Biochar and compost behaviour in soil – leaching tests

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Introduction

Over the last 3 years almost 200 biochar and compost samples were analysed by WESSLING Hungary Ltd. Animal bone biochars (ABC) contain very high amount of phosphorus (>30%) and other plant nutrients. Plant based biochars (PBC) are not efficient as fertilisers but due to their microporous structure (high water- and nutrient holding capacity) and high carbon content, they are useful as soil improvers. High quality biochars contain negligible quantities of potentially toxic elements, and PAHs under 1 mg/kg. Due to inappropriate treatment technologies PAHs over 40 mg/kg were detected in some PBC samples. As we had a huge analytical database of biochars and composts, but no information about their behaviour in soil, the aim of the tests is to examine the mobilization of nutrients and potentially toxic elements from soils mixed with different treated organic wastes.

Materials and methods

Soils were used from 4 countries. Different mixtures were prepared using a special shaker. Doses were calculated for plowing pepth of 25 cm. 25m/m% sand was also added as an inert dilution material to ensure solvent permeability because of the compact structure of the soils. 6×80 cm size plastic tubes were filled with 2.5 kg of this mixture. A soil/eluent ratio of 10:25 was chosen. Three different eluents were used: distilled water (pH 7) to represent rainwater, Olsen-solvent (pH 8.5; $NaHCO_3$) and ammonium-lactate (pH 3.7) to measure plant available elements. Eluates were filtered and than analysed (ICP-MS, ICP-OES, GC-MS, IC, AAS). Nutrients, potentially toxic elements and pH were measured in all samples. PAHs were measured only in distilled water eluates, because their solubility is not pH dependent.

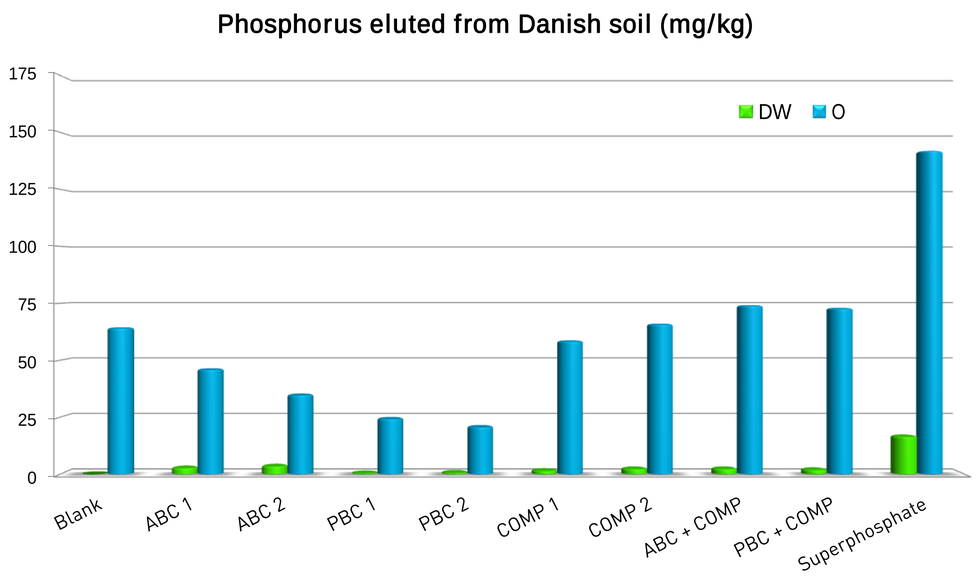
SOIL SAMPLES	pH	TOC (%)	CEC (meq/100g)	Texture
German	7.6	1.04	10.4	rough sand
Italian	8.2	0.39	10.6	sand with silt
Hungarian	7.9	1.69	28.2	silt
Danish	5.5	1.64	8.8	sand

TEST	Dose (kg/ha)	Dose (kg/m³)
Blank	n.a.	n.a.
ABC 1	300	0.12
ABC 2	600	0.24
PBC1	2500	1
PBC 2	5000	2
COMP 1	5000	2
COMP 2	10000	4
ABC + COMP	300 + 5000	0.12 + 2
PBC + COMP	2500 + 5000	1 + 2
Superphosphate	300	0.12

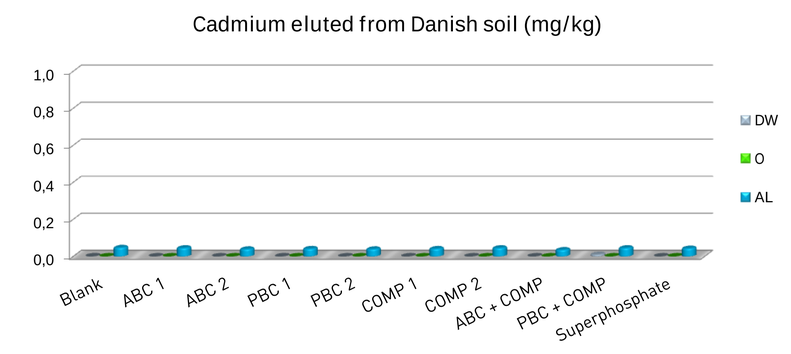
Results

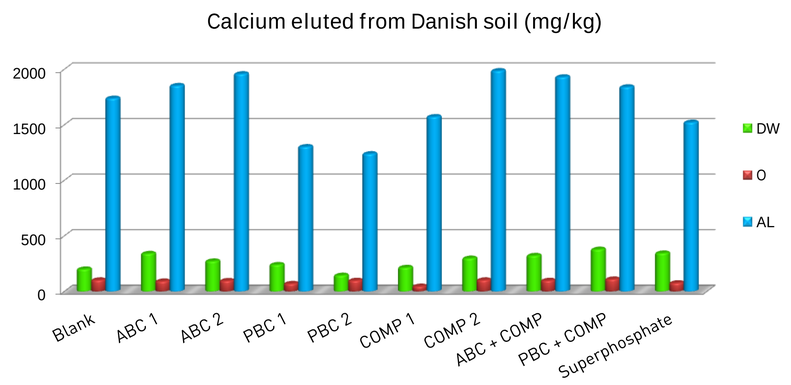
No great differences were observed in the chemical/physical properties of soil samples. The two most distinct ones were the Hungarian and Danish soils, so we focused on the results of these.

In the case of phosphorus the total dissolved amount was highest for superphosphate fertilizer as expected. ABC gave higher values than PBC and compost exceeded ABC. To explain this, it was interesting to see the amount of phosphorus dissolved as the percentage of the total amount in the mixtures. In this case, compost sample gave also higher values than PBC, which were in turn higher than those for ABC. This shows the nutrient holding capacity of ABC macroporous structure too.

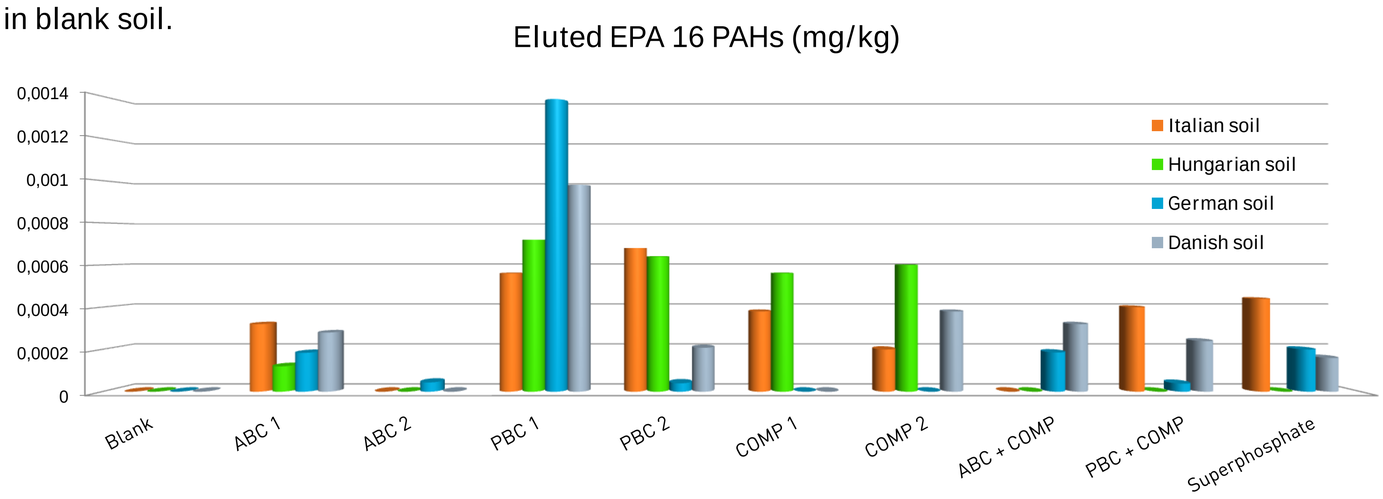


pH dependence of the mobility of nutrients is quite diverse when considering the three primary nutrients, nitrogen, potassium and phosphorus. Results show that the leaching of nutrients is decreased by the addition of additives to the soil, they are retained by the additives and can be taken up to a larger extent by plants, thus increasing the production of agricultural fields. For calcium and other acid soluble metals (e.g. Mn, Cr, Cd, Fe, Mg, Sr), the element content of the ammonium lactate eluate was much higher than that of the Olsen eluate. Concentrations of potentially toxic elements in the sample mixtures never exceeded the quantity that was measured in blank soil.





Concentrations of the 16 EPA PAH components were extremly low in the eluates, 0.0001 mg/kg on average. Comparing the additives, PBC had the highest concentrations but these were still very low. Blank samples did not contain dissolved PAHs, so it can be stated that the concentrations measured were caused by the additives.



Summary

ABC showed slow phosphorus release as a synthetic fertiliser. This continuous leaching provides a smaller chance for nutrient leaching, thus serving environmental aspects while aslo increasing the fertility of soils. Potentially toxic elements could be detected, but these could be originate from the soil samples. Highest PAH contents were found in PBC additioned samples, but still in negligible quantities. Modelling of leaching is challenging, because soil is a very heterogenic matrix, both in the field as well as in the laboratory. This expriment can only be considered as a preliminary-trial because of some deficiencies, but since it raises many questions, it serves a very good basis for further studies.

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