Influence of pyrolysis conditions on the properties of bio-chars produced from aquatic biomass – algae and hornwort

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1. Introduction

Production of clean energy and reducing usage of constantly decreasing levels of fossil fuels has become attention worldwide. Using alternative sources of energy is becoming more common nowadays in aim to reduce CO_2 release to the atmosphere and overcome the problem of global warming. Aquatic biomass due to short carbon cycle has become an interest to investigate the possibility of processing into value added products i.e. bio-diesel or bio-ethanol. Both hydrothermal liquefaction and pyrolysis have been widely studied to investigate liquid and solid products respectively (Minowa, 1995; Demirbaş, 2006).

Fast growing aquatic plant like hornwort might become an interesting raw material for processing. Hornwort occurs worldwide mostly in swamps, rivers or lakes and does not require special treatment.

The aim of this research was to compare two different aquatic biomass sources: algae (*Cladophora* L.) and hornwort (*Ceratophyllum demersum* L.) in pyrolysis process and estimate potential application of solid product.

2. Materials and methods

Hornwort and algae were sieved to a particle size <0.4 mm for further processing. Pyrolysis was conducted in quartz reactor in N_2 flow of 20 L/h to ensure inert atmosphere of the process. Temperatures of the process were 500, 600 and 800°C with heating rate 10°C/min and residence time 1 hour. Proximate analyses were conducted according to standard procedure to investigate content of: moisture (W), volatile matter (VM), ash (A) and fixed carbon (FC). Cellulose, hemicellulose and lignin contents were also investigated. First biomass was treated with acetone using Soxhlet extraction method to remove organic compounds and moisture. For hemicellulose determination, sample was boiled in 0.5M NaOH solution and residue was weight. Lignin was determined after boiling in 72 wt.% H_2SO_4 and ashing of the reside. Cellulose was determined by difference. Results of proximate analyses are given in table 1 and results of cellulose, hemicellulose and lignin content are shown in Fig. 1.

3. Results and discussion

Both aquatic biomasses exhibited comparable amounts of ash (~19%). The main difference was observed in cellulose and hemicellulose content. Algae contains 41% of hemicellulose and 10% of cellulose, while hornwort 18% of hemicellulose and 40% of cellulose. More lignin was found in algae than in hornwort (17% and 5% respectively). Such composition gives an insight to possible behavior of sample in pyrolysis process.

Proximate analysis allowed to define volatile mater, moisture, ash and fixed carbon content in derived samples. Algae bio-chars contains more ash than hornwort. Bio-char obtained at 800°C has 57% of ash (dry basis) while corresponding bio-char obtained from hornwort 47%. Algae also exhibits higher amount of volatile matter as expected due to (higher hemicellulose content) up to 600°C. At 800°C samples contain comparable amounts of volatile matter. Hornwort bio-chars exhibited higher amounts of fixed carbon (~47%), while algae fixed carbon content varied from 31-37%.

Table 1. Comparison between proximate analysis of algae and hornwort.

Biomass	Temperature (°C)	Moisture (%)	Ash (%)	Volatile matter (%)	Fixed carbon (%)
Algae	500	1.6	42	27	31
	600	1.2	46	23	31
	800	0.8	57	6	37
Hornwort	500	4.0	40	14	46
	600	4.0	43	10	47
	800	5.0	47	5	48

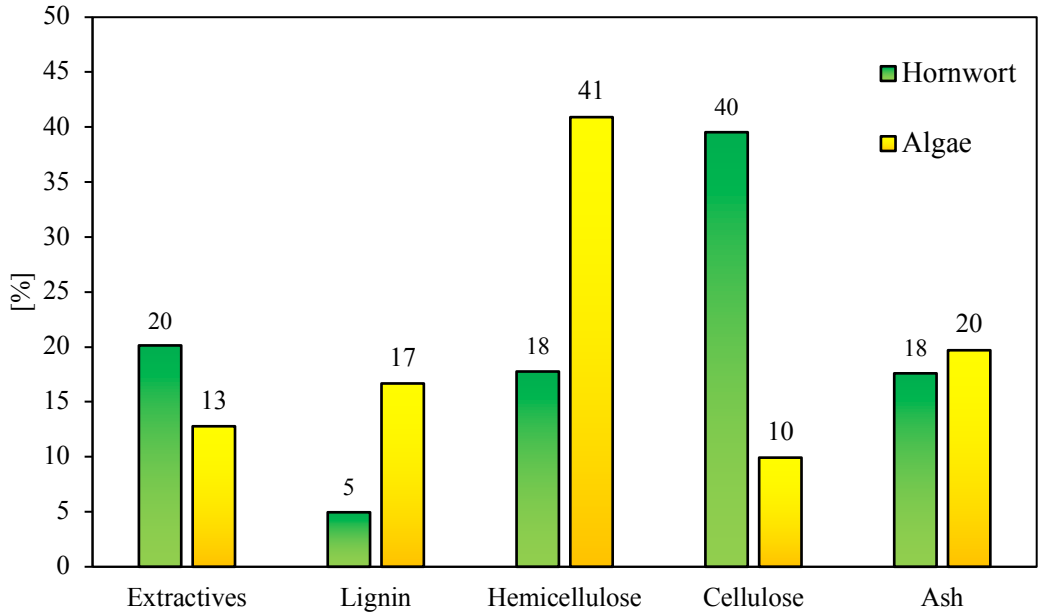

Fig. 1. Comparison composition of algae and hornwort.

4. Conclusions

Aquatic biomasses were investigated in pyrolysis process. Different chemical composition mostly cellulose and hemicellulose content resulted in different proximate analyses results and biomass behavior during thermal treatment process. Hemicellulose tends to produce volatile matter while cellulose gaseous products and char. Nearly 4-fold higher amount of lignin in algae might suggest that this material will give better yields of various phenols at higher temperatures. Relatively high amount of ash in both raw materials and bio-chars might find application as a component of fertilizers or deacidification of soils.

5. Acknowledgement

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6. References

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