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CHEMICAL PROPERTIES OF FUEL PEAT

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SUMMARY

The chemical properties needed to characterise the critical properties of peat as fuel and the analytical methods to be used are given in the Nordtest Method, NT ENVIR 009 – Quality Guidelines for Fuel Peat (approved in November 2005) and in former Finnish guidelines 1989 and 1991.

A large quality data set of fuel analyses concerning years 2001 to 2011 was collected.
The samples of this quality data are taken mainly from deliveries in order to determine the properties needed for invoicing, verification of the agreed quality, and control of emissions: net calorific value, ash content, CHNS and volatile matter. Samples taken for production control, for quality control and management of storage and for R&D purposes are also included. The main statistical figures as well as the distribution for all the determined properties are also given.

KEYWORDS: fuel, peat, quality, chemical properties

INTRODUCTION

Fuel peat is a local, solid biomass fuel used in significant amounts for energy production in Finland, Sweden, Estonia and Ireland. Milled peat is used in combined heat and power production; briquettes, pellets and sod peat are also used in smaller facilities, such as heating plants and households.

There have been quality guidelines in Finland since 1976 for defining the procedures, properties and analytical methods needed for the specification of commercially traded fuel peat types, for quality assurance, and for quality control. This report discusses the chemical properties and their analytical methods given in the guidelines of 1989 and 1991 (Polttoturpeen laatuohje 1989, Polttoturpeen laatuohje 1991), and in 2006 (Energiaturpeen laatuohje 2006).

MATERIALS AND METHODS

The quality data (n = 23820) concerns years 2001 - 2011and is almost solely from Finland (99.6 %). The samples have been taken and prepared for analysis according to the procedures given in the guidelines 1989, 1991 and 2006. They are collected mainly from deliveries in order to determine the properties of the peat dry matter which are needed for invoicing, verification of the agreed quality, and for the control of emissions (74.2 %). The sampling point (manual procedure or automatic equipment) has been at a receiving station located as near as possible after the unloading of the trucks (receiving bunker or conveyors). The data also includes samples for production control, for quality control and management of storage, and for R&D purposes. They have been taken either by manual methods (scoop or shovel) or using drills; 1.5 and 3 meter long during production, and 8 meter long for the ready storage stockpiles.

The properties determined (all expressed on a dry basis) are gross and net calorific value, ash content (815 °C and 550 °C), CHNS and volatile matter. All the analytical methods used are given in the above mentioned guidelines; they are ISO standards and CEN/TS or EN standards. The change from the methods given in the 1989 and 1991 guidelines to the NT ENVIR 009 methods took place in 2005 - 2007. The EN standards have been used since they were published in 2011.

Until August 2005 the determinations were performed in the laboratory of Vapo Oy and thereafter in Enas Oy, which was established by merging the laboratories of Vapo Oy and VTT Technical Research Centre of Finland in Jyväskylä.
The main statistical characteristics. i.e. average, median, variance, standard deviation, maximum and minimum (plus their difference max – min) and the 95% confidence limits were calculated together with histograms describing the distribution of the results of each property.
Also the number of measurements (results) n is given.

RESULTS AND DISCUSSION

The statistical figures are given in Table 1 and the distributions for each chemical property in Figure 1. The 95% confidence limits, upper and lower, are calculated as average ± standard deviation * 2. Please note that the comma has been used as the decimal mark in Table 1 and Figure 1.

Table 1, Chemical properties of fuel peat.

	Ash (815 °C)	**Ash** (550 °C)	**Gross calorific value**	**Net calorific value**	**Volatile matter**	**Hydrogen** (from V_d)	**Carbon** (CHN)	**Hydrogen** (CHN)	**Nitrogen** (CHN)	**Sulphur**
Methods	ISO 1171	EN 14775	ISO 1928 EN 14918	ISO 1928 EN 14918	EN 15148	empirical equation	EN 15104	EN 15104	EN 15104	ASTM D 4239 EN 15289
Symbol	A_d	A_d	$q_{V,gr,d}$	$q_{p,net,d}$	V_d	H_d	C_d	H_d	N_d	S_d
Units	**w-%**	**w-%**	**MJ/kg**	**MJ/kg**	**w-%**	**w-%**	**w-%**	**w-%**	**w-%**	**w-%**
n	21686	51	20008	20027	666	655	1229	67	662	19745
average	**5,63**	**5,73**	**22,00**	**20,78**	**67,85**	**5,52**	**53,84**	**5,64**	**1,63**	**0,213**
median	5,0	5,5	22,04	20,83	68,0	5,53	53,8	5,70	1,59	0,20
std	3,2	2,0	0,89	0,89	2,5	0,13	1,6	0,25	0,38	0,11
variance	10,4	4,0	0,80	0,80	6,0	0,02	2,4	0,06	0,14	0,01
max	39,9	14,9	25,42	24,20	74,5	5,8	59,4	6,20	3,25	3,01
min	0,5	2,4	13,68	12,46	56,6	4,7	46,3	4,90	0,19	0,01
max-min	39,4	12,5	11,74	11,74	17,9	1,1	13,1	1,30	3,06	3,00
95%max	12,1	9,7	23,78	22,56	72,8	5,77	57,0	6,14	2,39	0,43
95%min	n.r.	1,8	20,21	18,99	62,9	5,26	50,7	5,13	0,88	n.r.

During the time of the 1989 and 1991guidelines, the hydrogen content for the calculation of net calorific value from gross calorific value was often determined by an old empirical equation (Norlin, 1924)

$$3 + 0.001672 * V(d) * Q(gr,d)$$

where V(d) is volatile matter and Q(gr,d) gross calorific value in MJ/kg (coefficient has been turned to units MJ/kg). Another, more common way was to use the default value 5.6 w-% (dry basis) for the peat hydrogen content.

After the publication of NT ENVIR 009, the calculation of the net calorific value was performed in accordance of the equations of CEN/TS 14918 (later EN 14918) using the default value 5.6 w-% for hydrogen and 35 for sum of nitrogen and oxygen (N+O) or the CHN-analyser determined values (O calculated as 100 – [ash + C+H+N+S], all w-% dry basis). It must, however, be noted that the determination of hydrogen by a CHN-analyser has been asked for very seldom. The sulphur content has been determined using an automatic analyser. The determination of ash content of fuel peat is still mainly done at 815 °C instead of 550 °C (NT ENVIR 009). The reason is partly that determination at 815 ° is more "stable" and easier to do, and partly that 550 °C leaves the carbonates unbroken, which is not the case in normal burning conditions. Determinations at 550 °C are concentrated in very limited geological areas in Finland, and therefore the results cannot be regarded as representative. Some of the distributions are very close to symmetric Gaussians (e.g. calorific values and carbon content), but some of them are clearly skew (sulphur and ash content) resulting in the value of the lower 95 % confidence limit (95%min) being negative and therefore not relevant (n.r., see Table 1).

CONCLUSIONS

The main conclusion is that the variation of the chemical properties of fuel or energy peat is so wide that the use of default values is not reasonable, especially if the price of fuel is connected to them.
A closer analysis of the data also evidences that different typical value levels can be seen in different geographical areas, e.g. within Finland. The most clear is the variation in the nitrogen content; the average level in the southern part of the country is around 1.57 w-% (std 0.30 w-%), but in the northern part around 2.48 w% (std 0.33w-%). There are regional differences in the sulphur content; elevated levels are found typically in the eastern part of the country, especially in North Karelia. The results of sulphur in general and the appearance of higher values follow closely the levels and trends found in bog surveys (Herranen, 2009).

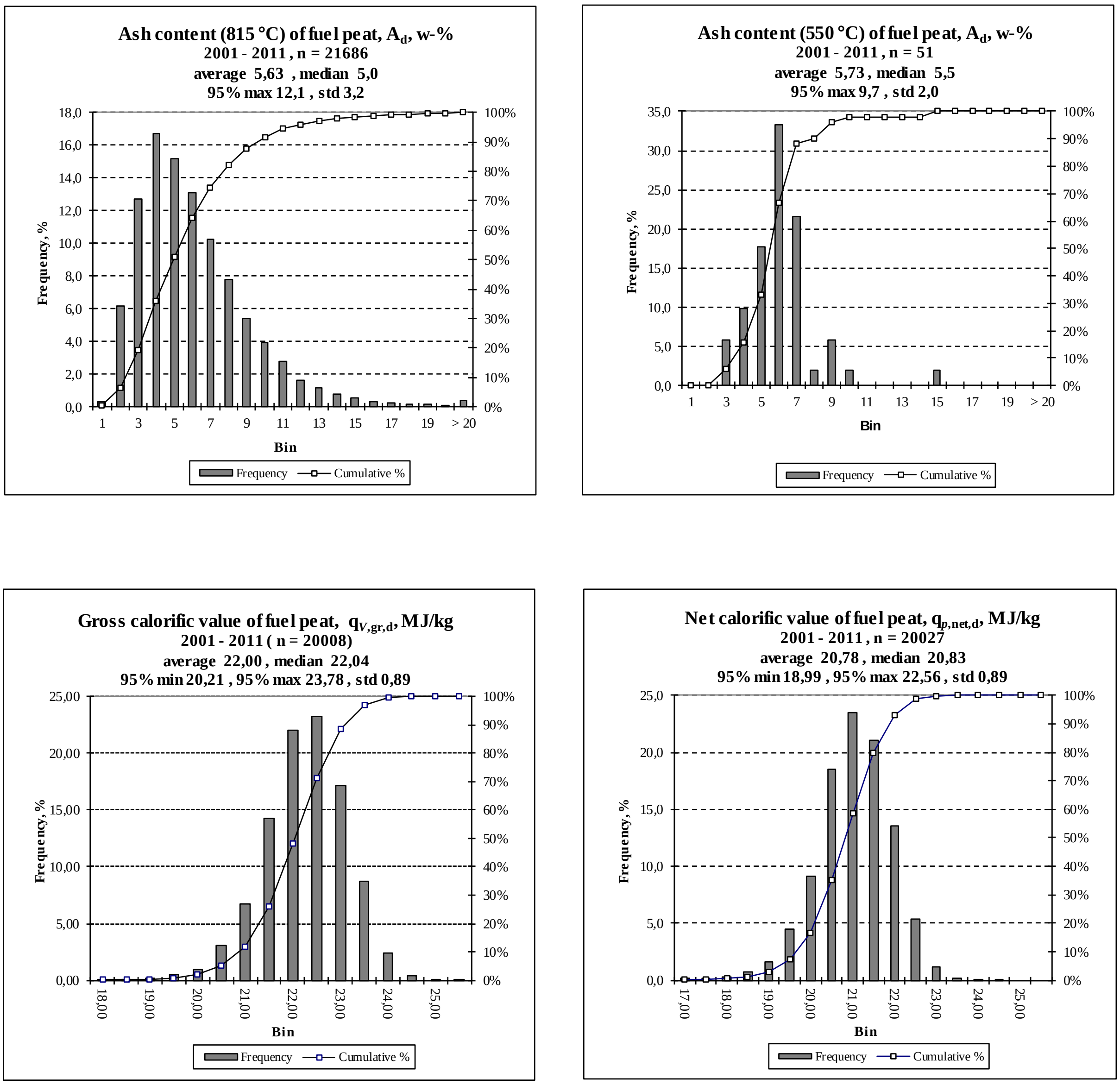
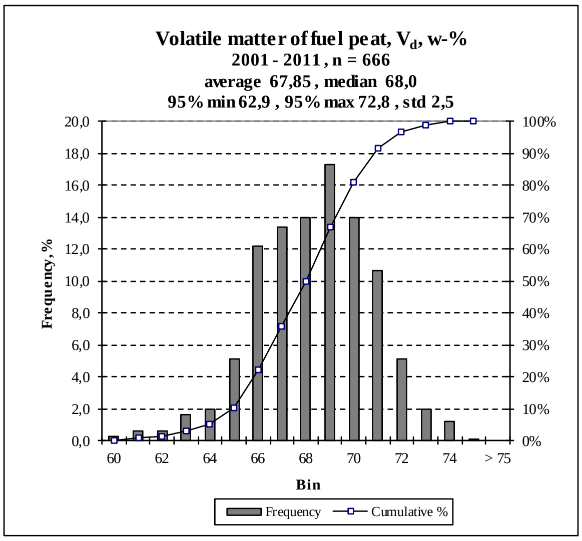
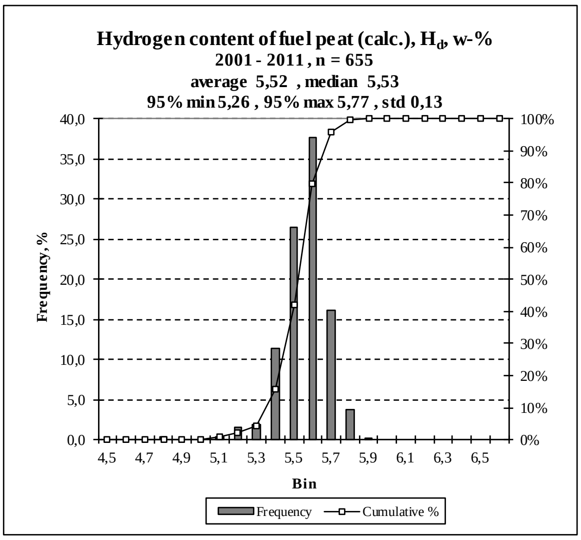
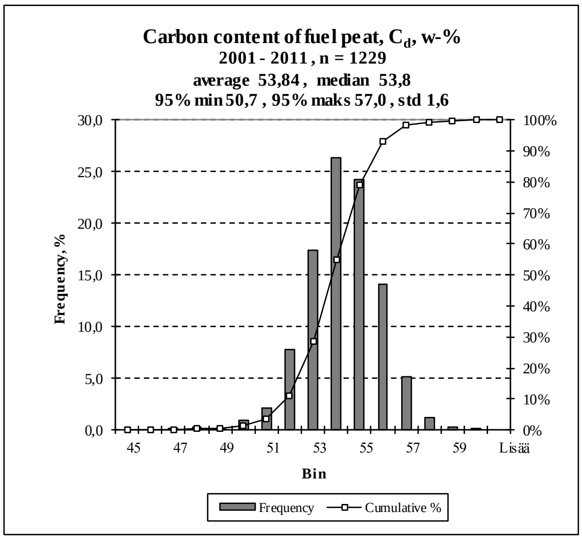
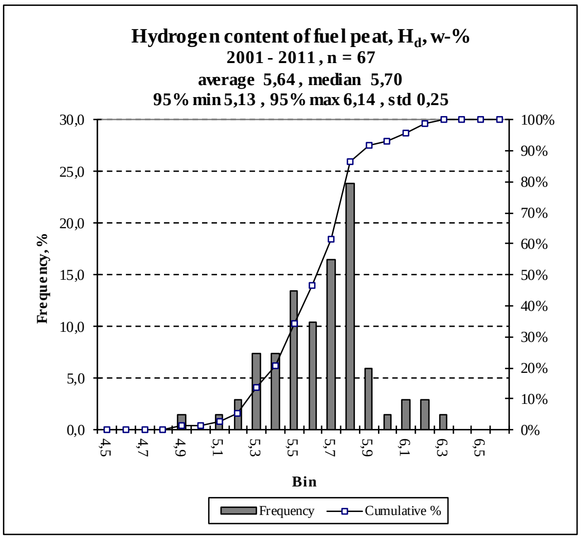


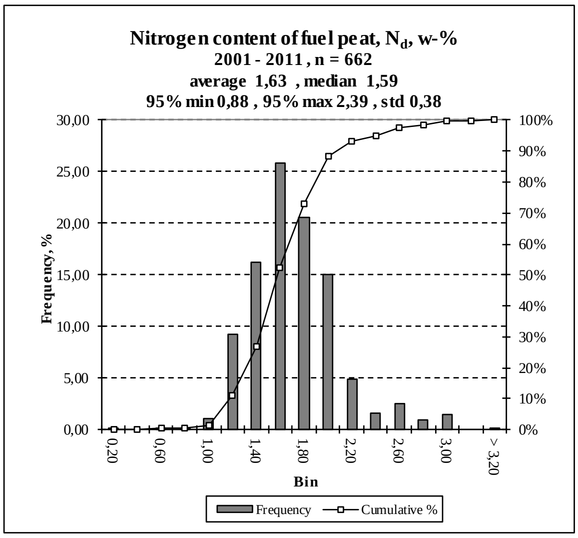
Figure 1, Distributions of the chemical properties of fuel peat











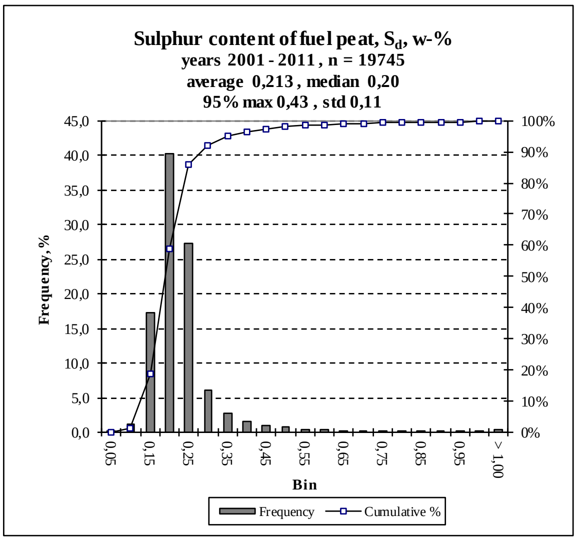


Figure 1, cont. Distributions of the chemical properties of fuel peat

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