Phosphorus Release from Biochar of Various Feedstocks: Implications for Land Management

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Introduction

- Land-application of biochar, a product of biomass heating, has recently been promoted as a sustainable agricultural practice that improves soil health and crop yield
- Phosphorus (P) desorption is an important biochar property as it is one of the macronutrients for plants and one of the main causes of eutrophication
- The diversity in biochar feedstock may result in varying P releases for plant uptake and potential P loss from soils when over-applied.

Hypotheses and Objectives

Hypotheses:

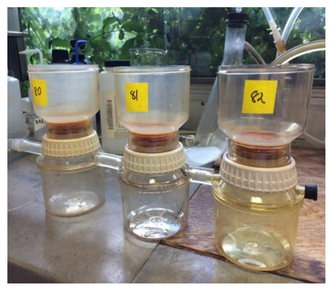
i. Animal-based biochar would release more P than a plant-based one when land-applied at the same rate
ii. The same rate of application from a given feedstock would result in available P that depends on soil P retention properties.

Objectives were to evaluate:

i. P associations in an animal-based and a plant-based biochar
ii. P desorption patterns when biochars applied at the same rate are mixed with distinct P retentive soils.

Materials and Methods

- Desorption experiments were performed by mixing 1% (w/w) biochar from *selected* feedstocks: i) poultry litter (PLB), an animal- based biochar & ii) mixed hard woods (HWB), a plant-based biochar
- 2 contrasting P retentive soils (Apopka, Candler)
- 20 extractions with 0.01 *M* KCl (3 replicates for each treatment)



- Extractions were analyzed for P (molybdenum blue method); Ca and Mg by ICP (Inductively Coupled Plasma Spectrometry)
- Biochars were analyzed for total P, and Mehlich 3-P, Ca, Mg, and K
- Solid state P of biochars assessed by X-ray diffration and SEM-EDS (Scanning Electron Microscopy).

Table 1. Chemical characterization of biochars – Total P and Mehlich 3-P (M3-P), Ca (M3-Ca), Mg (M3-Mg) and K (M3-K) in animal-based and plant-based biochars. Units are in mg kg^{-1}.

Biochar	Total P	M3-P	M3-Ca	M3-Mg	M3-K
			Animal-based		
PLB	25 615	14 545	16 005	5520	46 950
Biosolids	67 330	7060	2325	5140	500
			Plant-based		
HWB	1900	480	670	290	4360
Maple	730	105	4810	670	4140

Results and Discussion

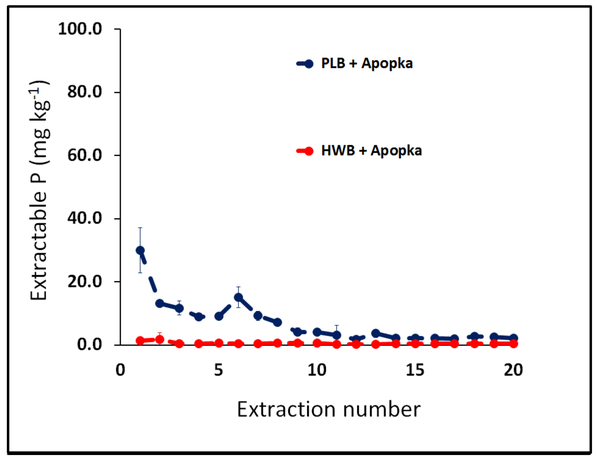


Fig 1. Apopka soil amended with 1% of poultry-litter biochar (PLB) or hardwood biochar (HWB). Apopka is a more retentive soil than Candler (Fig. 2). Bars represent standard deviation of the mean (n=3).

- Less P is released from the more P retentive Apopka (Fig. 1) compared to the Candler (Fig. 2)
- PLB with the higher M3-P concentration (Table 1) released more P initially than the HWB
- HWB released almost no P
- PLB showed the presence of whitlockite, a Ca-P mineral with or without Mg (Fig. 3a), a slow releasing P form
- SEM-EDS of PLB showed Ca-P associations (Fig. 3c)
- The extractant also showed concentrations of Ca and Mg (data not shown)

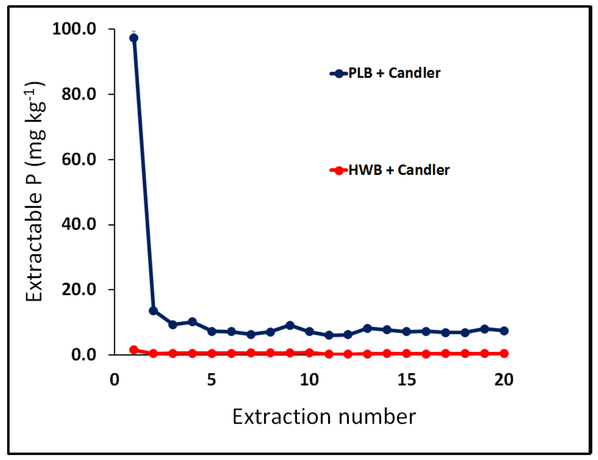


Fig 2. Candler soil amended with 1% of poultry-litter biochar (PLB) or hardwood biochar (HWB). Candler is a less retentive soil than Apopka (Fig. 1). Bars represent standard deviation of the mean (n=3).

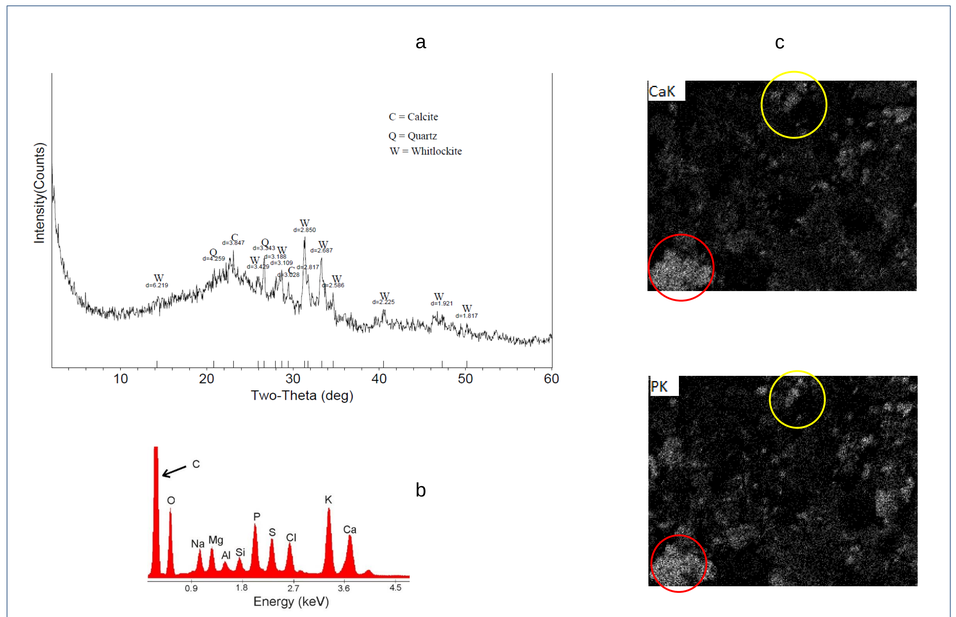


Fig 3. X-ray diffraction pattern (a), SEM-EDS elemental dot maps (b), and EDS elemental spectrum (c) for the poultry litter biochar (PLB). The x-ray diffraction analysis was performed after washing, dissolving KCl (sylvite) which was abundant in the PLB. Removing sylvite was advantageous in assessment of other minerals in the PLB.

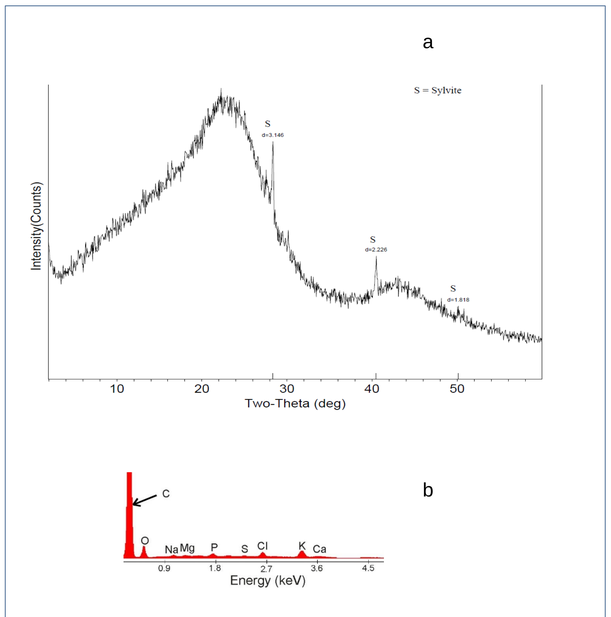


Fig. 4. X-ray diffraction (a) and EDS spectrum (b) for hardwood biochar. No P –associations with other elements were detected from SEM-EDS analyses.

Summary

- Biochar with high P concentration, e.g., PLB, releases more of this element compared to biochar with low P concentration, such as HWB
- P released from a biochar is retained by a more P-retentive soil (Apopka) compared to a less retentive soil (Candler)
- PLB could act as a slow P-releasing fertilizer.

Implications

- P release depends not only on biochar feedstock (biochar source), but also on the P retention capacity of the soil
- Application of biochar should take into account the P retention capacity of the soil to minimize environmental problems due to over-application.

Acknowledgment
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