BIOREFINERY OF VERGE GRASS TO PRODUCE BIO-FUEL

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ABSTRACT: Verge grass is an abundant biomass resource in The Netherlands that is available for energy production. The high content of ash, K, Cl and N limits its uses for thermal conversion due to corrosion and ash agglomeration problems. Experiments were carried out to separate verge grass material into a fibre fraction of good quality as a solid bio-fuel and other fractions for possible use as a protein source and/or fermentation fluid. In a mild pretriatment and separation proces the solid fibrous and wet fractions were separated. Asa Agglomeration test showed that agglomeration temperatures were increased to over 850°C. This was mostly due to a decrease in K and Na contents by 84% and 72% respectively. Thus it was possible to produce a solid bio-fuel suitable for thermal conversion using low value grass material. Improvements in the harvest and delivery chain and in the extraction procedure should make it possible to reduce water usage and increase protein (N) and free sugar concentrations in order to make use of the fluid fraction for other purposes like fodder or fermentation substrate.
Keywords: Agglomeration, biomass pre-treatment, biorefining.

1 INTRODUCTION

At the Kyoto Conference in 1997, the European Union (EU) and it's member states committed themselves to significantly reduce greenhouse gas emissions. As part of the Dutch commitment to the reduction of CO2 emissions the government has set a goal of producing 10% (270 PJ) of the total energy consumption from renewable sources by 2020. Up from less than 1 % in 1999. Energy from biomass will have to provide 75 PJ per year, equivalent to 5 million tonnes of biomass per year.

In a small and densely populated country like the Netherlands (<4 million ha and 16 million inhabitants) land for biomass production is scarce. Optimal use will have to be made of the available sources. Verge grass is an attractive biomass which generally has a low to negative value (-5 to -55 Euro per tonne). Harvesting the vegetation is necessary to maintain short vegetation for traffic safety and also reduces nutrient availability which decreases biomass production but also can increase the ecological value. The total area of verge grass mown in the Netherlands is approximately 50.000 ha producing approximately 200.000 tonnes (dry matter) which is collected. Some 20% of this grass is used as cattle feed. The remaining 80% is composted at high costs. These costs range from approximately 25 to 50 Euro per tonne fresh weight (approx. 50% DW). Furthermore there are extensive natural areas covered with grass vegetation where removal of the vegetation is part of the necessary maintenance.

Depending on the vegetation type and time of year verge grass contains valuable proteins, sugars and minerals, and often more than 50% fibre material. Using the verge grass for bio-energy production would both contribute to lowering the cost of highway and nature reserve maintenance and contribute to the production of renewable, CO2 neutral, energy. Several tests have shown that quality is (too) low to be of use for thermal conversion (low ash agglomeration temperatures, high moisture, N, K, Cl, ash and bad handling characteristics).

An answer to this problem may be the use of bio-refinery techniques. Bio-refinery concepts are used to produce a variety of products from biomass, thereby generating products for the food, feed, chemical and energy industries and obtaining the highest added value for the biomass producer. Bio-refinery concepts have been proposed as a way to improve properties of biomass for multifunctional and also for energy purposes.

1.1 Objective

The objective of this project was to investigate methods to separate verge grass material into a fibre fraction of good quality as a solid bio-fuel and other fractions for possible use as a protein source and/or fermentation fluid.

2. EXPERIMENTAL

In the fall and winter of 2000 grass material was harvested and collected according to standard current management practices from several natural areas in the Netherlands and transported to the laboratory. The material was stored under cold conditions (approximately 4°C) for approximately one day.
Samples were then treated according to the following general procedure:
- Chopping to 5 cm length
- Extraction using an extruder (low energy input)
- Rinsing with water (1:20)
- Pressing to remove water

The procedure yielded a solid fraction, consisting mainly of fibre, and a dilute fluid fraction. The fibre mass was air-dried at room temperature and standard analyses for composition were conducted. Agglomeration tests under realistic conditions were performed according to a procedure developed at ECN. Fluids from the rinsing procedure were collected and analysed for sugar and protein content.

3 RESULTS

The yield from the fibrous fraction amounted to at least 50% of the initial material (on a dry weight basis). The fibrous fraction clearly had better handling characteristics than the original material and can possibly be used in wood chip feeding systems.

In Table 1 analysis and agglomeration test results are shown of 3 samples before and after the extrusion and rinsing procedure. The ash agglomeration temperatures increased by the treatment to over 850°C, making the verge grass suitable as fuel for a wide range of thermal conversion systems. The material could be used as a fuel in current wood burning facilities in the Netherlands.

Table 1: Results from chemical analysis and combustion tests before and after extrusion and rinsing for three verge grass samples collected in the fall and winter from three different locations.

		De Wieden		Weerribben		Baarle-Nassau	
Component	unit[1]	before	after	before	after	before	after
HHV[2]	kJ/kg daf[4]	19571	20308	20246	20317	20375	20363
LHV[3]	kJ/kg daf	18143	18918	18919	19081	18999	19078
Moisture	wt% fresh	68.8	60.7	66	53.6	71	63.4
Ash	wt%	6.8	5.8	9.4	14.8	9.6	9.3
Aggl. Temp	°C	870	no	>825	no	825	no
Fuel flow	g/hr	985	1100	990	670	1055	820
Ash flow	g/hr	53	58	20	34	51	39
Volatile matter	wt%	73.3	76.1	71.3	68.9	70.6	72.9
N	wt%	1.47	1.51	1.32	1.06	2.51	1.67
S	wt%	0.190	0.131	0.150	0.088	0.260	0.131
Cl	wt%	0.314	0.077	0.278	0.015	0.678	0,021
Ca	mg/kg	6611	5290	4055	2890	5901	4515
K	mg/kg	5157	1405	3261	465	20707	1255
Na	mg/kg	1669	425	902	195	342	125
P	mg/kg	1386	730	692	240	3072	480
Si	mg/kg	11315	14130	6736	7230	2556	3765

[1]*All values are expressed on a dry weight basis except when indicated differently.*
[2]*HHV= Higher Heating Value*
[3]*LHV= Lower Heating Value*
[4]*daf= Dry and Ash Free*

The results of chemical analysis show that the treatment was effective in reducing some of the most important components responsible for lowering biomass fuel quality. The average Cl content was decreased by 89%, K by 84%, Na by 72%, P by 65%, S by 40%, and Ca by 25%. The average effectiveness in removing N was only 16%. A general ranking of the effectiveness in removing components is: N, Ca < S < Na, P < Cl, K

The concentration of nitrogen in the rinsing fluid was between 175 and 890 mg/L indication a protein concentration of 1.2 to 5.6 g/L. The concentration of free sugars in the extraction fluid was very low. This relatively low yield of N and free sugar could be explained by the harvest late in the year when N and free sugars concentrations decrease in the grasses and by the relatively long lag time between harvest and processing.

Using grass mown earlier in the season and processing the material sooner after harvest should increase the potential nitrogen (and protein) and free sugar concentrations. Through optimisation (under pilot conditions) of the extraction procedures, for example by recycling of extraction fluid and more efficient de-watering methods, it should be possible to increase N removal rates from the fibrous material and decrease the moisture content. Furthermore the increased N and free sugar concentrations will make utilisation of the extraction fluid for fermentation or extraction of products more attractive.

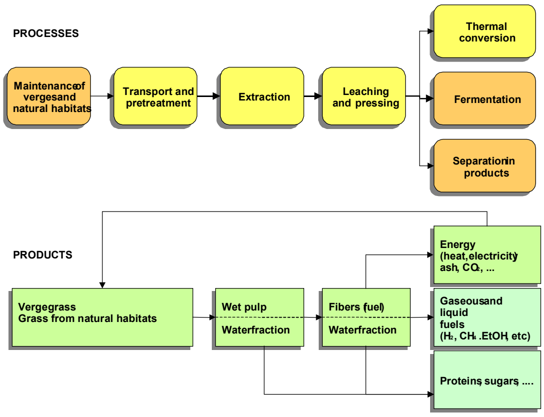

Figure 1: Scheme of a proposed verge grass to products and fuel process.

4 CONCLUSIONS

The results show that it is possible to produce a solid bio-fuel suitable for several thermal conversion options using low value verge grass material in the Netherlands. Improvements in the harvest and delivery chain and in the extraction procedure should make it possible to reduce water usage and increase protein (N) and free sugar concentrations. This will also contribute to reduce ash and nitrogen content of the fibrous (bio-fuel) fraction.

5 ACKNOWLEDGEMENTS

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