IN LINE: WASTE - BIOCHAR – PHOSPHORUS FERTILIZER

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INTRODUCTION

The search for alternatives for rock phosphate as a resource for fertilizer production is an important issue for global food production. The processing of phosphorus-rich municipal and agricultural wastes could support the closure of the geochemical phosphorus cycle. Thermo-chemical conversion processes provide the key for the transfer of phosphorus from waste materials to stabilized products. Pyrolysis as a carbonization technology converts biomass thermochemically into stable, recalcitrant organic carbon compounds that can serve as nutrient carriers to be applied as fertilizer for agricultural soils.
The main aim of our work is to assess the effectivity of different agricultural waste feedstocks to produce biochar-based fertilizers and to produce biochar-based sorbents for phosphorus from liquid wastes.

EXPERIMENTAL DESIGN & METHODS

Biochar samples were produced in slow pyrolyses process from two different feedstocks: beech wood chips (BC A) and garden green waste residues (BC B). Both materials had been pyrolyzed at 500° C and residence time 120 min in a rotary furnace. The biochars were ground and sieved to particles with size 0.5 - 1.0 mm.
Top soil samples (0-20 cm) were collected from a P-deficient rendzina in Arnoldstein, Austria. For incorporation 1 and 5 % (w/w) amendments of BC A and BC B were applied. For comparison the commercial fertilizer superphosphate (P_2O_5) was used. Amended soil samples were incubated at 19 ± 2° C, 65% water content for 14 days.
For the determination of labile forms Calcium-Acetate-Lactate (CAL), deionized water (DW), Mehlich 3 (M3) and Olsen (OL) extraction protocols were used. For total phosphorus content modified HNO_3 – H_2O_2 (Enders and Lehmann, 2012) was applied. Malachite green microplate UV-VIS method was used for phosphorus determination in soil extracts.
Fe-impregnated biochars were prepared by direct hydrolysis of $Fe(NO_3)_3$.

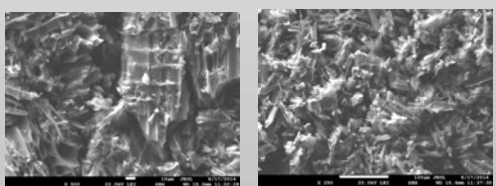

Fig. 1a,b: SEM-pictures of the two biochars used in this study (BC A, BC B). Magnification: 250x

RESULTS & CONCLUSIONS

•**Unmodified biochars from plant residues produced by slow pyrolysis** (Fig. 1, Table 1)**, release P much slower than reference P fertilizers** (Fig. 2, Table 2)**.**
•**An Fe-based impregnation of the same biochars increased the sorption efficiency for P dramatically** (Fig. 3).
•**It is suggested that Fe-modified biochar produced from feedstock with low P-content could be used for efficient recycling of P from liquid wastes, thereby opening the potential of P fertilizer production without using rock phosphates.**

Table 1: Biochar and soil characterization

	BC A	BC B	S
pH (H_2O)	8.78	9.03	6.29
pH (KCl)	8.46	8.77	5.45
EC (mS cm^{-1})	0.54	1.67	0.05
Density (kg L^{-1})	0.36	0.34	1.45
AEC (cmol kg^{-1})	0.63	0.73	1.05
C (%)	80.30	79.78	n.a.
H (%)	1.60	1.59	n.a.
N (%)	0.40	0.65	n.a.
P_{TOT} (mg kg^{-1})	2153 ± 89	6197 ± 369	196 ± 6

Table 2: Effect of biochar amendments

	1 % BC A	1 % BC B	1 % P_2O_5
pH (H_2O)	6.61	6.64	6.18
pH (KCl)	5.61	5.79	5.42
EC (mS cm^{-1})	0.06	0.07	0.18
AEC (cmol kg^{-1})	0.99	0.98	1.08
P_{TOT} (mg kg^{-1})	205 ± 6	219 ± 4	822 ± 13
	5 % BC A	**5 % BC B**	**5 % P_2O_5**
pH (H_2O)	6.64	6.92	4.92
pH (KCl)	5.72	6.13	4.75
EC (mS cm^{-1})	0.07	0.10	0.96
AEC (cmol kg^{-1})	0.95	0.92	1.02
P_{TOT} (mg kg^{-1})	253 ± 8	321 ± 9	1112 ± 38

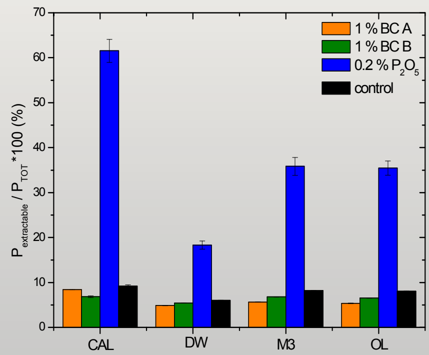

Fig. 2: P-extractability from unmodified biochar produced from wood chips and green waste residues after 2 weeks of incubation in soil. Standard superphosphate fertilizer is shown as Preferencen.

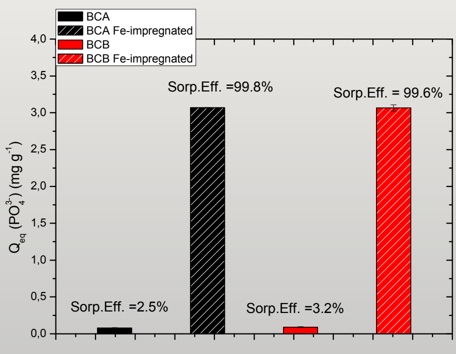

Fig. 3: Sorption efficiency of unmodified BC A, BC B and Fe-impregnated BC A and BC B for $PO4^{3-}$ (c_0 = 95 mg dm^{-3} KH_2PO_4), contact time 24 h, particle size 400-250 µm, ratio sorbent:solution = 1:30.

References:

- Enders, A, Lehmann, J. *Communications in Soil Science and Plant Analysis*, 2012, 43: 1042-1052.

Acknowledgements:

The authors thank the Austrian FFG for financial support of the Research Studio FERTI-MINE.

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