Potential of hydrothermally carbonized water hyacinth as fuel substituent and liquid fertilizer

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Introduction

Hydrothermal carbonization (HTC) is a thermal degradation process of biomass in subcritical water in temperature ranges of 180-250°C.

HTC is considered to have great potential for a world-wide application in waste conversion, biofuels and carbon storage. The present study investigates the hydrothermal carbonization of water hyacinth (*Eichhornia crassipes* [Mart.] Solms), an invasive water plant species causing manifold ecological and socio-economic problems due to its competitiveness and its enormous growth rate (70-100 t/ha/a dry weight).

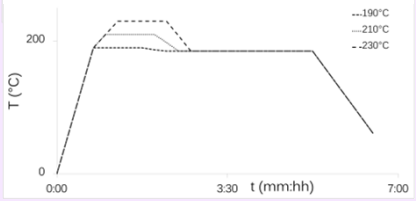
Aim

An elemental mass balance is conducted in order to gain an understanding of the concentrations and allocation of nutrients in HTC-products. Process parameters temperature and pH-value are investigated for their impact on the energetic characteristics of HTC-products as well as on the distribution on minerals between hydrochar and process water. Results allow for assessing the potential of HTC-products of water hyacinth as energy carrier and liquid fertilizer.

Methods

230 g of fresh water hyacinth are mixed with either 150 ml deionized water or citric acid (0.033 molar) to observe impacts of pH-lowering on HTC-products.

Ramped heating curves applied



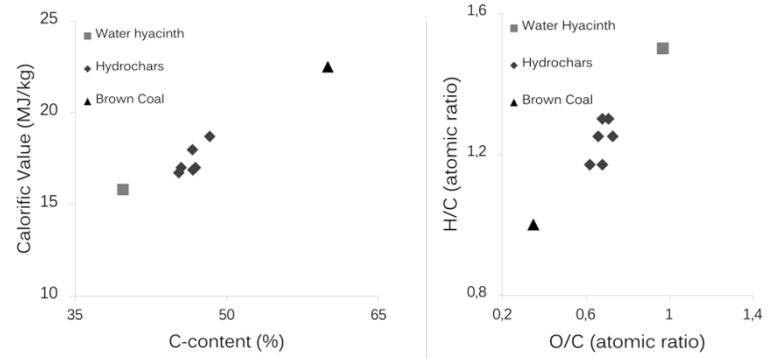
Total reaction time $t_{>180\ °C}$ is 4:30 h. Hydrochar is analyzed for Calorific Value, total C/H/N/S content and concentrations of nutrients, metals and trace elements (P, K, Ca, Mg, Al, Fe, Cu, Mn, Ni, Zn). Process waters are observed for TOC and COD in order to assess organic loading. Ion concentrations of NH_4^+, NO_2^-, NO_3^-, PO_4^{3-}, SO_4^{2-} and Cl^- as well as element contents of N, P, K, Ca, Mg, Al, Fe, Cu, Mn, and Zn are determined.

Conclusion

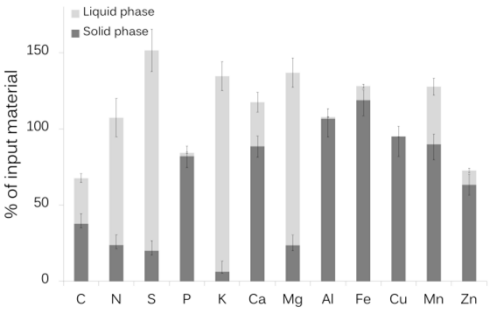
- Process conditions applied (T_{mean}=206 °C; pH=5.3) are not severe enough to acquire a fuel similar to brown coal
- Dry weight content (16.3g dw ≙ 4.3 %) fed to the reactor is far too low
- Average C-content of hydrochars increased by 6.7 % to 47 %; mean Calorific Value increased by 1 MJ/kg to 16.7 MJ/kg
- Process water holds strong potential as fertilizer due to high rates of main nutritional elements N (1.350 mg/l), K (1.980 mg/l), Ca (440 mg/l), Mg (295 mg/l) and S (262 mg/l)
- Elements N, S, K, and Mg mainly dissolve into the process water whereas Ca, P, Al, Fe, Cu, Mn and Zn remain in the hydrochar

Results

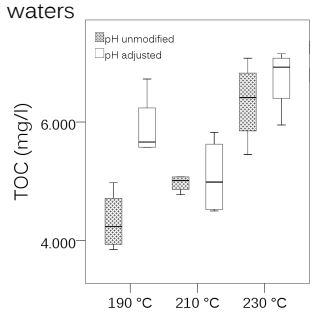
Energetic properties of hydrochars in comparison to brown coal



Element mass balance in HTC-products



Carbon-loading of process waters



Further Readings

Libra, J.; Ro, K.; Kammann, C.; Funke, A.; Berge, N.; Neubauer, Y. (2011): Hydrothermal carbonization of biomass residuals: a comparative review. In: *Biofuels* 2 (1), p. 89–124

Funke, A.; Ziegler, F. (2010): Hydrothermal carbonization of biomass. A summary and discussion of chemical mechanisms for process engineering. In: *Biofuels, Bioproducts & Biorefining (Biofpr)* (4), p. 160–177

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