Supplement of Biogeosciences, 17, 89–101, 2020
https://doi.org/10.5194/bg-17-89-2020-supplement

Biogeosciences Open Access EGU

Supplement of

Anoxic conditions maintained high phosphorus sorption in humid tropical forest soils

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Supplementary Material

Table S1. Model efficiency (E) and P concentration in solution (mg P L^{-1}) of the P sorption isotherms.

Site	Position	Treatment	E	P concentration in solution (mg P L^{-1})			
				500 mg P kg^{-1}	1000 mg P kg^{-1}	5000 mg P kg^{-1}	10,000 mg P kg^{-1}
El	Slope	Anoxic	0.945	5.5±1.1a	26.4±1.2a	249.5±4.2a	571.3±8a
Verde		Oxic	0.967	11.2±0.9b	34.9±1.8b	278.8±4.6b	649.2±7.1b
	Valley	Anoxic	0.966	6.5±1.1b	17.7±1.2b	175.3±9.4a	497.4±22.5a
		Oxic	0.919	0.08±0.04a	7.8±1.4a	209.7±2.7b	541.1±13.2a
Rio	Slope	Anoxic	0.901	2.2±0.3a	13.4±1.6a	264.7±5.3a	610.5±4.3a
Icacos		Oxic	0.781	3.9±0.1b	23.1±0.3b	344.6±11.3b	723.7±7.8b
	Valley	Anoxic	0.866	1.2±0.1a	6.1±0.8a	215.9±4.8a	494.8±35a
		Oxic	0.838	0.8±0.1a	9.2±0.9b	244.4±11.7a	645.9±41.5b

Different letters indicate significant differences between two redox treatments at $\alpha = 0.05$.

Table S2. Phosphorus sorption index (PSI, L kg^{-1} soil) calculated at four levels of P addition levels (n = 4).

Site	Position	Treatment	E	PSI, L kg^{-1} soil			
				500 mg P kg^{-1}	1000 mg P kg^{-1}	5000 mg P kg^{-1}	10,000 mg P kg^{-1}
El	Slope	Anoxic	0.945	616±70a	505±14a	1018±19a	1513±31a
Verde		Oxic	0.967	363±18b	405±14b	877±29b	1236±27b
	Valley	Anoxic	0.966	637±86a	740±28b	1622±62a	2079±109a
		Oxic	0.919	-385±152b	1229±147a	1408±16b	1893±62a
Rio	Slope	Anoxic	0.901	1552±267a	785±59a	972±25a	1398±17a
Icacos		Oxic	0.781	783±21b	565±5b	614±48b	967±29b
	Valley	Anoxic	0.866	12143±4275a	1257±150a	1218±26a	1883±157a
		Oxic	0.838	-1635±2527b	954±53a	1073±59a	1266±157b

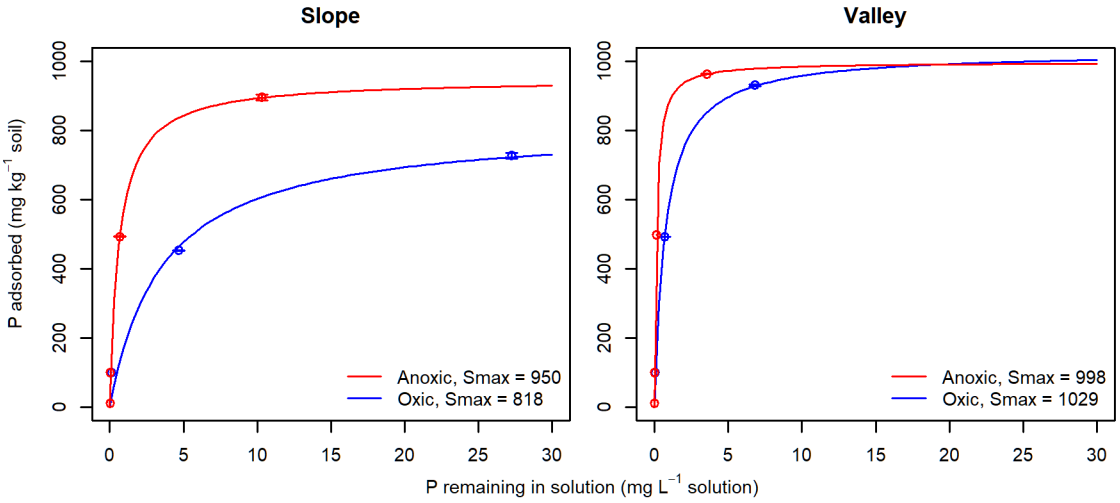
Different letters indicate significant differences between two redox treatments at $\alpha = 0.05$.

Table S2. Saturation index of vivianite calculated by Visual MINTEQ using soluble Fe(II), inorganic P, and solution pH as input. Results from slope soils from El Verde under anoxic conditions are shown. Bold values indicate oversaturation.

P loading rate (mg P kg^{-1} soil)	500	1000	5000	10,000
Average HCl-Fe(II) (mg g^{-1} soil)	3.4	3.4	3.4	3.4
Estimated water-soluble Fe(II) (mg L^{-1})[a]	34	34	34	34
Average P in solution (mg P L^{-1})	5.5	26.4	249.5	571.3
Soil pH[b]	5.9	5.9	5.9	5.9
Saturation index[c]	**3.5**	**4.8**	**5.9**	**5.9**

[a] Peretyazhko and Sposito (2005) found that ~10% of the HCl-Fe(II) was soluble in H_2O in a similar soil after anaerobic incubation, which is consistent with Fe(II) sorption reported by Wilmoth et al. (2018); the soil:water ratio was 1:10 (mass:volume).

[b] estimated based on similar soils (Lin et al. unpublished)



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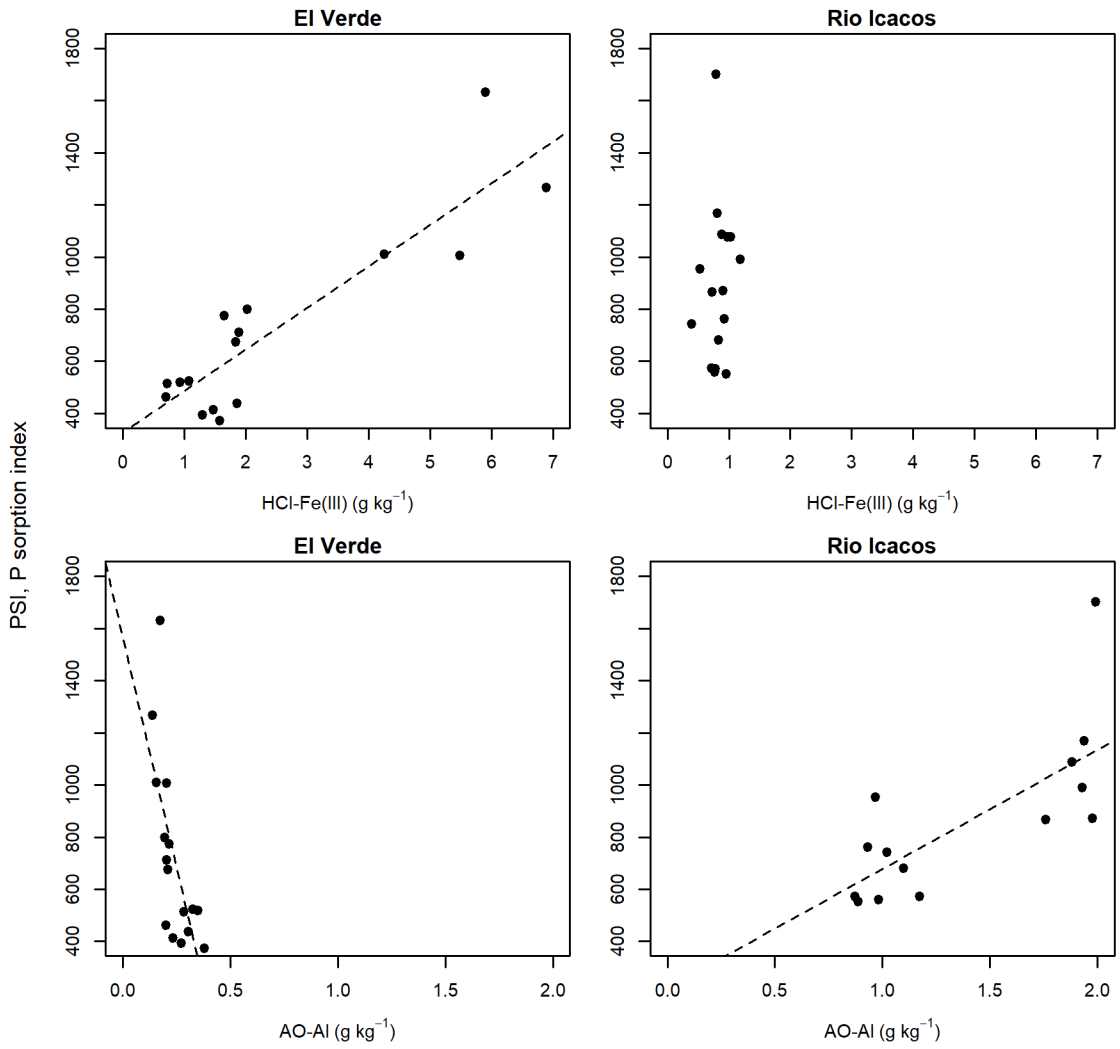
17 Figure S1. Preliminary results showing the effects of anoxic vs. oxic pre-incubation on the P sorption

18 isotherms of slope (left panel) and valley (right panel) soils from Rio Icacos. Levels of P addition

19 included 10, 100, 500, and 1000 mg P kg^{-1}. Means and standard errors of means are shown. Smax,

20 maximum P sorption capacity of the Langmuir equation.



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22 Figure S2. Correlations between phosphorus sorption index (PSI) and soil HCl-extractable

23 Fe(III) (HCl-Fe(III)) and ammonium oxalate-extractable Al (AO-Al) concentrations at El Verde

24 and Rio Icacos. Dash lines indicate significant correlations.

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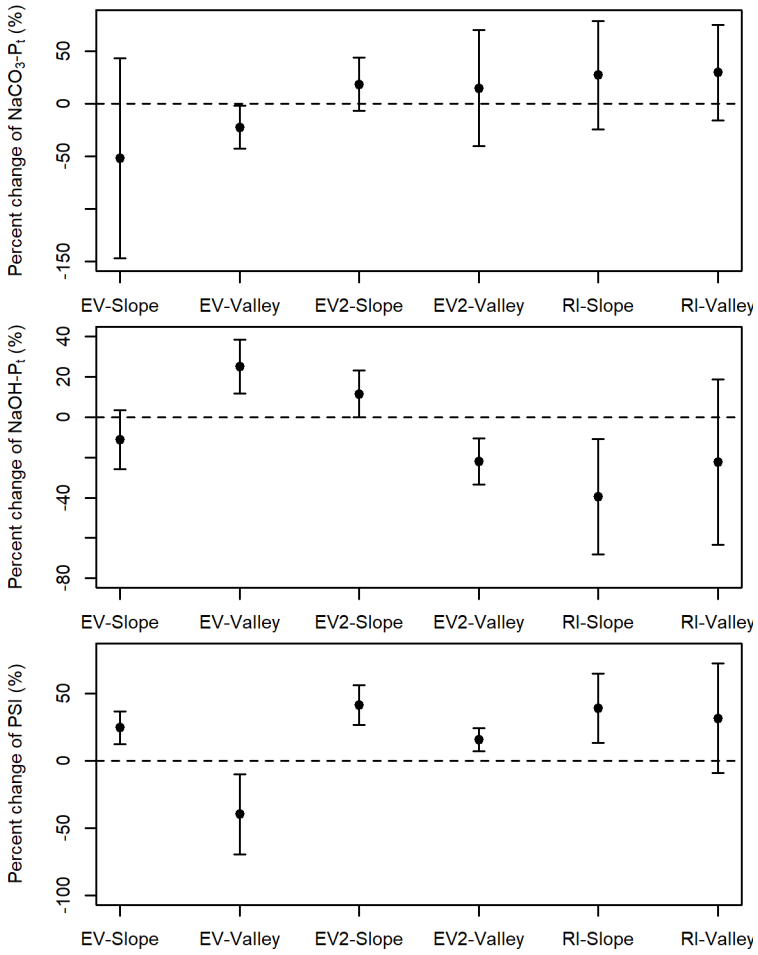

Figure S3. Percent changes of soil $NaHCO_3$-extractable total P ($NaHCO_3$-P_t) concentration, NaOH-extractable total P (NaOH-P_t) concentration, and phosphorus sorption index (PSI) in response to anoxic conditions. Error bars indicate 95% confidence interval. EV-2 refers to the 2nd sampling of El Verde soils for measuring the solubility of sorbed P.