Opportunities for biochar in the sugarcane industry

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Introduction

Globally, the requirements of food and energy are increasing. The sugarcane industry is well positioned to meet these rising demands, in that it can offer both food and energy production (in the form of fuels , both first and second generation), and stationary power from crop residues such as lignin wastes, bagasse and trash. It has the capacity to meet these demands without increasing the quantity of greenhouse gases in the atmosphere. Climate mitigation can be achieved through both displacement of fossil fuels, as well as the conversion of labile organic carbon into very stable organic carbon (biochar) that is used as a soil amendment.

Historically, sugarcane cogeneration systems were designed with low efficiency boilers, aimed primarily at disposing of the bagasse waste stream. This limited opportunities to sell excess electricity to the grid. Large-scale modern renewable electricity production from cogeneration projects can grid-input around 0.44MWh per t bagasse [1]. As sugarcane regions are updating milling and processing of wastes, significant opportunities exist to implement new technologies that diversify income from this industry.

The introduction of green cane harvesting presents challenges and opportunities for the management of trash, which was previously burnt in-field. Trash can impact some agronomic practices such as irrigation, while the higher biomass volumes transported to mills adds cost, and results in greater biomass residues for disposal. Trash may also pose technical difficulties if used in cogeneration due to high concentration of K (0.64%w/w).

This presentation details the opportunities for implementing slow pyrolysis for the production of renewable energy and biochar from sugarcane residues.

Results and Discussions

To provide alternative management of residues, we investigated the use of Pacific Pyrolysis technology using a highest heating temperature of 550^0 C with mean residence time of 40 minutes and a heating rate of 5^0 C/min. It was shown that trash yielded 34% by weight biochar while bagasse yielded 31% biochar. Both feedstock's generated 1.33MW/t, which at 37% engine efficiency, would generate 0.5MWh of electricity- equivalent to modern co-generation systems.

The resulting biochars were analysed (Table1) for a range of chemical properties. Trash biochar had high levels of total K, while levels of this mineral were lower in the bagasse biochar.

Table 1. Properties of sugarcane biochar

Sample ID	Trash biochar	Bagasse biochar	Millmud biochar
EC dS/m	4.8	0.18	0.50
pH ($CaCl_2$)	9.6	8.4	9.2
Bray P mg/kg	250	67	400
$NH4^+$-N mg/kg	0.73	2.2	8.7
NO_3-N mg/kg	<0.20	<0.20	<0.20
N%	1.2	1.1	1.4
$CaCO_3$- eq%	4.6	1.1	7.2
K %	2	0.25	0.35
P %	0.25	0.22	3.4
Carbon %	68	65	24
Molar H/C	0.45	0.43	na
Exchangeable Cations cmol(+)/kg			
Al	<0.03	<0.03	<0.03
Ca	6.4	2.1	11
K	27	0.94	1
Mg	5.3	0.25	8.3
Na	0.9	0.25	1.2

In combustion systems like traditional co-generation facilities, alkali compounds such as K foul heat transfer surfaces, participate in slag formation in grate-fired units and contribute to the formation of fluidized bed agglomerates [2].

The concentrations of K in bagasse feedstock were not significant; however, concentrations in the cane trash would certainly contribute to fouling. These fouling problems are overcome through the use of slow pyrolysis. In addition, K, an important sugarcane nutrient, is recycled with an almost 100% efficiency back into the biochar for soil application.Ultimate analysis of the biochars revealed they had molar H/C ratio's of 0.45 for trash biochar and 0.43 for bagasse biochar. Parent feedstock had ratios of 1.50 and 1.45 (data not shown), indicating disproportionate loss of H and therefore conjugated aromatic structures, conferring long residence times in the soil.

The CEC of the biochar from trash was 40 cmol(+)/kg, while the bagasse biochar was lower at 3.5cmol(+)/kg.

Many of the biochar trials undertaken have used values of 10t/ha application rate. Applications of this rate would be equivalent to increasing soil carbon from a hypothetical value of 2.0% to close to 2.5% carbon, assuming a bulk density of 1.5g/cm^3. The application would be equivalent to 200kg application of K, and a minor addition of P. pH of soil would be expected to increase with an equivalent addition of 460kg agricultural lime. The effects on soil fertility including CEC however can not be fully predicted and field assessments are necessary.

It has been estimated that over 2.5MT of unutilised biomass exists in the Australian sugarcane industry every year (Bernard Milford pers comm.). This waste biomass could generate around 140MW/hr of electricity if processed via slow pyrolysis, and close to 855,000 t biochar production annually. Putting numbers into perspective, this would equate to ca. 350,000 t avoided CO_2 emissions though offsetting fossil fuels, and around 2 MT CO_2 equivalents locked up in soil.

Conclusions

The global sugar industry is well positioned to implement large-scale slow pyrolysis for the production of energy and biochar from bagasse, cane leaf (trash) and other waste streams (including mill mud, fermentation residues and 2nd generation biofuel residues). The technology will help meet rising demands for food and fuel, and has the potential to offer climate mitigation through the stabilization of carbon into biochar.

[1] Balasankari, P. K.; Mathias, A. J. 2009 Renewable Energy World International, 12, 4.
[2] Turn, S. Q.; Kinoshita, C. M.; Ishimura, D. M. 1997 Biomass and Bioenergy, 12, 241- 252.