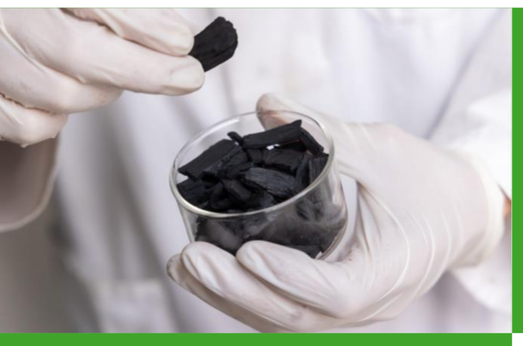

Investigation of main elemental recoveries during pyrolysis of agricultural and wood-based feedstocks

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Introduction

Biochar is a promising and valuable resource for industry and agriculture alike. As a green source of carbon, it could be another step towards a circular economy and, due to its stability in soils, function as a negative emission technology at the same time. In order to further advance the understanding of how process related aspects can be used to adapt biochar qualities in a defined way, an investigation on the emission behavior of the main biomass elements C/H/N was conducted. The focus of the study was on how different feedstocks lead to different elemental recoveries in the produced biochars.

Materials & Methods

Ten different residues were pyrolyzed in a customized muffle furnace setup at the *BOKU University* in Vienna. The mostly locally sourced feedstocks were Japanese knotweed (*Reynoutria japonica*) stems (JK), wheat bran (WB), walnut shells (*Juglans regia*) (WS), screen overflow from composting (CS), residues from poppy flower (*Papaver somniferum*) (PR), rape seed (*Brassica napus*) (RS), mary thistle (*Silybum marianum*) (MR) and hemp (*Cannabis sativa*) (HR) production, spruce chips (only stem wood, SC) and wood chips from broadleaf forestry (stem wood + bark, BC). The feedstocks were pyrolyzed at 500 and 700 °C under nitrogen (1 L/min) atmosphere. The heating rate was 10 °C/min and the time at target temperature was 1 h. The samples were left to cool over night. Figure 1 shows the WB and WS residues before and after pyrolysis. Biochar and feedstock samples were characterized regarding their main elemental content C/H/N according to ISO 16948:2015. Elemental recovery rates were calculated according to equation 1.

Figure 1: The WS and WB samples pre- and post-pyrolysis

$$Elemental\ recovery\ (\%) = 100 * \frac{c(biochar) * yield}{c(feedstock)}$$

Equation 1: Used to calculate the elemental recoveries

Results

Figure 2 shows the elemental recovery rates for the main elements C/H/N at 500 °C. The average C recovery rate was 44.4 ± 8.9%. The average H recovery rate was 11.2 ± 2.4 The average N recovery rate was 49.9 ± 14.4 %.

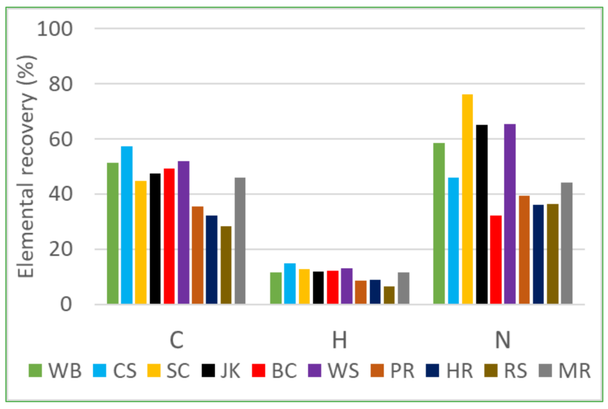

Figure 2: Elemental recoveries for the samples pyrolyzed at 500 °C

Figure 3 shows the elemental recovery rates for the main elements C/H/N at 700 °C. The average C recovery rate was 42.0 ± 8.1%. The average H recovery rate was 4.4 ± 1.1%. The average N recovery rate was 42.8 ± 20.2%.

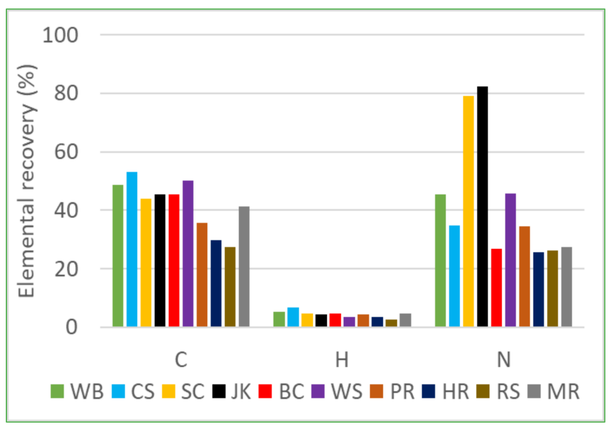

Figure 3: Elemental recoveries for the samples pyrolyzed at 700 °C

Discussion

The results clearly show a drop in elemental recoveries for nearly all investigated samples when the pyrolysis temperature is increased from 500 to 700 °C. In contrast, the SC and JK samples did actually show an increase in the N recovery rates, but this is most likely due to the very low total N content (<0.2% of feedstock dry matter) of these feedstocks, which makes the calculation of elemental recovery prone to feedstock inhomogeneities. Aside from the two outlier samples, N recovery generally decreased the most, going from 500 to 700 °C, with samples mostly showing a decrease of N recovery rate >10 %. H and C recoveries seem to be connected in some way as Figure 4 shows. Positive correlation of H and C recoveries is supported by pyrolysis mechanisms of biomass in the literature[1]. For N, no correlations of recovery rates with H or C were found.

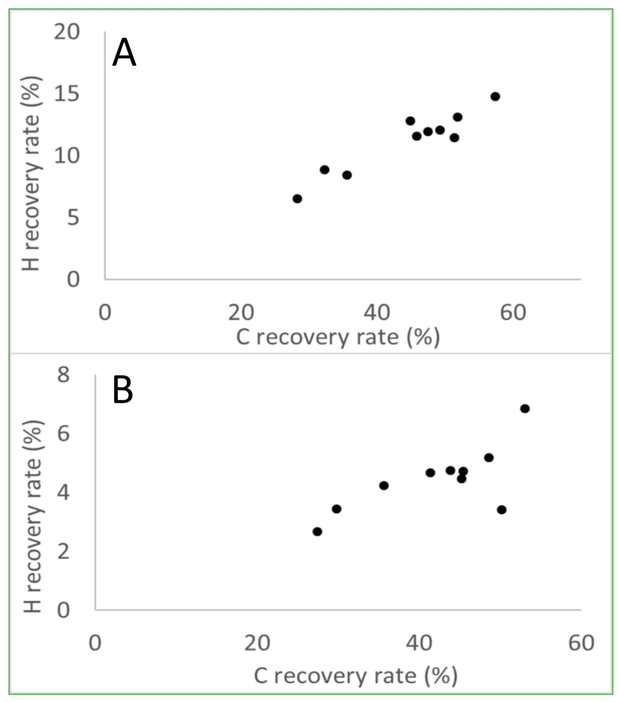

Figure 4: H and C recovery correlation at 500 °C (A) and 700 °C (B), r>0.7 and p<0.01 for both Pearson calculations

Conclusion

Based on the findings of this investigation, it can be said that considerable amounts of the C/H/N elements are lost during pyrolysis, with emissions of C and H being positively correlated to one another. Nevertheless, a certain fraction still remains in the biochar, depending on the element and feedstock, highlighting the importance of feedstock choice. This is, for example, relevant for its application as a soil amendment, as it can re-introduce some of the N back into the soil. However, no statement on the bioavailability of the N contained in biochar can be made from the data presented.

Acknowledgements

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**The presented results are part of a bigger scientific study, which currently is in the sub mission stage.*

[1]*Fates of Chemical Elements in Biomass during Its Pyrolysis Wu-Jun Liu, Wen-Wei Li, Hong Jiang, and Han-Qing Yu Chemical Reviews 2017 117 (9), 6367-6398 DOI: 10.1021/acs.chemrev.6b00647*

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