Phosphorus Association and Release from Biosolids and Corresponding Biochars

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Introduction

- Extensive research on P release from biosolids originating from various processes has been done (Brandt et al., 2004); little is known about biochar derived from biosolids (Gonzaga et al.,2017)
- Further investigation of biosolids-biochar properties is imperative to match cropping requirements and safe environmental application (IBI White Paper, 2013)
- P retention in non-calcareous soils is a property of the soil and independent of the nature of the biochar feedstock (Dari et al., 2016)

Objectives

Evaluate P associations (solid state assessment), and solution chemistry of biosolids and their respective biochars from different locations: Franca-SP, Brazil; Jacksonville-FL, US and Lugo-Spain) obtained by different processes

Materials and Methods

- Biosolids from different locations and processes were evaluated:
  Franca – SP, Brazil: anaerobic digestion
  Jacksonville – FL, US: anaerobic digestion
  Lugo, Spain: i) Anaerobic, ii) Anaerobic-composted, iii) Anaerobic-pelletized
- Biosolids were converted into biochar in lab
- Desorption experiments were performed by mixing 1% (w/w) biosolids-biochar with two contrasting P retentive soils (Apopka and Candler) and incubated for 20 days. Mixes were subjected to 20 extractions with 0.01 *M* KCl and extractants were analyzed for P (molybdenum blue method)
- Solid state P associations assessed by X-ray diffration and SEM-EDS

Results and Discussion

Jacksonville - FL US

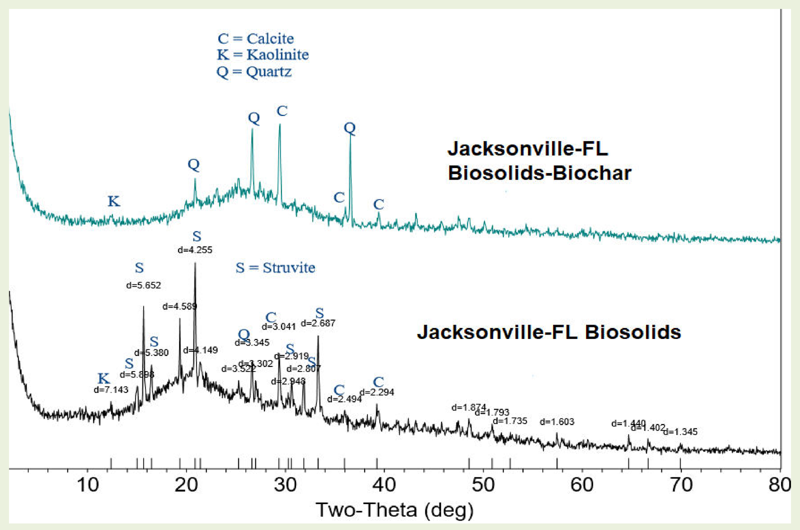


Fig 1. XRD indicates the loss of struvite ($NH_4MgPO_4 \cdot 6H_2O$) during pyrolysis. Calcite, kaolinite and quartz were identified in both materials

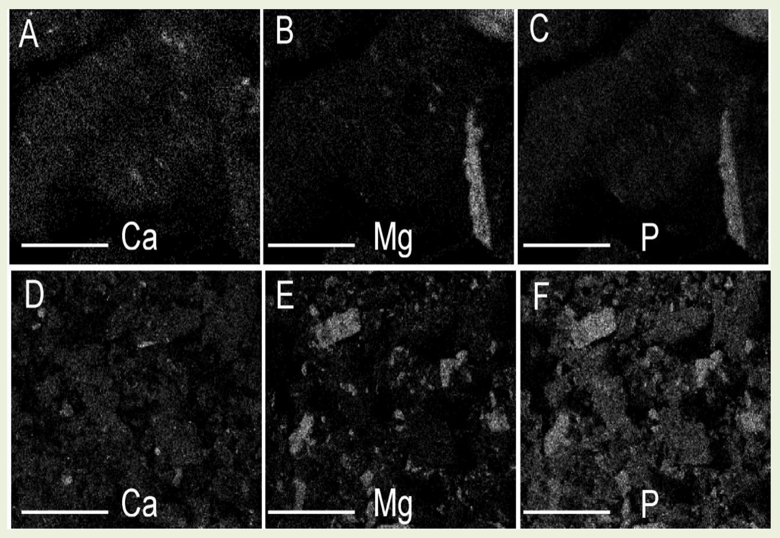
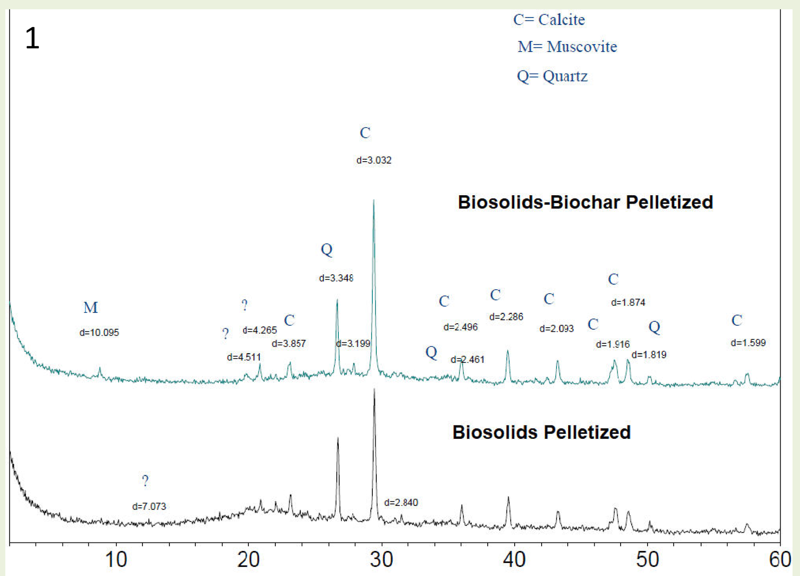


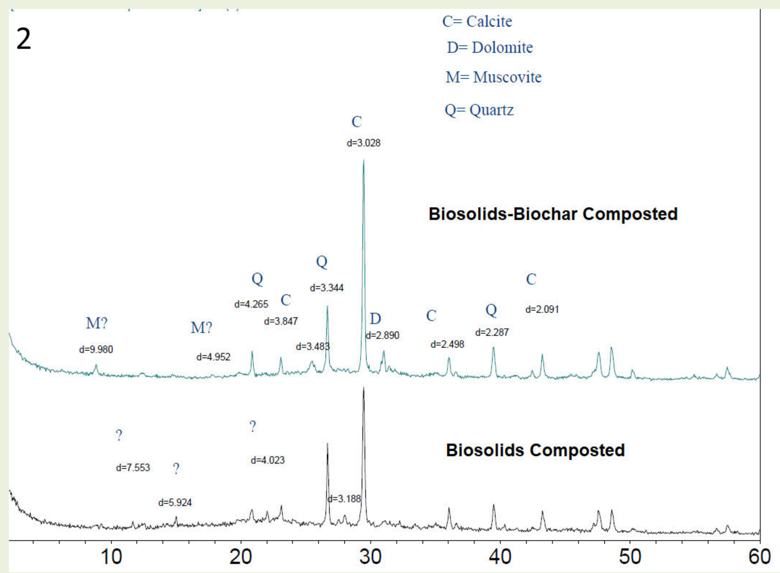
Fig 2. Biosolids (A, B and C) and their corresponding biochars (D, E and F) showed Mg-P associations

Selected chemical characteristics of biosolids and biochars; Mehlich 3 (M3). Units: mg kg^{-1}

Jacksonville-FL US	M3-P	M3-Ca	M3-Mg	M3-Fe	M3-Al	Total P	TKN	WSP
Biosolids	10 960	4730	6271	573	258	32 486	54 224	3295
Biosolids-Biochar	7062	2326	5139	437	188	67 330	50 689	303

Lugo - Spain





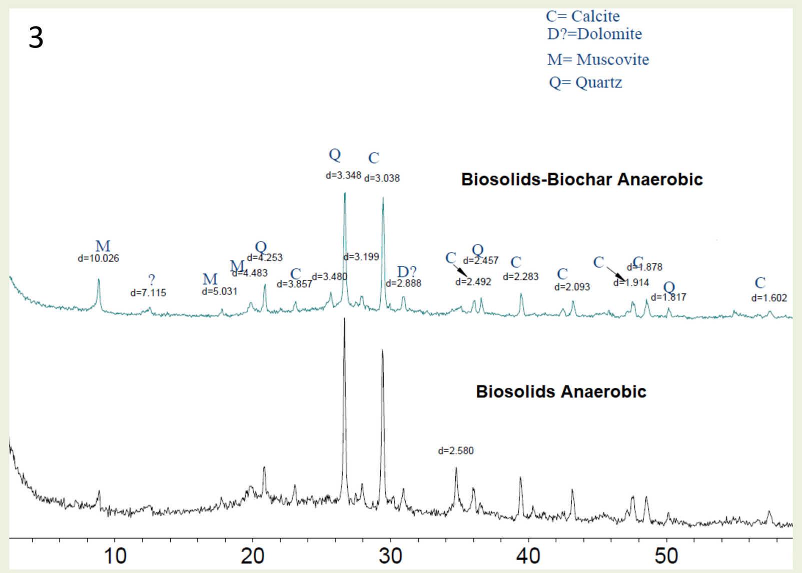


Fig 3. XRD patterns 1, 2 and 3 of biosolids and their corresponding biochars did not show mineralogical diferences. Common minerals found were: Calcite ($CaCO_3$), Dolomite ($CaMg(CO3)_2$, Muscovite ($KAl_2(Si_3Al)O_{10}(OH,F)_2$) and Quartz ($SiO_2$). Scale bar = 200 μm

Selected chemical characteristics of biosolids and biochars; Mehlich 3 (M3). Units: mg kg^{-1}

Biosolids	M3-P	M3-Ca	M3-Mg	M3-Fe	M3-Al	Total P	TKN	WSP
Anaerobic	2010	15 601	1389	293	513	19 548	32 960	328
Anaerobic-composted	2456	17 835	1723	404	329	22 619	21 676	293
Anaerobic-pelletized	1555	10 949	1357	225	442	21 330	32 160	87
Biosolids-Biochar								
Anaerobic	1921	18 085	985	300	731	31139	16 353	140
Anaerobic-composted	2128	19 287	1130	326	493	39 472	13 945	67
Anaerobic-pelletized	2437	18 885	1706	218	313	41 321	18 068	69

Franca - SP Brazil

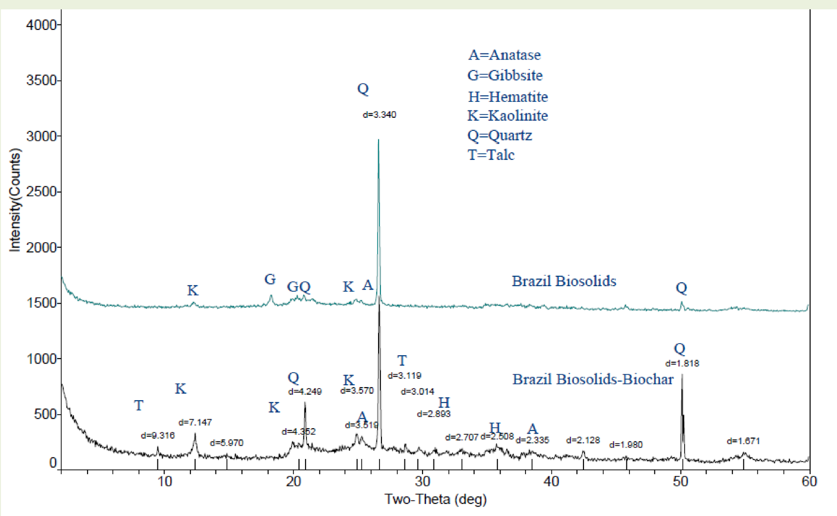


Fig 4: X-ray diffraction pattern for biosolids and biosolids-biochar from Franca-SP Brazil.
No crystalline phosphate mineral was identified. Presence of weathering-resistant soil minerals were found extensively in both materials.

Selected chemical characteristics of biosolids and biochars; Mehlich 3 (M3). Units: mg kg^{-1}

Franca-SP Brazil	M3-P	M3-Ca	M3-Mg	M3-Fe	M3-Al	Total P	TKN	WSP
Anaerobic Biosolids	677	2980	655	383	1349	NA	39 614	69
Anaerobic Biosolids-Biochar	600	4147	741	487	1386	NA	21 302	17

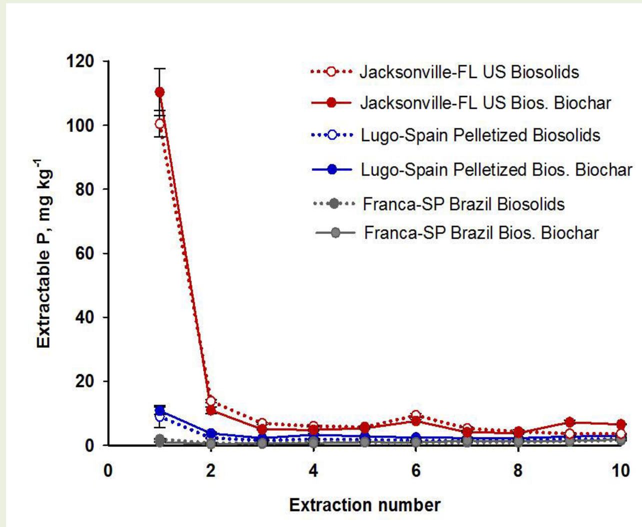


Fig 5. Candler soil amended with 1% of various souces of biosolids and respective biochars. Candler is less retentive soil than Apopka (Fig. 6). Bars represent standard deviation of the mean (n=3).

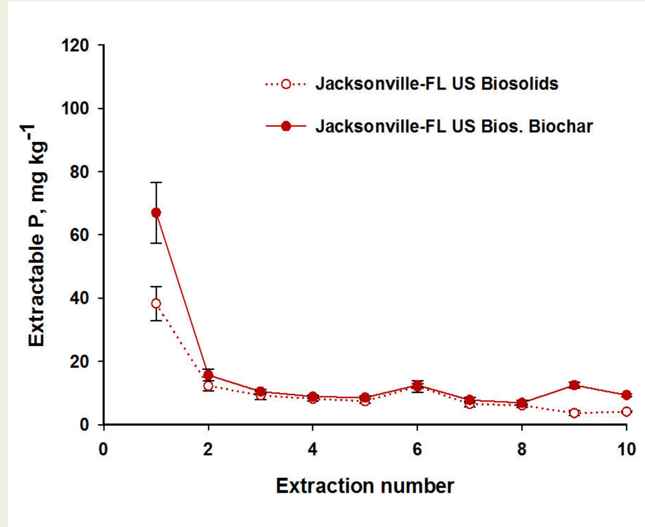


Fig 6. Apopka soil amended with 1% of biosolids from Jacksonville-FL and respective biochar. Apopka is more retentive soil than Candler (Fig. 5). Bars represent standard deviation of the mean (n=3).

Summary

- Materials obtained by the same process (e.g., anaerobic digestion) varied in composition and P release behavior
- Conversion of biosolids into biochar modified the mineral composition of the final product (e.g., loss of struvite in biosolids-biochar from Jacksonville-FL)
- P release was dependant on the nature, origin of the materials and the P retention capacity of the soil that biosolids or biochar is applied

Implications

- P release from biosolids and biosolids-biochar is highly dependent on their origin and process of production. Therefore in addition to the P retention capacity of the soil, properties of biosolids and their biochars should be considered during land application to minimize environmental risk of P loss from the soil

References

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Acknowledgment

Support for the soil analyses in this study by USDA-Hatch Funds is greatly appreciated.