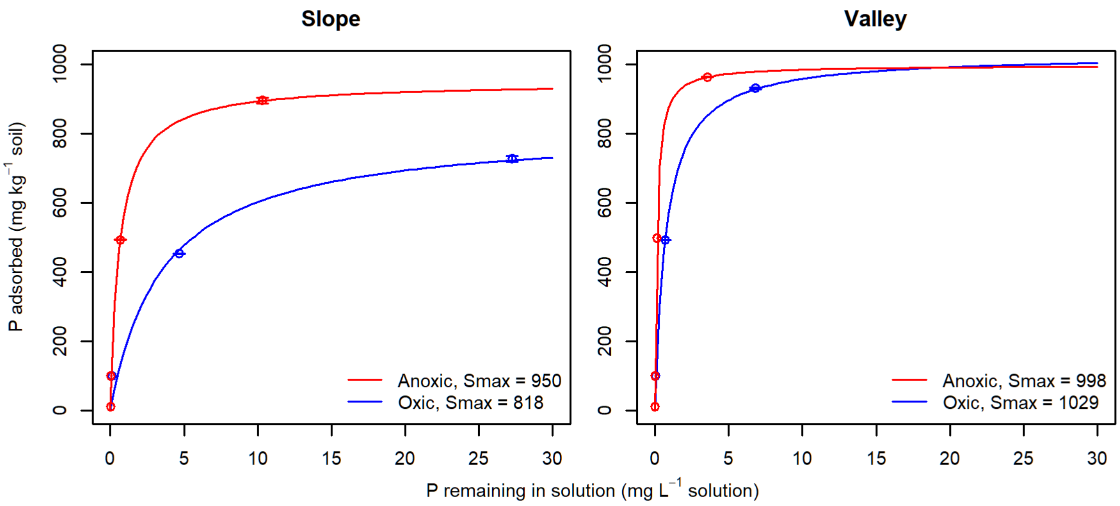
General comments: This manuscript by Lin et al. examines the influence of anoxic conditions on phosphorus sorption in highly weathered, acidic soils in humid tropical forests. It is well known that phosphorus solubility and bioavailability in soils and sediments can be impacted by fluctuations in redox conditions that lead to iron reduction and pH changes. However, to my knowledge (and based on the literature reviewed by Lin et al.), this topic has not been well studied in tropical forest soils (or tropical soils used for agriculture) that are rich in Fe- and Al-minerals and characterized by large P sorption capacity. Therefore, this is a welcome study and the authors have done a nice job generating results that increase understanding of this topic. They perform their experiments using humid tropical forest soils (0-15 cm depth) from two sites in Puerto Rico featuring different parent materials and soil characteristics. Tests include P sorption isotherms, P sorption time curves, soil Fe and Al analyses and P fractions, and a P solubility experiment. The methods used are appropriate for the study questions. I support the publication of this manuscript in Biogeosciences once my comments below have been taken into account.

> ***We appreciate Dr. Roy's interest in our work.***

Specific comments: 1) Re: the choice of P concentrations for the sorption isotherm experiments: a. Can the authors provide more justification for their decision to omit the lower concentrations (i.e., 10 and 100 mg P kg-1 soil)? Typically, sorption isotherm experiments have included a 0 mg P kg-1 soil treatment, as well as lower concentrations where most P is sorbed (e.g., Graetz and Nair 2000). Would including these results influence the Langmuir models in this study?

> ***We did not include a P-blank treatment because there was no detectable water-extractable P (or anion exchange resin P, which is higher in concentration) in these soils (McGroddy and Silver 2000 Biotropica). Please see the next section for our response to the comment that our P sorption experiments did not include low P concentration.***

b. The range of concentrations used (500 – 10,000 mg P kg-1 soil) is very high. It should be noted that estimates for Smax can be dependent on the concentrations used in the P sorption isotherm experiment, particularly when testing a material with high P sorption capacity. For example, Drizo et al. (2002) found that the Smax for a steel slag material tested for use in constructed wetlands varied from 0.31 to 3.93 g P kg-1 material depending on the range of P concentrations used. Here, the authors report maximum P sorption capacities ranging from 2526 ± 667 mg P kg-1 to 8256 ± 2517 mg P kg-1 soil. These are high compared to other studies of P-fixing soils that used lower, more conventional ranges in P concentrations (e.g., Brazilian forest soils tested in Roy et al. 2017 using the range of 0 - 1,500 mg P kg-1 soil exhibited Smax up to 1167 mg P kg-1 soil). I think the authors should provide some discussion of whether their Smax results are method-dependent, and how their results compare to other studies, including those that used more conventional, lower ranges of P concentrations. This discussion can add nuance to their conclusion that Smax was "at least one of magnitude above total soil P concentrations."



As mentioned in the manuscript, our preliminary trials included low P concentrations (10, 100, 500, and 1000 mg P kg^{-1}). As shown in the figure above, the two Icacos soils showed P sorption capacity (Smax) extremely close to or higher than the maximum P addition (1000 mg P kg^{-1}). Furthermore, average P concentrations in solution were 0.01 and 0.04 mg P L^{-1} in samples receiving 10 and 50 mg P kg^{-1}, respectively. Many samples showed no detectable P in solution. Thus, we needed to use higher P concentrations to discern actual sorption potentials. We included the above justification in the methods (Page 4 Line 15-20) and added the figure to the supplement (Figure S1).

We agree with Dr. Roy that concentrations of P would influence the estimation of sorption capacity. We have added the following text in the discussion: "Our estimates of S_{max} were relatively high relative to other humid tropical soils. For example, de Campos et al. (2016) applied up to 8000 mg P kg^{-1} to a set of strongly weathered Brazilian forest soils and reported a wide range of S_{max} (61-5460 mg P kg^{-1}). Compared to our preliminary trials with maximum P addition of 1000 mg P kg^{-1} (Fig. S1), S_{max} were higher when more P was added (5000 and 1,0000 mg P kg^{-1}; Table 2), suggesting that S_{max} can be influenced by the concentrations of P used in the experiment. However, even when the maximum P addition level was similar (up to 1500 mg P kg^{-1} soil), S_{max} from the preliminary trials were also high compared to other strongly weathered soils, including Brazilian forest soils (295-1167 mg P kg^{-1}, Roy et al., 2017) and Thai upland soils (47-1250 mg P kg^{-1}, Wisawapipat et al., 2009).".

2) The authors state that "sorption isotherms of all soils followed Langmuir functions", however, no model fit diagnostics appear in the manuscript. Can the authors please provide quantitative evidence to justify this statement? The standard errors for Smax presented seem somewhat high to me and it would be helpful to know how well the Langmuir model fit the data. Model efficiency is one option (Bolster and Hornberger 2007).

We adopted the Bolster and Hornberger's method as recommended by the reviewer and updated the estimates of Smax and standard errors. Model efficiency ranged between 0.781 to 0.967, indicative of good model fit (Page 7 Line 23-24). Results of model efficiency were included in the supplement (Table S1).

3) Page 6, Line 20 – Can the authors please explain here how they determined that vivianite precipitation was occurring? There is some discussion on subsequent pages that I suggest be moved to the first mention of vivianite precipitation. Furthermore, the calculations made using Visual MINTEQ should be described somewhere in the Methods.

> ***We suspected that vivianite precipitation would contribute to P sorption in anoxic treatments, as the concentrations of P and Fe(II) were high in these samples. We moved some of the discussion from later pages to the results where we first mentioned vivianite precipitation. We also added information on the Visual MINTEQ modeling to the methods (Page 6 Line 13-22).***

4) Page 8, Line 10 – The evidence that soils experienced reducing conditions mentioned here should probably come earlier in the paper given its importance for all results presented.

> ***We agreed with this comment and reorganized the results to emphasize the effects of redox treatments (Page 7, Lines 5-21).***

References Bolster, C. H., & Hornberger, G. M. (2007). On the use of linearized Langmuir equations. Soil Science Society of America Journal, 71(6), 1796-1806. Drizo, A., Comeau, Y., Forget, C., & Chapuis, R. P. (2002). Phosphorus saturation potential: a parameter for estimating the longevity of constructed wetland systems. Environmental science & technology, 36(21), 4642-4648. Graetz, D. A., & Nair, V. D. (2000). Phosphorus sorption isotherm determination. In Methods of phosphorus analysis for soils, sediments, residuals, and waters (Vol. 369, pp. 35-38). North Carolina State University Raleigh. Roy, E. D., Willig, E., Richards, P. D., Martinelli, L. A., Vazquez, F. F., Pegorini, L., ... & Porder, S. (2017). Soil phosphorus sorption capacity after three decades of intensive fertilization in Mato Grosso, Brazil. Agriculture, ecosystems & environment, 249, 206- 214.