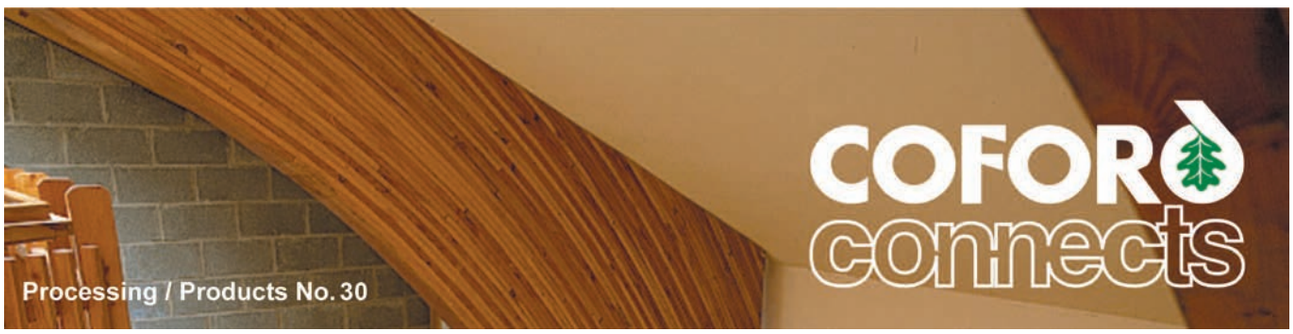

Ash content of Irish woodfuel

Eleanor Owens and Sarah Cooley

- *The ash content of woodfuel (green or seasoned) varies according to species and assortment. Content decreases in the order: wholetree, energy wood, firewood, shortwood. The summary table displays the mean ash concentration range for Sitka spruce assortments (whole tree, short wood, energy wood and fire wood).*

Ash content of Sitka spruce

Assortment	Green	Seasoned (one summer)	Seasoned (two summers)
		Range % ash w/w db	
Wholetree	0.85 – 2.07	0.59 – 1.27	0.64 – 0.84
Shortwood	0.29 – 0.54	0.32 – 0.54	0.30 – 0.43
Energy wood	0.39 – 1.46	0.49 – 1.26	ns
Firewood	0.20 – 0.61	0.51 – 0.57	ns

ns: not sampled

- *Wholetree, shortwood, energy wood and firewood assortments experienced no substantial decrease in ash concentration on seasoning*
- *Mean ash concentration decreases in the order ash[1] > Sitka spruce > hybrid larch.*

Introduction

In Ireland, the large-scale use of wood fuels is a relatively recent development. However, wood is one of the most important renewable energy sources in Ireland in terms of contribution to primary energy requirements [1]. The estimated 2011 total demand for wood energy, excluding post consumer recovered wood (PCRW), on the island of Ireland is 1.59 million m^3 (ROI 0.95 million m^3), and this is estimated to increase to 3.08 million m^3 (ROI 1.67 million m^3) by 2028 [2].

As well as being renewable, woodfuel does not contribute to net greenhouse gas emissions where replacement trees are planted to remove emitted carbon dioxide from the atmosphere. Also, wood (if properly dried and combusted) is a virtually smoke-free fuel and, unlike some fossil fuels, emits low levels of polluting sulphur.

The end product of full woodfuel combustion is ash. It is an inorganic material and comprises some of the major and minor nutrient elements that trees need to grow (although nitrogen may only be present in trace amounts since it is oxidised during the combustion process). Ash content is not fixed, but depends on tree species, wood assortment, where the trees have come from, as well as combustion conditions. Unexpectedly high levels of ash may indicate that woodfuel has been contaminated along the supply chain, with for example soil or sand. Woodfuels that result in high amounts of ash may cause problems for the end-user, by the need to empty ash more frequently, but for large installations it is costly if the ash has to be land-filled. It is also generally accepted that ash deposits can cause problems for burners. Agglomerates of ash can adhere to the surfaces of the burner and may result in corrosion (especially if the ash contains high amounts of alkali metals and chlorides), leading to reduced net output of heat or device failure. Therefore, knowing the ash content of the wood is important in certain applications.

Sampling and ash content determination

Wood fuel samples were collected from the ForestEnergy programme 2006-08 sites. Samples were taken from different species, wood assortments and at different seasoning times. Unless specified, all samples were taken from a commercial first thinning harvesting trial (COFORD Connects Notes Harvesting/Transportation Nos. 26 and 27) [3, 4].

In the ForestEnergy programme trial, four different assortments were harvested:

- Whole trees, including top and branches, which were chipped after a seasoning period;
- Shortwood, 3m long cleanly delimbed pulpwood logs;
- Energy wood, 3 to 6m long crudely delimbed logs, with some branch stubs and
- Firewood, cut and split to 25-30 cm lengths.

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1. *Where underlined, ash refers to the tree species Fraxinus excelsior, elsewhere it refers to ash material.*

Samples were taken at the time of felling (green samples) and after one or two summer's seasoning (brown samples).

The ash content was determined in accordance with the European Standard EN 14775:2009, *Solid Biofuels -Method for the determination of ash content* [5]. The percentage ash is determined from the mass of residue remaining after the sample is heated under air controlled conditions. A Nabertherm muffle furnace was used to ash the samples at 550 ± 10 °C. Ash content is expressed as the weight of ash as a percentage of the moisture-free dry weight (w/w) of the sample (db).

Triplicate ash content values were determined for each sample. The mean ash value and standard deviation (SD) of the triplicate values are tabulated below. The standard deviation shows how much variation there is between the three samples.

Results

Typical ash contents for virgin wood materials and virgin bark for coniferous and broadleaved species are shown in Table 1 [6].

Table 1: Typical ash contents for virgin wood materials and bark.

Source of wood	Coniferous species		Broadleaved species	
	Typical Value	Typical range	Typical Value	Typical range
	% ash w/w db			
Virgin wood (with or without insignificant amount of bark, leaves and needles)	0.3	0.2- 0.5	0.3	0.2-0.5
Virgin bark material	4	2-6	5	2-10
Virgin wood materials (logging residues)	2	1-4	1.5	0.8-3.0

Table 2 shows typical ash contents for whole tree samples, based on the Phyllis database (which contains information on the composition of biomass and waste) [7].

Table 2: Typical ash contents of wholetree samples for a number of tree species [7].

Species	Phyllis ID	% ash w/w db
Beech	55	0.6
Beech	2215	1.0
Birch	74	0.3
Birch	1773	0.4
Lodgepole pine	124	4.7
Red alder	67	0.4
Red oak	95	0.2
Sitka spruce	181	2.1

In Table 3, the mean ash content of Sitka spruce assortments (wholetree, shortwood, energy wood and firewood) from eight of the ForestEnergy programme sites, and from one other site, are presented. At all locations, trees or logs were seasoned for one summer and some for two summers.

Across all sites the ash content was greatest in wholetree freshly-felled Sitka spruce. This is to be expected, since the wholetree assortment contains the highest amount of branch wood, bark, twigs, needles and shoots/leaves with typical ash contents of 0.5%, 2.6%, 2.3%, 5.2% and 4.0%, respectively [8].

Ash contents of wholetree Sitka spruce were similar across all sites, except Abbeyfeale where a lower ash content was recorded. However, trees at this site were much larger than those from other sites, which may explain this result. Also, wholetree samples taken from Swan and Kilbrin appeared to have ash contents which were much higher than at other sites. It should be noted that the standard deviation value of the Swan value was very high possibly indicating some contamination. The ash content for the wholetree assortment did not decrease on seasoning in samples from Abbeyfeale, Ballybofey, Bweeng, Woodberry, and Croaghrimcarra, whereas the ash content did reduce in samples taken after seasoning at Kilbrin. The seasoned mean ash concentration at Kilbrin was similar to the seasoned values from the other sites. This suggests that the green Kilbrin sample may have experienced some contamination along the supply chain.

Shortwood gave similar mean ash contents across all sites which did not change on seasoning, except for Woodberry. At Woodberry, the green shortwood sample had an ash value which was 31% lower than the corresponding values at the other sites. On seasoning this value increased to a value similar to the other sites.

Table 3: Mean ash content of Sitka spruce assortments from different locations and with varying seasoning.

Site	Assortment	Condition (and storage duration)	Mean	Standard deviation
			% ash w/w db	
Abbeyfeale	WT	Green	0.85	0.08
Abbeyfeale	WT	Brown (5 months)	0.84	0.10
Abbeyfeale	WT	Brown (16 months)	0.84	0.10
Abbeyfeale	SW	Green	0.40	0.02
Abbeyfeale	SW	Brown (5 months)	0.48	0.11
Abbeyfeale	SW	Brown (16 months)	0.43	0.06
Abbeyfeale	EW	Green	0.44	0.11
Abbeyfeale	EW	Brown (5 months)	0.54	0.11
Abbeyfeale	FW	Green	0.49	0.10
Ballybofey	WT	Green	1.01	0.06
Ballybofey	WT	Brown (5 months)	1.19	0.07
Ballybofey	SW	Green	0.41	0.06
Ballybofey	SW	Brown (5 months)	0.32	0.04
Ballybofey	EW	Green	0.58	0.04
Ballybofey	EW	Brown (5 months)	0.50	0.01
Ballybofey	FW	Green	0.63	0.01
Bweeng	WT	Green	1.16	0.15
Bweeng	WT	Brown (5 months)	1.27	0.17
Bweeng	SW	Green	0.46	0.04
Bweeng	SW	Brown (5 months)	0.40	0.07
Bweeng	EW	Green	0.53	0.03
Bweeng	EW	Brown (5 months)	0.49	0.02
Bweeng	FW	Green	0.55	0.04
Swan	WT	Green	1.87	0.79
Swan	WT	Brown (6 months)	0.59	0.11
Swan	SW	Green	0.54	0.04
Swan	SW	Brown (6 months)	0.51	0.11
Swan	EW	Green	1.46	0.16
Swan	EW	Brown (6 months)	1.26	0.08
Swan	FW	Green	0.60	0.08
Swan	FW	Brown (6 months)	0.57	0.18
Croaghrimcarra	WT	Green	1.16	0.13
Croaghrimcarra	WT	Brown (6 months)	0.90	0.09
Croaghrimcarra	WT	Brown (14 months)	0.64	0.06
Croaghrimcarra	SW	Green	0.40	0.03
Croaghrimcarra	SW	Brown (6 months)	0.32	0.02
Croaghrimcarra	SW	Brown (14 months)	0.30	0.09
Croaghrimcarra	EW	Green	0.39	0.06
Croaghrimcarra	EW	Brown (6 months)	0.52	0.01
Croaghrimcarra	FW	Green	0.20	0.04
Woodberry	WT	Green	1.02	0.13
Woodberry	WT	Brown (6 months)	0.78	0.10
Woodberry	SW	Green	0.29	0.01
Woodberry	SW	Brown (6 months)	0.54	0.05
Woodberry	EW	Green	0.63	0.06
Woodberry	EW	Brown (6 months)	0.58	0.02
Woodberry	FW	Green	0.61	0.11
Kilbrin	WT	Green	2.07	0.04
Kilbrin	WT	Brown (6 months)	0.66	0.20
Kilbrin	SW	Green	0.44	0.11
Kilbrin	SW	Brown (6 months)	0.51	0.08
Kilbrin	EW	Green	0.96	0.22
Kilbrin	EW	Brown (6 months)	0.60	0.27
Kilbrin	FW	Green	0.57	0.11
Kilbrin	FW	Brown (6 months)	0.51	0.24
Stradbally	WT	Green	1.55	0.32
Lismore	WT	Green	1.04	0.05

WT: wholetree, SW: shortwood, EW: energy wood, FW: firewood

Similar trends were found in the energywood samples. Again Swan energy wood samples had higher ash contents than the other sites. The mean ash values did not change on seasoning.

The Swan and Kilbrin sites were harvested and seasoned during 2006 whereas the remaining sites were harvested and seasoned from 2007 to 2008.

Comparing the ash contents in Table 3 with those Tables 1 and 2, shows that ash content of Irish Sitka spruce is within published values.

Table 4 shows the ash content for hybrid larch. Again the wholetree assortment contained higher ash contents than the other assortments. The other assortments contained similar amounts of ash. The ash content of hybrid larch (0.89%) was lower than the Sitka spruce value (1.30%). On seasoning, the wholetree assortment appeared to show an increase in ash content. However, when the standard deviation is taken into account the apparent increase is very small and not significant. There was no significant difference in ash content across the other assortments, again seasoning produced no change.

Table 4: Mean ash contents of Ballybofey hybrid larch assortments over one summer.

Assortment	Condition (and storage duration)	Mean	Standard deviation
		% ash w/w db	
Wholetree	Green	0.89	0.06
Wholetree	Brown (5 months)	1.25	0.16
Shortwood	Green	0.32	0.02
Shortwood	Brown (5 months)	0.29	0.09
Energy wood	Green	0.26	0.05
Energy wood	Brown (5 months)	0.51	0.12
Firewood	Green	0.31	0.06
Firewood	Brown (5 months)	0.40	0.11
Wholetree	Green	0.72	0.03
Wholetree	Green	0.62	0.08
Wholetree	Green	0.81	0.05

Ash wood from the Dovea and Greenane sites experienced some limited seasoning (Table 5). As expected, the wholetree assortment had higher ash content than other assortments, irrespective of location or season.
Given the limited number of seasoned samples, it appears that there was no change in ash content on seasoning.

Table 5: Ash content of wholetree ash at Dovea and Greenane.

Site	Condition (and) storage duration)	Assortment	Mean	Standard deviation
			% ash w/w db	
Dovea	Green (July)	Wholetree	1.92	0.50
Dovea	Brown (plus 2 months)	Wholetree	2.09	0.28
Greenane	Green (February)	Wholetree	1.50	0.11
Greenane	Brown (plus 7 months)	Wholetree	1.39	0.09
Greenane	Green (February)	Firewood	1.14	0.04
Greenane	Brown (plus 7 months)	Firewood	0.86	0.02
Greenane	Brown (plus 10 months)	Firewood	1.06	0.06

Ash, hybrid larch and Sitka spruce samples were taken from the Ballybofey site from May 2007 through to February 2008 for ash content determination (Table 6). Although a very limited data set is presented it is clear that the harvesting month influences the ash content in both the wholetree and firewood samples.

Table 6: Ash content of Ballybofey green ash, hybrid larch and Sitka spruce.

Sampling date	Assortment	Species					
		Ash		Sitka spruce		Hybrid larch	
		% ash w/w db					
		Mean	*Standard Deviation*	*Mean*	*Standard Deviation*	*Mean*	*Standard Deviation*
May 2007	Wholetree	1.36	0.24	ns		ns	
	Firewood	ns		ns		ns	
July 2007	Wholetree	1.96	0.09	2.30	0.12	0.71	0.07
	Firewood	1.11	0.02	ns		ns	
August 2007	Wholetree	1.36	0.25	1.34	0.14	1.29	0.14
	Firewood	1.01	0.10	ns		ns	
September 2007	Wholetree	1.20	0.05	ns		0.60	0.06
	Firewood	0.79	0.06	Ns		ns	
November 2007	Wholetree	1.34	0.01	2.05	0.15	0.72	0.13
	Firewood	0.98	0.01	ns		ns	
February 2008	Wholetree	1.07	0.05	1.17	0.09	ns	
	Firewood	1.00	0.09	ns		ns	

ns: not sampled

Ash contents for other species harvested during the ForestEnergy programme are provided in Table 7. However, it should be stressed that these samples were not part of the first thinning harvesting trials, but were from trees growing at ForestEnergy sites. Typically, the trees were small and as such the ratio of bark to wood would be greater, and probably having higher ash contents than equivalent trees at the first thinning stage. Age information was not available for the trees from the sites, so care should be exercised in using the data. Within a species a wide range of ash contents can be found, depending on the bark to wood ratio.

Table 7: Ash content (green) of a number of tree species at different sites.

Species	Site	Assortment	Mean	Standard deviation
			% ash w/w db	
Alder	Ballybofey	Wholetree	0.89	0.06
Beech	Ballybofey	Wholetree	2.09	0.16
Beech	Dovea	Wholetree	1.88	0.04
Beech	Greenane	Wholetree	3.17	0.27
Birch	Bweeng	Wholetree	0.61	0.03
Cherry	Greenane	Firewood	1.09	0.18
Douglas fir	Ballybofey	Wholetree	2.01	0.15
Douglas fir	Lismore	Wholetree	1.04	0.03
Douglas fir	Stradbally	Wholetree	1.20	0.12
Japanese larch	Ballybofey	Wholetree	0.87	0.04
Japanese larch	Lismore	Wholetree	0.48	0.07
Lodgepole pine	Bweeng	Wholetree	1.25	0.04
Lodgepole pine	Croaghrimcarra	Wholetree	3.34	0.37
Norway spruce	Ballybofey	Wholetree	2.22	0.11
Oak	Ballybofey	Wholetree	1.70	0.08
Oak	Dovea	Wholetree	2.46	0.13
Oak	Dovea	Shortwood	1.97	0.20
Oak	Greenane	Wholetree	2.32	0.11
Oak	Greenane	Firewood	1.71	0.07
Oak	Portlaw	Wholetree	2.60	0.17
Oak	Stradbally	Wholetree	1.81	0.15
Red alder	Ballybofey	Wholetree	1.00	0.07
Red oak	Ballybofey	Wholetree	1.80	0.07
Sycamore	Ballybofey	Wholetree	1.76	0.13
Sycamore	Dovea	Wholetree	2.38	0.12
Sycamore	Dovea	Shortwood	1.16	0.14
Sycamore	Dovea	Wholetree	2.89	0.1
Sycamore	Greenane	Wholetree	1.92	0.08
Sycamore	Greenane	Firewood	1.62	0.08
Sycamore	Portlaw	Wholetree	1.50	0.10
Western red cedar	Ballybofey	Wholetree	2.82	0.27

Conclusions

The results show that the ash content of a wood fuel (green or seasoned) is affected by species, assortment, tree size, location and time of harvesting and chipping method.

- Whole tree assortments produced the greatest amount of ash irrespective of species or site.
- For Sitka spruce mean ash concentration of WT > EW > FW > SW. From the limited number of hybrid larch and ash samples included in this programme, it also appeared that WT > EW > FW > SW.
- On seasoning there was very little change in the mean percentage ash values, irrespective of assortment or site.
- Hybrid larch contained less ash than Sitka spruce but displayed similar trends on seasoning.
- Harvesting month affected ash content, peaking in the summer months.
- Although a more comprehensive study of Sitka spruce was undertaken, the ash content of ash was higher, irrespective of assortment or seasoning (Table 8).

Table 8: Ash content of ash and Sitka spruce.

Assortment	Condition	Species	
		Ash	Sitka spruce
		% ash w/w db	
Wholetree	Green	1.50	1.30
Wholetree	Seasoned	1.91	0.86
Shortwood	Green	0.95	0.42
Shortwood	Seasoned	ns	0.42
Energy wood	Green	ns	0.71
Energy wood	Seasoned	ns	0.64
Firewood	Green	0.90	0.52
Firewood	Seasoned	0.80	0.54

ns: not sampled

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