Programme Area: Bioenergy

Project: Characterisation of Feedstocks

Title: D6 Final Report (Phase 1) Appendix 9

Abstract:

The primary objective of this 2015/16/17 Project was to provide an understanding of UK produced biomass properties, how these vary and what causes this variability.
This document is one of the appendices to the Final Report from the first Phase (2015/16) of the Characterisation of Feedstocks (CofF) project, Deliverable D6. D6 is provided in a number of parts consisting of the main body text plus 13 Appendices, provided in 17 files. These 13 appendices are provided in 12 pdf files plus 46 data files in Microsoft Excel format. The purpose of this report plus its related parts is to report the variability in feedstock properties of UK produced energy biomass, the causes of these variations and the relationship between the feedstock properties and the provenance data collected. Five feedstocks were studied: Miscanthus, willow short rotation coppice (SRC), poplar SRC, poplar grown as short rotation forests (SRF), and spruce SRF, with poplar and Sitka spruce selected to represent broadleaved and coniferous biomass crops respectively. Provenance data include site properties (such as general climate zone and soil chemistry), the conditions at the time of sample collection, and past management of the site and crop with soil samples also collected for analysis. The feedstock samples were analysed in UKAS accredited laboratories.

Context:

The Characterisation of Feedstocks project provides an understanding of UK produced 2nd generation energy biomass properties, how these vary and what causes this variability. In this project, several types of UK-grown biomass, produced under varying conditions, were sampled. The biomass sampled included Miscanthus, Short Rotation Forestry (SRF) and Short Rotation Coppice (SRC) Willow. The samples were tested to an agreed schedule in an accredited laboratory. The results were analysed against the planting, growing, harvesting and storage conditions (i.e. the provenance) to understand what impacts different production and storage methods have on the biomass properties. The main outcome of this project is a better understanding of the key characteristics of UK biomass feedstocks (focusing on second generation) relevant in downstream energy conversion applications, and how these characteristics vary by provenance.

Appendix 9: Total feedstock variance explained by consideration of the structured factors using REML, expressed as % of total variance

	Miscanthus	Willow SRC		Poplar SRF			Conifer SRF		
Variable (analysis basis of variable)		Stems	Leaves	Trunks	Tops	Leaves	Trunks	Tops	Bark
Structured factors included (and combinations thereof)	Climate zone Soil type Storage	Soil type Storage	Soil type	Climate zone Soil type Harvest Time Storage	Climate zone Soil type Harvest Time Storage	Climate zone Soil type	Climate zone Soil type Harvest Time Storage	Climate zone Soil type Harvest Time Storage	Climate zone Soil type Harvest Time
Moisture (ar)	50.4	30.2	0.9	68.7	78.5	22.4	59.5	60.8	22.0
Net calorific value (ar)	50.2	30.4	0.0	67.9	78.7	28.2	59.7	62.0	25.9
Ash content (d)	22.6	4.9	1.6	24.0	67.5	29.5	43.8	48.4	31.1
Volatile matter (DAF)	47.1	8.6	16.0	51.3	48.2	8.7	25.6	34.2	12.0
Gross calorific value (DAF)	40.8	19.1	26.9	37.7	39.6	11.2	21.8	41.9	37.6
Carbon (DAF)	43.6	61.0	0.2	38.8	56.5	4.4	50.3	32.4	19.2
Hydrogen (DAF)	46.2	51.4	67.4	28.6	55.0	5.6	40.8	58.5	25.1
Nitrogen (DAF)	40.6	7.8	38.9	63.2	62.5	22.7	48.3	40.4	35.8
Sulphur (DAF)	13.1	67.4	1.8	15.5	77.7	8.3	25.4	45.2	
Chlorine (DAF)	32.3	14.7	5.0	30.9	63.6	26.6	51.5	51.5	29.5
Barium (d)	13.5	11.9	7.5	29.9	20.4	31.1	41.9	40.1	19.1
Chromium (d)	7.9	58.2	2.9	20.5	15.7	27.8	27.7	20.8	19.9
Cobalt (d)	28.1	60.9	0.0	15.7	46.5	8.5	19.9	31.2	40.6
Copper (d)	24.4	50.9	23.1	27.6	30.1	9.6	34.2	60.0	40.1
Molybdenum (d)	36.1	54.6	3.6	22.9	59.1	28.7	41.4	46.8	40.6
Nickel (d)	35.2	20.5	2.7	22.1	33.6	3.1	25.9	49.5	25.6
Vanadium (d)	63.0	23.5	16.6	42.6	64.1	28.7	29.2	34.9	30.1
Zinc (d)	21.0	53.2	4.0	16.0	36.6	3.8	42.8	31.6	20.1
Antimony (d)			0.1			32.4			

Arsenic (d)			9.6			32.4			
Mercury (d)			3.1			15.9			
Bromine (d)			20.8			12.0			
Cadmium (d)	13.8		36.1	24.5	13.4	2.7	17.0	34.8	8.4
Lead (d)	17.5	20.1	60.9	29.1	7.7	21.1	21.1	38.4	14.0
Al_2O_3 (na)	22.4	31.5	29.8	32.7	56.3	29.2	34.4	43.4	33.6
BaO (na)	10.0	9.6	4.4	17.0	24.1	35.8	25.0	54.7	33.6
$CaCO_3$ (na)	39.7	7.2	18.0	27.2	53.1	6.3	25.7	46.7	38.3
Fe_2O_3 (na)	47.4	41.9	8.9	27.9	37.3	17.3	41.3	34.7	28.3
K_2O (na)	34.1	12.6	8.3	51.6	34.3	15.4	30.7	54.4	26.2
MgO (na)	47.6	13.9	8.8	15.6	14.3	13.4	35.1	20.1	16.1
Mn_3O_4 (na)	33.8	16.6	19.8	82.0	26.0	15.8	20.5	13.6	22.8
Na_2O (na)	32.1	9.3	60.5	19.4	64.3	49.8	25.1	34.8	42.7
P_2O_5 (na)	25.5	33.2	5.8	13.3	29.3	2.0	39.4	29.1	47.3
SiO_2 (na)	23.8	17.6	19.0	29.5	64.4	10.0	29.0	45.7	31.3
TiO_2 (na)	7.7	9.9	19.3	22.1	19.1	41.2	13.9	52.2	23.7
Aluminium (d)	14.4	41.7	36.3	32.8	66.2	10.9	23.8	45.4	37.4
Calcium (d)	34.9	18.1	2.5	14.7	50.6	22.0	49.2	39.9	27.7
Iron (d)	24.0	59.1	10.2	14.7	27.8	8.9	26.9	27.3	32.4
Potassium (d)	21.6	17.0	19.1	45.5	60.6	14.4	47.3	52.1	20.8
Magnesium (d)	33.9	18.5	8.4	29.1	35.2	14.9	38.0	33.8	28.3
Manganese (d)	25.3	19.3	20.8	75.4	48.9	9.4	24.3	22.8	21.3
Sodium (d)	16.7	27.1	44.8	22.3	38.1	43.5	28.7	35.8	50.9
Phosphorous (d)	20.1	14.1	4.2	23.0	41.4	19.5	38.5	22.5	45.2
Silicon (d)	18.1	23.3	15.8	29.5	76.4	12.3	32.0	47.4	36.3
Titanium (d)	8.3	17.8	16.4	30.7	30.9	45.7	22.8	47.6	26.4
Alkali index	21.6	16.4	17.2	45.3	60.1	14.8	48.3	51.7	21.0