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Material Value Chains

Effects of biochar addition on anaerobic digestion and comparison of different biochar qualities

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Introduction

Anaerobic digestion (AD) is a useful tool in organic waste management, since it is both pollution control and energy recovery. Although AD has been established for some decades, unsolved problems still exist. The process stability and methane yields, utilization of digestate, nutrient circulation, and waste waters are some of the biggest current issues.

Biochars are carbon-rich material obtained from pyrolysis or hydrothermal carbonization (HTC) of biomass in an oxygen limited environment. They have been especially studied as soil improvers, but in recent years biochars have also been applied to AD. Integration of biochars and AD promises several synergies. Digestate could serve as a feedstock for biochars, biochars could improve AD via adsorption of inhibitive compounds, and biochar in remaining digestate could act as a soil improver when the digestate is composted.

The effects of biochar in AD was studied and the synergies related to nutrient circulation, composting and biochar production were discussed in a co-operation project of Helsinki Region Environmental Services (HSY) and University of Jyväskylä.

Materials and methods

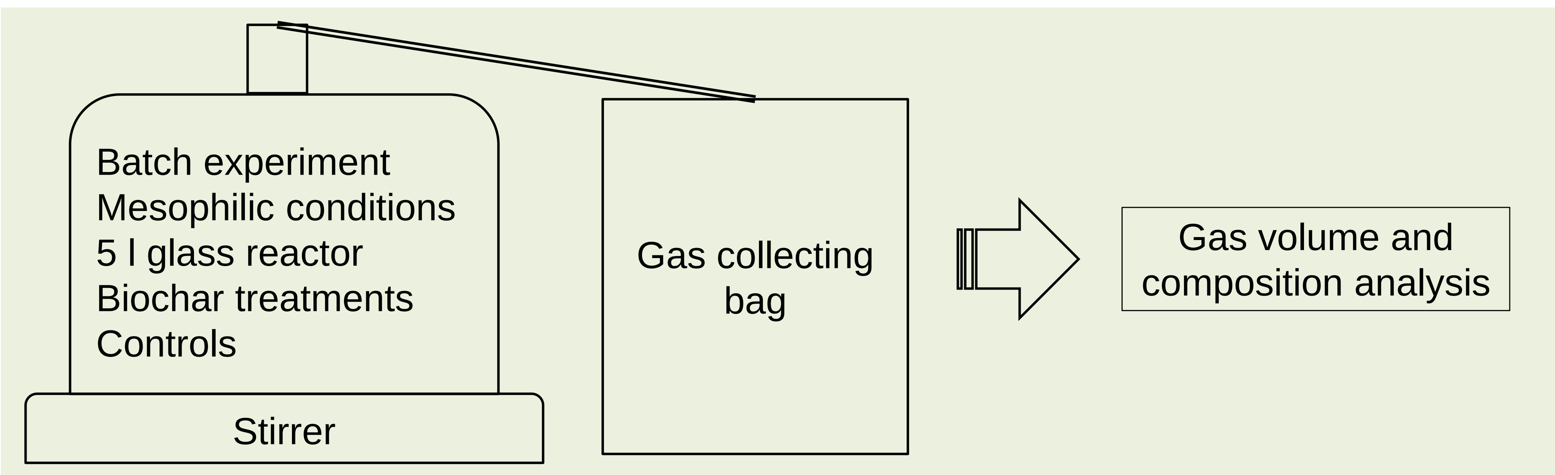
Altogether eight different biochar samples (BC1-BC8) and a zeolite reference sample were collected from Finland and abroad.

Sample type	Label	Feedstock	Temperature (°C)
Pyroytic	BC1	Birch	350
Pyroytic	BC2	Pine	350
Pyroytic	BC3	Willow	320
Pyroytic	BC4	Willow	420
Pyroytic	BC5	Broadleaved trees	450
Pyroytic	BC6	Food production residues	-
Pyroytic	BC7	Wood residues	-
HTC	BC8	Digestate (sewage sludge)	210
Zeolite	ZEO	-	-

Ammonium adsorption capacity was measured from the biochar samples. During AD the nitrogen in the feedstock degrades to ammonium and digestate and process waters are rich in it. Also the excess of ammonium can cause inhibition in AD. Well known ammonium adsorbent zeolite was used as reference.

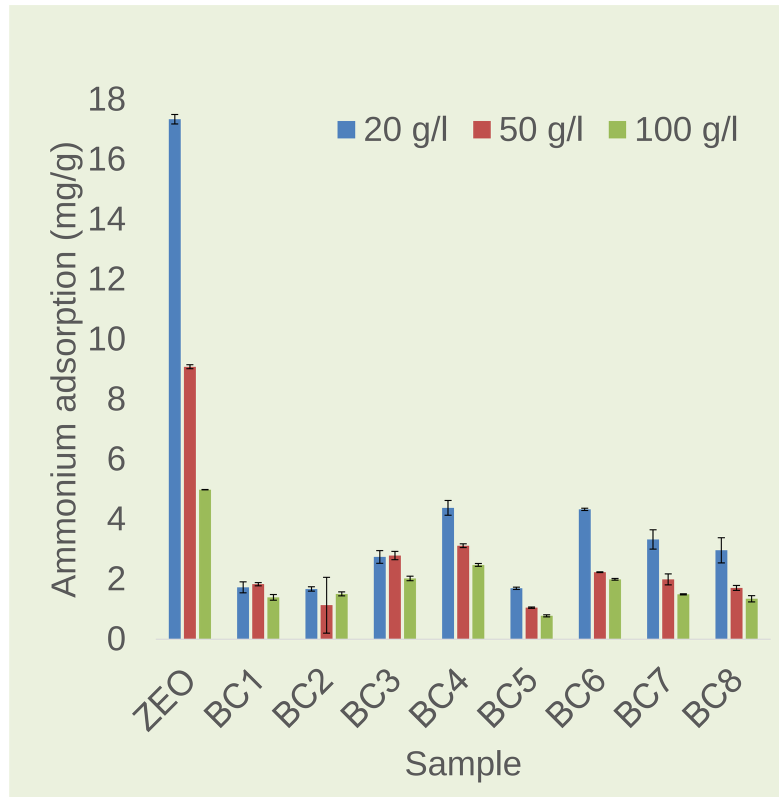
PAH-compounds in the biochars were measured. PAHs are organic contaminants and biochars are known to contain them. In future PAH guidelines can regulate the use of biochars.

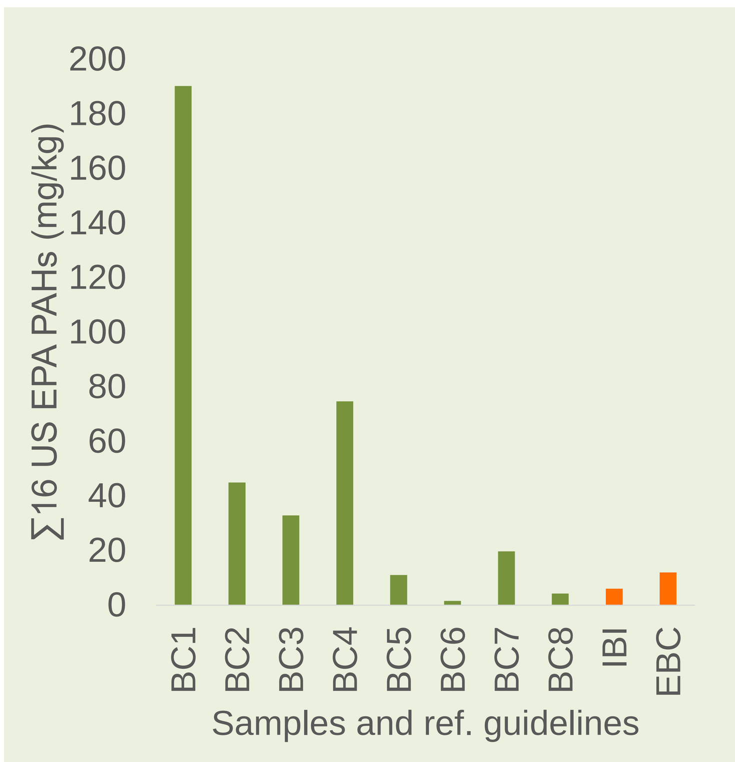
Biogas experiments with two biochars produced with different technologies (pyrolysis and HTC) were made in order to study the effects of biochar to biogas production in AD. Feedstocks were collected from HSY biogas plant and dry conditions were simulated. In HTC experiment treatments with additional ammonium (NH_4^+) were included in order to simulate strong ammonia inhibition.



Results and discussion

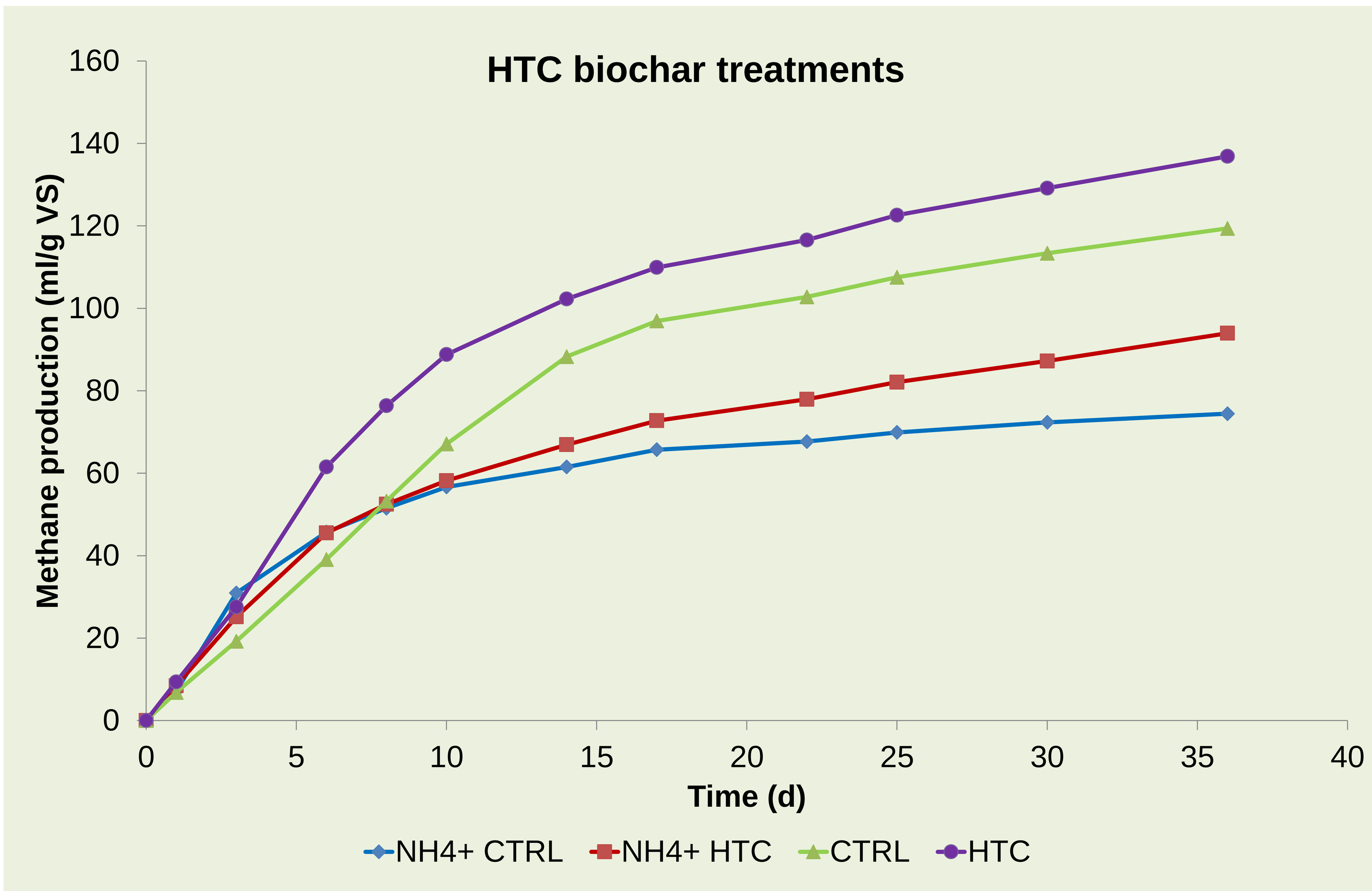
Biochars had the ability to adsorb ammonium (0.7-4.4 mg/g) but compared to zeolite (4.9-17.3 mg/g) adsorption was lower. In literature greater adsorption values (> 50 mg/g) for biochars exist. If the adsorption capacity can be maximized by optimizing manufacturing, biochars could be a feasible and cost-effective method in adsorbing nutrients from digestate and leachate waters.





PAHs in biochar samples had a lot of variation (the highest value 190 mg/kg and the lowest 2 mg/kg). Six biochars exceeded the International Biochar Initiative (IBI) and five the European Biochar Certificate (EBC) guideline value (6 mg/kg and 12 mg/kg). More attention should be focused in PAHs in order to manufacture safe and usable products.

Pyrolytic biochar did not increase the methane production but HTC biochar seems to work better. This can result from a larger fraction of biologically degradable material in HTC biochar or its better ammonium adsorption capacity. The optimization of biochars seems to be essential when considering their use in AD. Only results from HTC experiment are presented.



Conclusions

- **Biochars have the ability to act as cost-effective nutrient (ammonium) adsorbents if the manufacturing is optimized.**
- **Nutrients could be captured from digestate and process water in the AD → promotes nutrient circulation.**
- **HTC biochar seems to enhance biogas production while pyrolytic biochar did not have an effect. The mechanism still remains unclear and further investigations are needed.**
- **The remaining biochar in digestate can act as a soil improver if the digestate is composted.**
- **Biochar PAH content should be considered carefully since there can be legislative guidelines in the future.**

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