

A CHARACTERISATION OF THE ASH CONTENT OF CONIFER STUMP WOOD HOGFUEL

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Abstract: A study was carried out in the south-east of Ireland in which stumps were harvested on two conifer clearfell sites: a peat soil site and a peaty gley site. The stumps were harvested by excavator machines with a stump harvesting head which split and shook the stumps during excavation in order to remove soil. The stumps were stored on the site for a period of 9 to 10 months to further reduce soil contamination by weathering. The stumps were forwarded to the roadside and comminuted into hogfuel with a shredder. Samples were collected and prepared in three ways: clean stumpwood, hogfuel as received, and sieved hogfuel. The clean stumpwood was collected from stumps with a chainsaw prior to shredding. The hogfuel as received was collected from the shredder. The sieved hogfuel was prepared using an oscillating screen sieve with sieves ranging between 1 mm and 63 mm circular holes. The samples were analysed for ash content using a muffle furnace, and gross calorific values using an oxygen bomb calorimeter. Results have allowed for the comparison of clean stumpwood and hogfuel as received, which identifies the proportion of ash content associated with soil contamination, and that which is inherent to stumpwood. Results also describe the ash content and calorific value along the particle size distribution, and describe which particles, and thus the proportion of the fuel, need to be sieved out in order to increase the fuel quality to an acceptable condition.

Key words: stump harvesting, ash content, sieving.

1. Introduction

The development of wood energy markets in Ireland has increased the interest of using stumps as a fuel. Extracted stumps contain soil and stone contaminants, which can cause high ash contents in the fuel. High ash content is

problematic for combustion, as it reduces the fuel calorific value, may cause clinker ash waste in the boiler and increases the management problem of ash disposal. In Sweden, it has been shown that is possible to reduce hogfuel ash content by sieving out soil and stone contaminants [1].

This paper aims to characterise the ash of

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stump hogfuel to describe:

- i) The ash inherent in stumpwood, i.e. clean stumpwood that is free from contaminants;
- ii) The ash content of stumpwood hogfuel as received (AR), and thereby evaluate the level of contamination due to soil and stones;
- iii) The ash content of sieved stumpwood hogfuel fractions, and thereby investigate the distribution of contamination and evaluate the possibility of improving the fuel quality using screens.

For each of these treatments, the gross calorific value of the material is also analysed, so that the effect of the ash content on the energy value of the fuel can be described.

2. Methodology

The study was carried out on two Sitka spruce (*Picea sitchensis* (Bong.) Carr.) forest plantations post clearfell. The stumps were harvested from the ground using a 12 tonne Kobelco excavator fitted with a stump harvesting head. The stump harvesting head was made by the contractor. The stumps were stored in windrows on the site for 7 to 8 months, extracted to the roadside using a John Deere 810D forwarder, left for a further 2-month storage period, and then shredded into hogfuel using a Jenz BA 725 shredder. The site details are as follows:

- Rossmore, IS 65432 IG 74872, 1.25 ha. Peaty Gley soil type, 913 stumps were excavated between May and June 2012 from recently felled clearfell trees (79%), 113 stumps were from previous thinning trees (10%), and 125 stumps were decayed (11%). The stumps were stored until February 2013;
- Errill, IS 19150 IG 77400, 0.81 ha.

Peat soil type. 1225 stumps were excavated between May and June 2012 from recently felled clearfell trees (66%), 38 from previous thinning trees (2%), and 600 were decayed (32%). The stumps were stored until February 2013.

After the storage period, a clean sample was taken from 30 whole stump pieces on each site. The surface was cleaned of all soil and stones, and the samples were taken using a chainsaw as a wedge from the main part of the stump in ground contact.

Thirty hogfuel samples were collected from each site during the shredding operation. This hogfuel contained the soil and stone particles that were attached to the stumps when they were being shredded. Each hogfuel sample was divided into two portions, so that each portion was representative of the whole sample, according to EN 14780. One portion of each sample was used as the As Received treatment.

The other portion of each sample was sieved, according to the particle size distribution determination method using an oscillating sieve as per EN 15149-1:2010. The sieve apertures used were: 63mm, 45mm, 31.5mm, 16mm, 8mm, 3.15 mm and 1 mm (Fig. 1). Particles with one or more dimensions bigger than 100mm were separated out. Sieving was performed for 15 minutes at approximately 220 rpm.

Ash content (Ad), expressed as percentage dry weight (Table 1), was determined using a Carbolite muffle furnace at 550 °C, according to EN 14775:2009. Gross calorific value (GCVdb), expressed in Mega Joules per kg dry matter, was determined using a Parr 5500 oxygen bomb calorimeter, according to EN 14918:2009.

Ash contents of Clean and As Received stumpwood on the two sites Table 1

Sample ID	Site	Soil type	Type	N	Ad % Mean	St. Dev.	Min.	Max.	Differs from*
a	Rossmore	Mineral	AR	30	19.1	11.4	3.7	49.3	bcd
b	Rossmore	Mineral	Clean	30	0.5	0.3	0.1	1.3	a
c	Errill	Organic	AR	30	0.7	0.4	0.2	1.7	a
d	Errill	Organic	Clean	30	0.7	0.5	0.1	2.8	a

*At the 95 % confidence level. AR = As Received



Fig. 1. Sieves used in fractioning out the particle sizes of the hogfuel

3. Results and Discussion

Table 1 details the ash contents of the Clean and As Received stumpwood as observed on the two sites. Statistically, there was no difference in ash content between sites for the Clean treatment, giving a good indication of the inherent ash within the stumpwood as being in the region of 0.5 - 0.7 %, and having a fairly homogenous nature. There was no significant difference between the Clean and As Received treatments ($\alpha=0.05$) on the

organic soil site. It was found that there was a large difference between the As Received and Clean treatments on the mineral soil site. The mean ash content As Received on the mineral soil site was 19.1%, whereas, the clean stumpwood was 0.5%, indicating a high level of contamination from the mineral soil. It also suggests that it may be possible to improve the fuel quality through sieving. The As Received treatment had a large variation, from 3.7% to 49.3%, indicating the heterogeneous nature of the stumpwood with contaminants. Also, the minimum observed ash content of the As Received samples were not as low as the maximum of the clean samples, suggesting that the contamination is widespread within the hogfuel. It is likely that certain parts of the stumps have a low ash content, particularly within the stump however, it is likely that during shredding the material is mixed so that a higher ash content is observed throughout.

The Errill site, which is located on an organic peat soil, had an average ash content of 0.7 % for both As Received and Clean treatments. This may be due to the peat soil having fallen off during stump processing and any remaining peat soil having a low ash content, with the organic fraction burned off in the combustion process. The data also shows that peat contamination adds to the energy content of the fuel ($\alpha=0.05$), as shown in Figure 2.

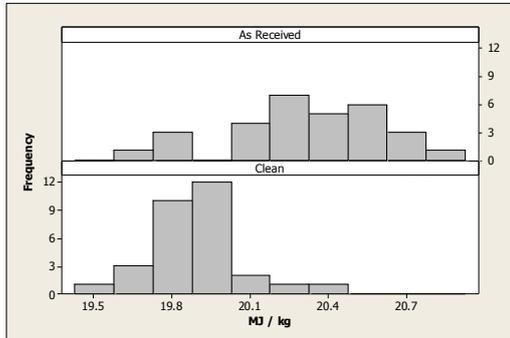


Fig. 2. Gross Calorific value (dry basis) of the As Received and Clean treatments on the organic peat soil site. Means: Clean = 19.9 MJ/kg, As Received = 20.3 MJ/kg.

The average calorific value of the Clean treatment was 19.9 MJ/kg, while the average for the As Received treatment was 20.3 MJ/kg. As a result, there would be no benefit in terms of ash content or calorific value in reducing peat soil contamination, unless there was some other component, such as sulphur, which needed to be monitored. However, this was outside of the scope of this study. As there was no significant difference in ash contents between the Clean and the AR treatments on the organic soil site (Errill), the data for this site was not included in the sieving analysis. Table 2 details the ash content and the gross calorific value of the sieved fractions observed on the mineral soil site,

and also the percentage dry mass of each fraction in the particle size distribution of the hogfuel. What can be seen from the data is that the majority of the ash resides in the finer particle sizes, possibly due to two reasons: *i*) during shredding, the contaminants are broken up into fine particles; *ii*) the sieving also mechanically separates contaminant particles off some of the larger pieces. The data shows that the fine particles less than 1 mm in dimension consist of 79.4 % ash, and the ash content reduces as particle size increases, to an ash content of 1.1 % for particles over 45 cm in dimension. The gross calorific value, dry basis also reflects this trend, increasing as particle size increases and as ash content decreases. The gross calorific value for the less than 1 mm dimension particles is 4.1 MJ/kg, whereas the gross calorific value for particles over 45 cm in dimensions is 19.9 MJ/kg. It should be noted, that these differences are mostly due to the incombustible mass attributed to the ash content. If the gross calorific value is calculated on a dry ash free basis, all of the fractions have a value of between 19.4 and 20.5 MJ/kg. Figure 3 illustrates estimates for the reduction in ash content possible when screening out particle size fractions from the hogfuel.

Ash Content and Gross Calorific Value (dry basis) of sieved fractions
(standard deviations in parenthesis)

Table 2

Particle Size (mm)	Percentage Dry Mass (%)	Ad (%)	GCVdb (MJ/kg)
>45.0	32.0 (2.3)	1.1 (0.3)	19.9 (0.1)
45.0-31.5	2.9 (1.0)	1.7 (0.2)	19.8 (0.2)
31.5-16.0	14.3 (0.3)	2.6 (0.8)	19.6 (0.2)
8.0 – 16.0	17.1 (1.0)	5.7 (1.9)	19.1 (0.1)
8.0-3.15	12.8 (1.9)	26.7 (2.9)	15.0 (0.2)
3.15-1.0	9.2 (1.1)	61.8 (5.0)	7.4 (0.2)
<1.0	11.8 (2.0)	79.4 (0.8)	4.1 (0.3)

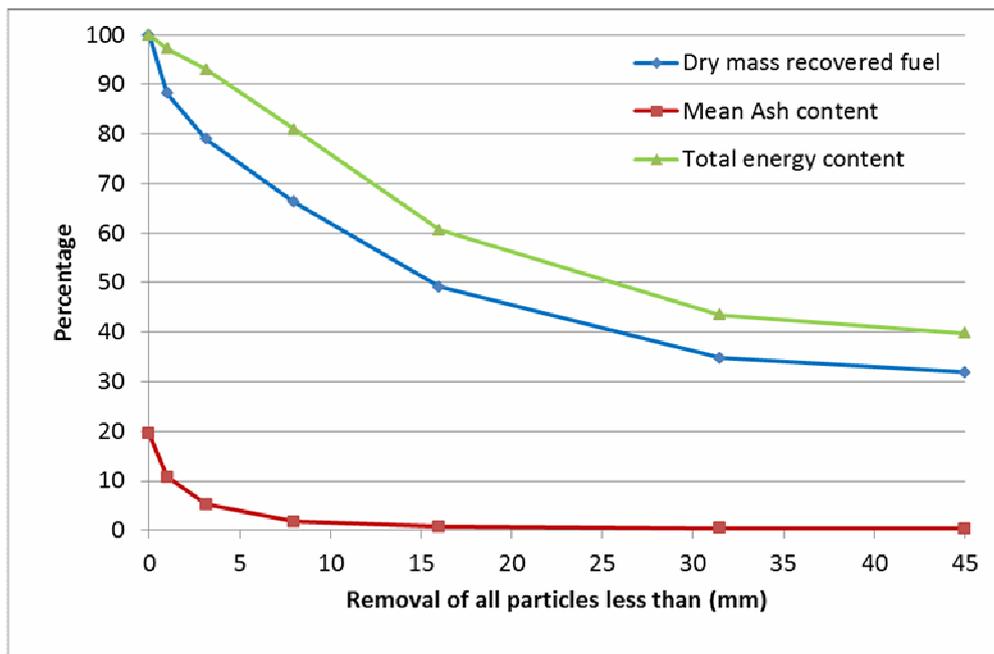


Fig. 3. Reduction in ash content, mass, and energy content from sieving on the mineral soil site

The data shows that the mean ash content can be reduced to 1.7 % by removing particles of less than 8 mm, with the consequences of reducing the dry mass of recovered fuel by 33%. However, because these small particles have such a high ash content, the reduction of the total energy is only 19 %.

4. Conclusions

The Clean stumpwood from both the mineral soil and organic soil sites had low homogenous ash contents, as did the As received hogfuel from the organic soil site. The As received hogfuel from the organic soil site had higher GCVdb than the clean stumpwood, probably due to the combustion of peat soil with a higher calorific value than wood. The As Received hogfuel from the mineral soil site had high mean ash content of 19.1%.

It was possible to reduce this high ash content to 1.7% by removing all particles

less than 8 mm in dimension. It is estimated that this would cause a loss of 33% of the hogfuel dry mass recovered, but only a loss of 19% of the total recovered energy content. More fuel could be recovered, while maintaining an acceptable ash content, by reducing the sieve screen size to between 3.15 and 8 mm. Further research would be required to determine the optimum screen size for a required ash content.

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References

1. Anerud E., von Hofsten H., Eliasson L., 2016. An alternative supply

- system for stump biomass - coarse grinding combined with sieving of the produced hog fuel. In: *International Journal of Forest Engineering*, vol. 27(2), pp. 109-114.
2. ***, 2009a. EN 14775:2009. Solid biofuels - Determination of ash content.
 3. ***, 2009b. EN 14918:2009. Solid biofuels - Determination of calorific value.
 4. ***, 2010. EN 15149-1:2010. Solid biofuels - Determination of particle size distribution.
 5. ***, 2011. EN 14780:2011 Solid biofuels - Sample preparation.