EGU 2014
B 162

Biochar application to sandy soils for agricultural nutrient management

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Introduction & Objectives

Soil fertility of agricultural soils is challenged by nutrients losses and increasing soil acidification. Furthermore, leached nutrients negatively affect the quality of ground and surface water [1].

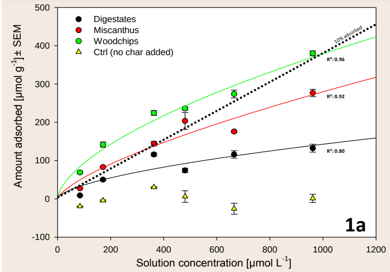
In addition to the possible soil carbon sequestration by applying biochars, many positive soil-improving properties are attributed to biochars. The application of biochars to agricultural – especially sandy – soils could reduce leaching of nutrients and may improve their availability [1,2]. Thus, biochar application to agricultural fields could be an ecologically and economically viable option to improve soils' fertility.

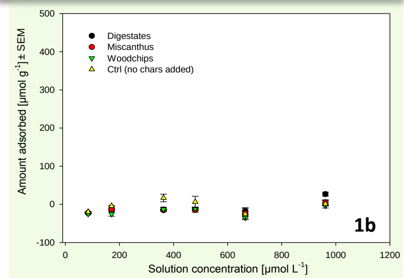
As little is known on the effects of different biochars on nutrient retention, **our objective was** to test the nutrient retention potential of nine different biochars mixed with a sandy soil using sorption batch experiments. To simulate biochar aging, washed and unwashed chars were used.

Results

Pyrochars | Hydrochars

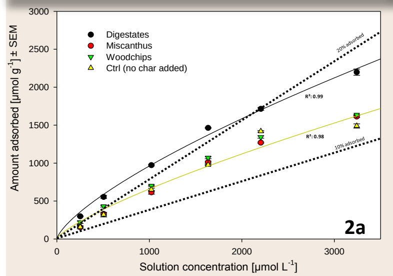
NO_3^--N

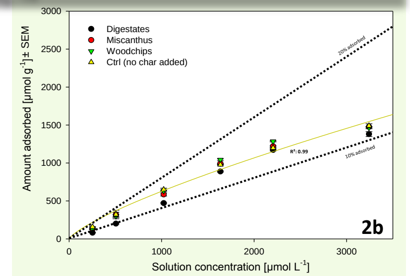




<u>1a & b:</u> Soil with **pyrochars** showed largest retention on NO_3^-. Pyrochars from woodchips (W) showed the highest potential for retention. No adsorption was found for soil-hydrocharmixtures.

NH_4^+-N





<u>2a & b:</u> Only **pyrochars** from digestates showed a retention potential for NH_4^+. No differences were found between control, *Miscanthus*, and woodchips. No retention potential was found for soil amended with hydrochars.

Figures show the adsorbed amount of NO_3^- and NH_4^+ for six different nutrient solution concentrations from the batch-experiment. Only the differences between Ctrl (▲) and soil-biocharmixtures indicate the biochar effect.

Conclusions

- **Pyrochars reduce the nutrient leaching more than hydrochars.** For most ions, hydrochar retention capacity was negligible
- **The retention potential of biochars depends on the used feedstocks.** Anions were most efficiently adsorbed on woodchip pyrochar whereas cations were adsorbed on digestate pyrochars

Material & Methods

Two types of biochars from three different feedstocks were used to determine sorption kinetics and sorption isotherms for the major nutrients NH_4^+, NO_3^-, (data for Ca^{2+}, Mg^{2+}, K^+, PO_4^{3-} are not shown) in a **batch experiment**. In addition, the biochars were washed to simulate aged char and create free binding sites on the chars' surface.

- Biochars from hydrothermal carbonization **HTC** (200°C, 6 h, 20 bar) and from **pyrolysis** (900°C, 0,75 h) of wooodchips, digestates and *Miscanthus* were used. The biochars were washed shaking 4.5 g biochars with 1 L deionised-water for 4h. Shaking time for the batch experiment was 24h.
- 10 g sandy soil with 1.25 % C from an agricultural field site was mixed with 0.5 g biochar in order to double soils' C content.
- Results were fit to the Freundlich-Isotherm ($Q_e = K_F \cdot C^{1/n}$). Logarithmized equilibrium-concentration (not shown) and log adsorbed amount was used to calculate the Freundlich sorption partitioning coefficients (K_F) and the Freundlich exponents (1/n).

	Feedstock			HTC-200			Pyrochar		
	D	M	W	D	M	W	D	M	W
O/C	0,87	0,86	0,71	0,46	0,46	0,40	-	-	-
H/C	0,14	0,13	0,12	0,10	0,10	0,10	0,04	0,02	0,02
N_t [%]	1,57	0.52	0.78	2,59	0.67	1,07	0.90	0.86	0.89
Ca [%]	0,87	0,22	0,62	1,39	0,30	0,90	2,91	1,14	3,43
Mg [%]	0,66	0,07	0,07	0,48	0,05	0,07	1,12	0,30	0,29
K [%]	2,88	0,53	0,27	0,98	0,27	0,25	8,10	2,12	0,87
P [%]	1,28	0,10	0,07	1,23	0,13	0,08	2,51	0,41	0,35

Tab 1: Basic parameters of the used biochars; D=Digestates M=*Miscanthus* W=Woodchips (analyzed by Andrea Kruse, KIT)

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[1] Liang et al. 2006: Black Carbon increases cation exchange capacity in soils. SSAJ 70, 1719-1730.
[2] Lehmann et al. 2009: Biochar for Environmental Management – Science and Technology. 1 An Introduction, 1.