The Characterisation of Peat Grown Willow and Silver Birch as potential Bioenergy Feedstocks

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Background

Humberhead Peatlands NNR

- Largest area of raised bog wilderness in lowland Britain and is located in South Yorkshire, consisting of 2887 hectares.
- Over 200 hectares of scrub woodland has established itself on peated soil, causing significant changes to the site's moisture with the soil become fragile and brittle.
- The trees within the naturally regenerated woodland have no uniformity in their ages, ranging from young saplings to well established specimens.
- The high level of stems per hectare make access difficult.

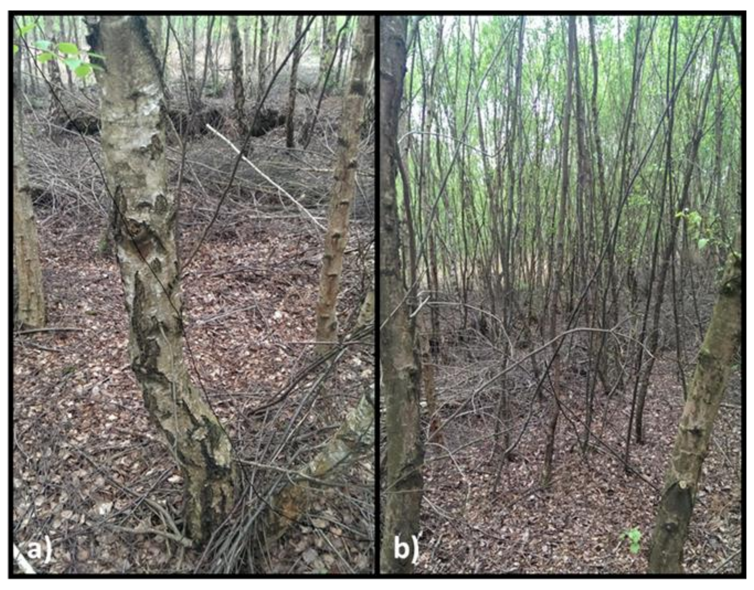

Figure 1. Silver Birch Growth on Peatland

Project Objectives

- Waste biomass is generated through the clearing of the natural regenerated woodland located on the NNR peat land.
- The potential utilisation of the biomass as a fuel source is a result of the RSPBs overriding conservation aim; to return the land back into a wet, peatland habitat.
- The quality of the biomass as a fuel is to be assessed by laboratory analysis in collaboration with Leeds University Energy Research Institute.

Energy Content Analysis

The Calorific Value of the biomass was measured using 'Bomb Calorimetry'.

The energy values of the Willow and Birch samples were dependent on the moisture content. The energy content of the RSPB samples were comparable to typical freshly harvested 'green' hardwoods, visibly higher in moisture content. In comparison the LUS Willow sample had been in dry storage which has resulted in the higher Calorific Value of 19.7MJ/kg.

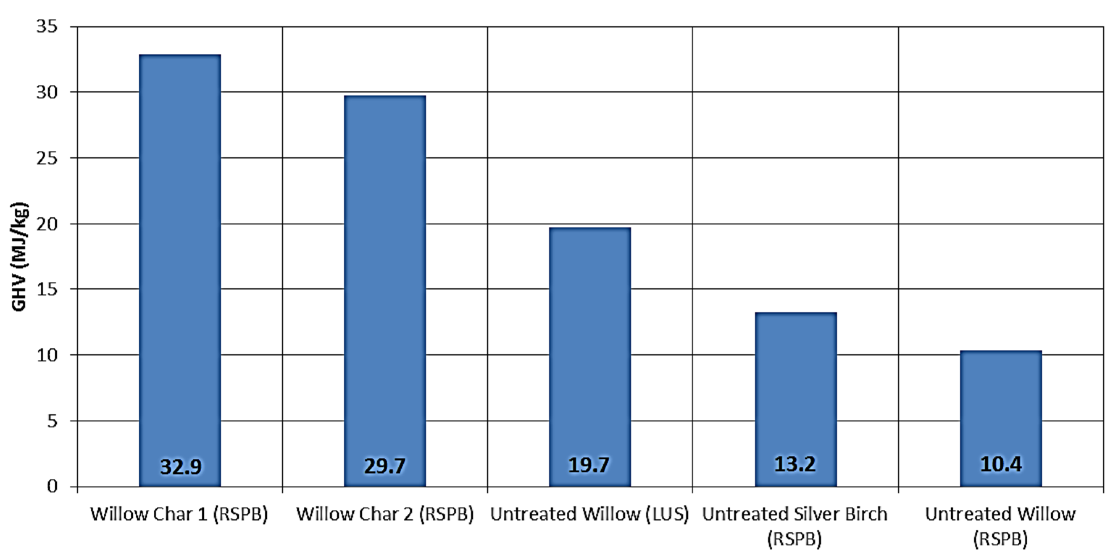

Figure 2. Heating values of Willow Chars, Untreated Willow and Silver Birch

Producing charcoal from the biomass removes water and volatile matter, increasing the energy density to around 30MJ/kg, which is comparable with a typical bituminous coal. However, the results show that there is a significant difference between the energy values of the two Willow Char samples.

Proximate Analysis

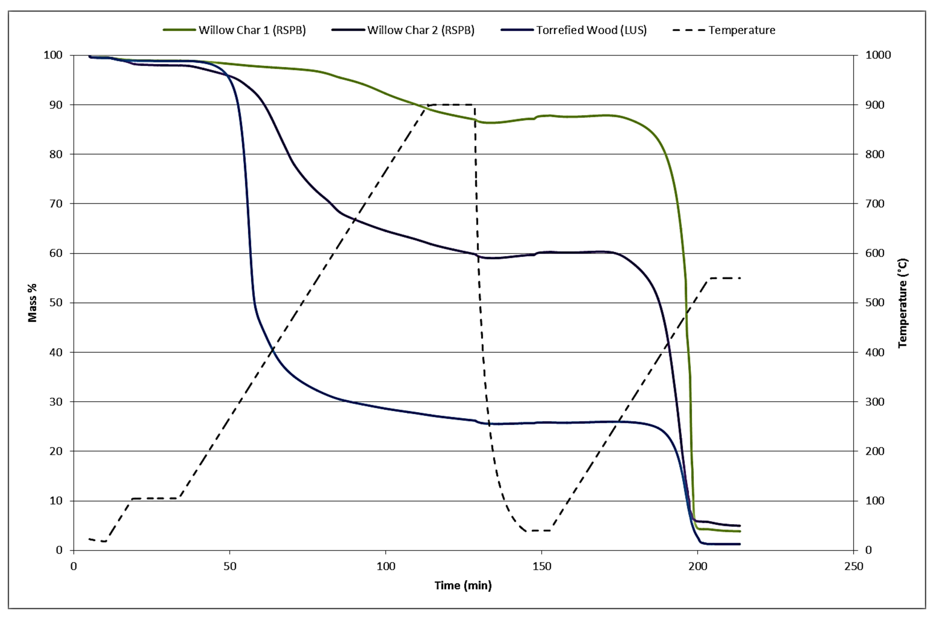

Figure 3. Mass Loss Curves for Chars and Torrefied Wood from TGA Analysis

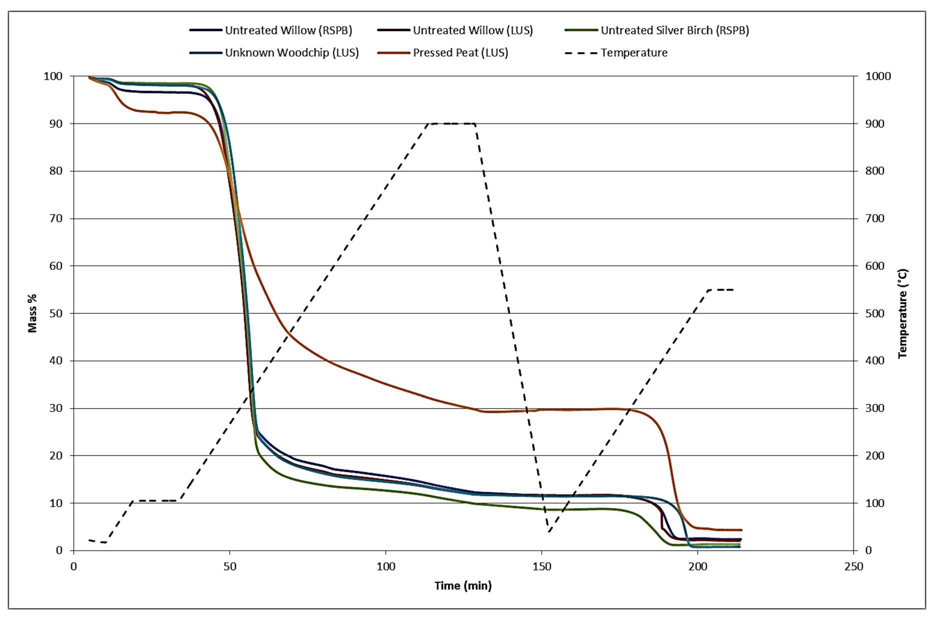

Figure 4. Mass Loss Curves for Wood and Peat Samples from TGA Analysis

Analysis of the amounts of volatile matter, fixed carbon and ash can be conducted using Thermo-gravimetric analysis-TGA. This form of analysis allows for the production of mass loss curves.

The mass loss curves for the Willow Chars showed that the basic constituents of the samples differed significantly. Willow Char 1 had a greatly reduced volatile content in comparison to Willow Char 2. On a dry mass basis. This has resulted in a difference of 28.3% of Fixed Carbon content between the two samples. An effective charring process should result in the majority of the volatile matter being removed, giving a certain level of uniformity.

The mass loss curves of the Silver Birch and Willow samples are all very similar with the volatile matter being the key component.

The ash content and composition is important for certain types of combustion systems so needs further analysis.

Fuel Quality – Trace Elements

The fundamental CHNO data for the samples showed very little difference between the untreated samples. However there was a clear differentiation between the two Chars. The results are consistent with the findings of the proximate analysis.

Trace elements contained in the biomass can have significant effects on its combustion performance. Inductively coupled plasma mass spectrometry (ICP-MS) was used to give a detailed chemical analysis of the trace elements found in the samples.

The most significant trace elements in the NNR wood samples were sodium, chlorine and calcium. High sodium and chlorine levels are due to the salty growing conditions.

Sodium and potassium are associated with slagging and fouling in large scale combustors, and chlorine is associated with corrosion, although there is less data available for small scale combustion units. Washing the samples could offer a potential solution for the reduction of trace elements found within the wood.

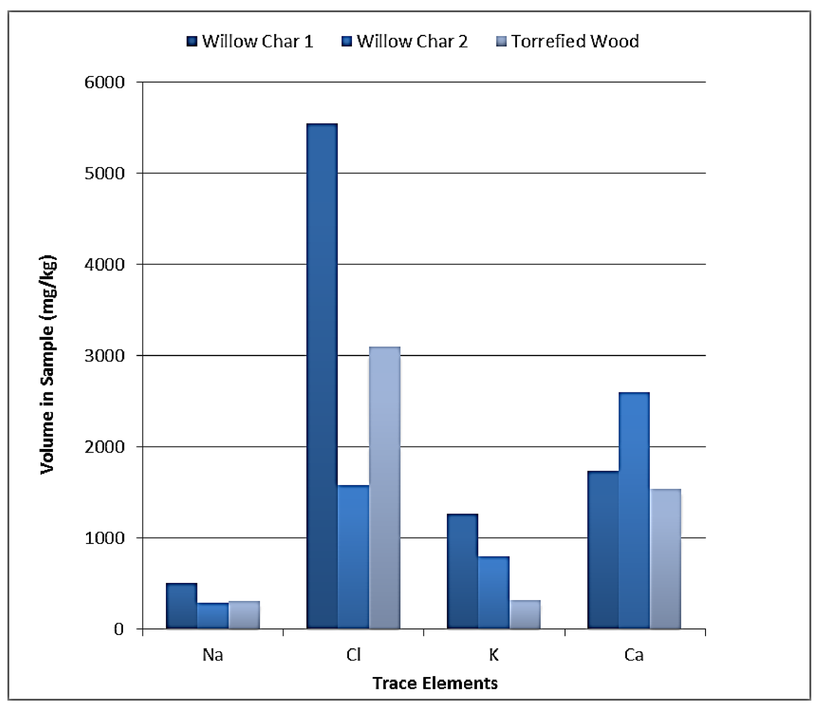

Figure 5. Trace Element Content within the Chars and Torrefied Wood

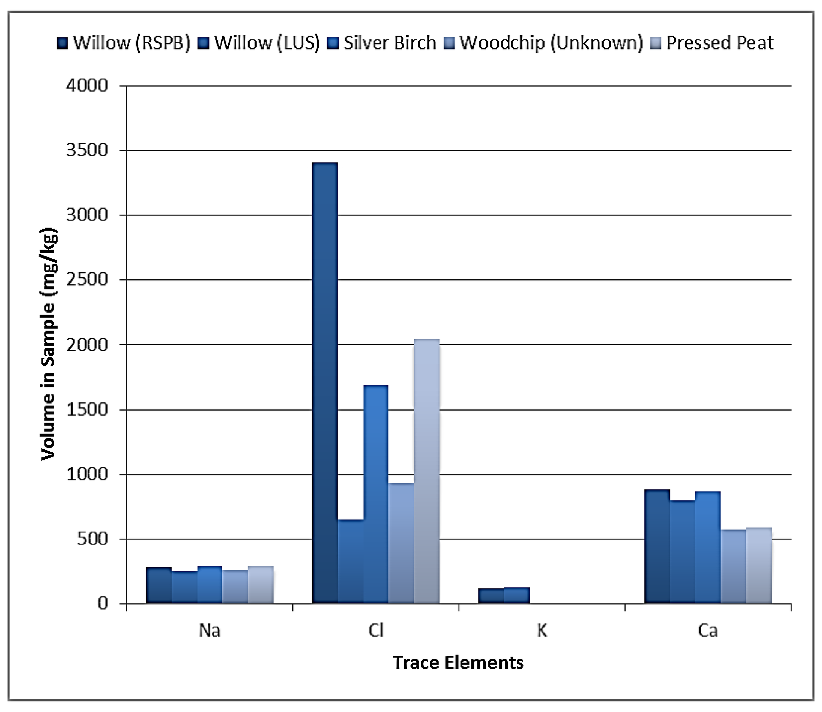

Figure 6. Trace Element Content within the Untreated Woods and Peat

Combustion tests

High levels of trace elements could be an issue in some combustors, although the effects on small scale lower temperature combustors is still to be evaluated.

Tests at Leeds will include an elemental balance to see whether trace elements are retained in the ash or emitted with the flue gases.

Tests using a 5kW domestic stove are underway.

Figure 7. Stove operating with scrub willow

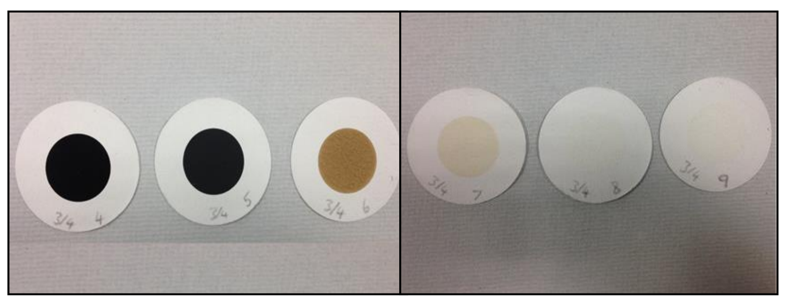

Figure 8. Particulate emissions from stove

Wood can be tested as small logs or as briquettes. With no processing of the wood, a standard stove would only be able to fit 1kg in, which burns quickly, requiring constant attention to ensure its stays lit.

- Analysis includes thermal performance and emissions
- Emissions tests include gaseous emissions such as CO, NO and NO_2
- Particulate emissions include mass and particle size.

Summary

- There are high levels of trace metals found in the NNR wood samples including problematic elements such as chlorine, sodium and potassium.
- To increase the viability of the feedstock, pre-treatment should be employed in the attempt to reduce the levels of trace elements.
- Some form of processing such as briquetting or pelletizing, is required to increase the density of the willow and silver birch for use on a domestic scale.
- Charred briquettes might provide the most benefit in terms of minimal transport and storage costs. However, the charring process should be reassessed to ensure uniformity issues are resolved.
- In future research, the gaseous and particulate matter emissions will be measured to evaluate the fuel's suitability as a commercially available solid fuel for biomass stoves.

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