8-20-2017

How to produce a potential high value bio-char from the worst invasive plant in Canada

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Recommended Citation
Biochar production from the worst invasive plant in Canada

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Preview

• Phragmites
• Pyrolysis
• Pre-treatments
• Results
• Conclusion
What are Phragmites?

*Phragmites Australis* (European common reed) are an alien, invasive plants.

- The stem can grow up to 5 meters tall.
- Extremely dense vegetation (200 plants per square meter)
- Seedhead contains upward 2000 seeds.
- The spread can happen through seed dispersal or via rhizomes
Why Phragmites represent a problem?

- Loss of biodiversity
- Loss of habitat
- Changes in hydrology
- Changes in nutrient cycling
- Increased fire hazards
- Economic and social impacts
Invasion

Pyrolysis

Batch system
### Batch system

**Main features:**
- Batch with progressive collection of products at different temperatures
- Mechanical agitation
- Pure char bed
- No dilution
- Compact

**Pyrolysis conditions:**
- Temperature = up to 700 °C
- Heating rate = 1 to 15 °C/min
- Biomass = up to 300 g
Pyrolysis
Continuous system
Continuous system

Main features:
- Continuous system with collection of product at different temperatures
- Mechanical agitation
- High flexibility on pyrolysis conditions
  - Continuous removal of char
  - Pure char bed
  - Overflow
- Adjustable gas dilution (0 to high)
- Design for post treatment of biochar (activation)
- Chamber to study the effect of bio-char on pyrolysis vapours

Pyrolysis conditions:
- Temperature = up to 900 °C
Scale-up unit developed in ICFAR

Partial condenser & electrostatic demister:
- Dry bio-oil

Hot electrostatic precipitator:
- Fine char

Reactor:
- Mechanical mixer
- Induction heating
- Arch breaker

Cooled auger:
- Coarse char
2.5 tons/day Mechanically Fluidized Reactor (MFR)
Pretreatments

From the field...

...to the lab...

- Milling and sieving (1 mm)
- Acid wash: 1% wt HCl
- Alkali impregnation: 1% wt NaOH

Biomass washed with 1% HCl at 60°C for 1 h

Biomass impregnated with 1% NaOH at 60°C for 1 h

Drying at 105°C for 16 h
Pyrolysis conditions

Batch system

**Pyrolysis conditions:**
- Temperature = room T to 500°C
- Heating rate = 8 °C/min
- Biomass = 200 g

Slow pyrolysis

Continuous system

**Pyrolysis conditions:**
- Temperature = 500°C
- Biomass = 100 g

Fast pyrolysis
# Biochar Characterizations

## Ash recovery in char

<table>
<thead>
<tr>
<th>Recovery %</th>
<th>Untreated</th>
<th>NaOH</th>
<th>HCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td><img src="image" alt="Untreated" /></td>
<td><img src="image" alt="NaOH" /></td>
<td><img src="image" alt="HCl" /></td>
</tr>
<tr>
<td>50%</td>
<td><img src="image" alt="Untreated" /></td>
<td><img src="image" alt="NaOH" /></td>
<td><img src="image" alt="HCl" /></td>
</tr>
<tr>
<td>100%</td>
<td><img src="image" alt="Untreated" /></td>
<td><img src="image" alt="NaOH" /></td>
<td><img src="image" alt="HCl" /></td>
</tr>
</tbody>
</table>

## Sample IDs (mg/kg)

<table>
<thead>
<tr>
<th>Sample IDs</th>
<th>Untreated</th>
<th>1% NaOH</th>
<th>1% HCl</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca</td>
<td>339.4</td>
<td>3904.9</td>
<td>6134.4</td>
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<tr>
<td>Cd</td>
<td>&lt;0.125</td>
<td>&lt;0.125</td>
<td>&lt;0.125</td>
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<tr>
<td>Co</td>
<td>&lt;0.125</td>
<td>&lt;0.125</td>
<td>&lt;0.125</td>
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<tr>
<td>Cr</td>
<td>3.2</td>
<td>9.2</td>
<td>45.5</td>
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<tr>
<td>Cu</td>
<td>22.1</td>
<td>234.7</td>
<td>81.6</td>
</tr>
<tr>
<td>Fe</td>
<td>491.1</td>
<td>90.1</td>
<td>335.4</td>
</tr>
<tr>
<td>K</td>
<td>1417.6</td>
<td>33.5</td>
<td>57.1</td>
</tr>
<tr>
<td>Mg</td>
<td>116.1</td>
<td>3.9</td>
<td>0.5</td>
</tr>
<tr>
<td>Mn</td>
<td>9.6</td>
<td>6.4</td>
<td>0.8</td>
</tr>
<tr>
<td>Mo</td>
<td>2.2</td>
<td>6.6</td>
<td>0.7</td>
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<tr>
<td>Na</td>
<td>643.1</td>
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<td>294.2</td>
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<tr>
<td>Ni</td>
<td>36.5</td>
<td>94.4</td>
<td>56.8</td>
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<tr>
<td>P</td>
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<td>183.8</td>
<td>94.6</td>
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<tr>
<td>S</td>
<td>740.9</td>
<td>5313.3</td>
<td>13162.3</td>
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<tr>
<td>Si</td>
<td>437.9</td>
<td>308.4</td>
<td>530.2</td>
</tr>
</tbody>
</table>

## Sample IDs

<table>
<thead>
<tr>
<th>Sample ID</th>
<th>Yield % (dry basis)</th>
<th>Ash content % (dry basis)</th>
<th>HHV (MJ/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Untreated</td>
<td>27%</td>
<td>22%</td>
<td>26.8</td>
</tr>
<tr>
<td>1% NaOH</td>
<td>30%</td>
<td>22%</td>
<td>26.3</td>
</tr>
<tr>
<td>1% HCl</td>
<td>28%</td>
<td>17%</td>
<td>28.3</td>
</tr>
</tbody>
</table>
What’s next?

Pre-treatments with different equipments
• Soxhlet extractor
• Sonic bath
• Water oven

And chemicals
• NaOH
• HCl
• Acetic acid
• water
Pyrolysis
What’s next?

Batch
Continuous
Acknowledgments
Thank you!
Questions?