Effect of Feed Source and Pyrolysis Conditions on Properties of Sugarcane Bagasse Biochar

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Sugarcane & Bagasse

Estimated 885,000 acres of Sugarcane for sugar production in the US in 2017

Production of 26.873 million metric tons of sugarcane from 338,560 ha in TX, LA, FL (Salassi et al., 2014. BioEnergy Research, 7:609)

Investment in new processing and harvesting equipment, adoption of new technologies, use of improved crop varieties and acreage expansion
The Leftovers That Linger

- Major by-products of crystalline sucrose manufacture from cane:
  - sugarcane bagasse, sugarcane molasses, filter mud (factory)
  - sugarcane extraneous leafy material (ag. residue)
- Fibrous bagasse is the most important by-product by volume
  - primary source of fuel - generation of steam and electricity to operate sugarcane factories
  - In LA, estimated 4 M tons produced, 15% (~ 0.7 M) tons surplus
  - Leafy residue can represent 13 tons/ac
- Commercially-viable value-added products:
  - animal feed, mulch, fuel, biochar, particle board, 2nd gen. biofuels
Sugarcane & Bagasse
Objectives

• Produce biochars sourced from both mill and field residues: fresh and aged sugarcane bagasse and sugarcane leafy trash

• Biochars were produced at various pyrolysis conditions and characterized for various properties

• Evaluate sugarcane bagasse biochar as sorbent for removal of heavy metals
Collection of Samples - Detrasher System at Cora Texas
American Biocarbon LLC Dry Cleaning System
Co-located at Cora Texas Factory, Louisiana

- Blown off sugarcane trash (leaves and tops) were utilized to manufacture biochars
Before the Detrasher
After the Detrasher

Approx. 2 min across Detrasher
Before and After the Detrasher
- Based on 1,515,571 tons for 2016 season with zero downtime
- Approx 4 ton/hr increase in processing with every 1% decrease in trash
Excess bagasse and trash residue converted into biochar

4 M t bagasse; 13 t/ac leafy residue
Biochar Production
Biochar Production

Bagasse source (3): Fresh | Trash | Old
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Peak temperature (4): 350 500 650 800 °C

(6 °C min⁻¹ ramp rate; 60 min at peak temp)
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Steam Activation (2): Activated, Not Activated
(DIW at 3mL min⁻¹ for 45 min on UP N₂ flow)
Biochar Assays and Analysis

- Moisture
- Volatile matter
- Ash content
- Fixed carbon

(TGA701)
Biochar Assays and Analysis

- Moisture
- Volatile matter
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Surface Area (total, external, micropore)
(Nova 2200 Surface Area Analyzer)
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Sorption Isotherms for Cd, Cu, Pb
(0.25g at 1:100 solid:solution ratio, pH 5.0 buffer solution)
Biochar Yield

![Graph showing Biochar Yield vs. Charring Peak Temperature for Fresh, Trash, and Old samples, with lines for Char and Activated char.]

Yield (%) vs. Charring Peak Temperature (°C)
Trash ≈ ‘old’ > Fresh
Biochar Surface Area

Non-Activated

- Old: 2 - 106 m²/g

Activated

- Trash or 'old' bagasse: 182 - 530 m²/g
- Fresh: Biochar Surface Area

Total Surface Area (m²/g)

Peak Temperature (°C)

‘Old’ >> Fresh or Trash
(Temp. dependent)

Fresh >> Trash or ‘old’ bagasse
Cu sorption capacity ($q_{\text{max}}$) and oxygen and ash content of old bagasse biochars (arrows point to the direction of increase in pyrolysis temperature of activated [solid line], and non-activated [dissected line] biochars. Solid regression line are exponential fit for all observations.
Biochar TGA Analysis

Trash ≈ ‘old’ >> Fresh

Trash ≈ ‘old’ ≈ Fresh

Fresh > Trash ≈ ‘old’
Activated Biochar TGA Analysis

Trash ≈ ‘old’ >> Fresh
Trash ≈ ‘old’ ≈ Fresh
Fresh > Trash ≈ ‘old’
Biochar TGA Analysis

Fixed C

Peak Temperature (°C)

Biochar

Biochar activated

Carbon Content, %

- Fresh
- Trash
- Old

- old bagasse biochar
- old bagasse biochar activated
- fresh bagasse biochar
- leaf trash biochar activated
Cd Sorption
350 °C

Fresh < Trash << ‘old’
Cd Sorption
650 °C

Fresh
Trash
Old

Fresh < Trash << ‘old’
Cu Sorption
‘Old’ Bagasse Biochar

- biochar 350°C
- biochar 500°C
- biochar 650°C

- activated biochar 350°C
- activated biochar 500°C
- activated biochar 650°C
Effect of Acid-Wash on Cu Sorption by ‘Old’ Bagasse Biochar

Non-activated

Activated

$Q_e (mg g^{-1})$

$C_e (mg L^{-1})$

$C_e (mg L^{-1})$

○ 500°C; Unwashed
● 500°C; Acid-washed
Uncovered storage of bagasse led to markedly reduced fuel value, increased ash content, and decreased carbon content.

HHV: high heating value, BTU/ton; LHV: lower heating value, BTU/ton; Numbers inside graph represent moisture content of bagasse at sampling time.
• Properties of sugarcane biochar are affected by bagasse source and pyrolysis conditions

• Pyrolysis of trash or field-aged bagasse resulted in higher yield of biochar and in biochar of higher ash content compared to that produced from fresh bagasse

• Biochar produced from fresh bagasse had higher levels of fixed carbon and higher surface area

• Biochar produced from field-aged bagasse had higher affinity and sorption capacity for Cd, Cu, and Pb compared to trash or fresh bagasse biochars

• Acid-wash significantly reduced biochar sorption capacity
Acknowledgments

USDA - Agricultural Research Service, Faculty Research Fellowships

West Virginia State University Land Grant Institute R&D Corporation