Bamboo Biochar As a Potential Source of Soil Humic Substance in Soil Ecosystem

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(2010-10-11 · Hangzhou China)
Outline

I . Question: Why we use bamboo as a feedstock for biochar?

II. The general characteristics of bamboo biochar.

III. Some study results

VI. A discussion: How can we utilize it economically and ecologically?
Question: Why we use bamboo as a feedstock for biochar?

More than 70 bamboo genera with 1,000 species exist throughout the world. Subfamily Bambusoideae of the family Gramineae. The global bamboo forest area extends to 25 million hectares.
Question: Why we use bamboo as a feedstock for biochar?

- While the forest coverage in tropical and subtropical is decreasing
- The bamboo forest area is increasing. It is estimated that the Bamboo area is increased annually by 1-2% per in the world and 2-3% in China

- The reasons behind this phenomena are:
  - Easy to be managed, high biomass production
  - High economic value
  - Replacing products of valuable woody .........
Question: Why we use bamboo as a feedstock for biochar?

- **Bamboo timber can be harvested every year after 4-5 years, compared to 20 to 50 years for trees. With 10-30% annual increase in biomass versus 2-5% for trees, bamboo can yield 20 times more timber than trees on the same area. Bamboo can be selectively harvested annually and regenerates without replanting.**

- **Bamboo generates 30% more oxygen than trees. It helps reduce carbon dioxide gases blamed for global warming. Some bamboo sequesters up to 12 tons of carbon dioxide per hectare, which makes it an efficient replenisher of fresh air. Other advantages......**
II. The general characteristics of bamboo biochar

- Pore size distribution
Terminal pyrolysis temperature (℃)
Specific surface area (m³/g)
Bamboo biochar pore size (MOSO bamboo 500°C)
Adsorption ratio to ammonia

- 300°C
- 400°C
- 500°C
- 600°C
- 700°C
- 800°C
- 900°C
- 1000°C

Time (day)
Adsorption ratio (%)
1 4 8 12 16 20 24 28

Graph showing the adsorption ratio to ammonia over time at different temperatures.
Nutrient characteristics

- The range of total N: 0.2-0.5%
- $P_2O_5$: 0.06-0.20%
- $K_2O$: 0.6-1.1%
- Ca, Mg and Na: 0.2-0.6%
Elemental components of bamboo biochar with EDAX method (%)

<table>
<thead>
<tr>
<th>Element</th>
<th>500 °C</th>
<th></th>
<th></th>
<th>750 °C</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Out surface</td>
<td>Inside</td>
<td>Inner surface</td>
<td>Out surface</td>
<td>Inside</td>
<td>Inner surface</td>
</tr>
<tr>
<td>C</td>
<td>49.25</td>
<td>91.43</td>
<td>95.53</td>
<td>49.27</td>
<td>96.22</td>
<td>96.53</td>
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<tr>
<td>O</td>
<td>11.29</td>
<td>2.81</td>
<td>2.92</td>
<td>11.19</td>
<td>1.90</td>
<td>2.31</td>
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<tr>
<td>Al</td>
<td>0.25</td>
<td>0.00</td>
<td>0.00</td>
<td>1.71</td>
<td>1.87</td>
<td>1.17</td>
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<tr>
<td>Si</td>
<td>35.92</td>
<td>0.00</td>
<td>0.25</td>
<td>32.75</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>K</td>
<td>3.30</td>
<td>5.75</td>
<td>1.30</td>
<td>5.08</td>
<td>0.90</td>
<td>1.02</td>
</tr>
</tbody>
</table>
Solid-state $^{13}$C NMR spectra of bamboo biochar

Up-field shift $\rightarrow$ polycyclic aromatic structures

Local anisotropic magnetic susceptibility

$^{13}$C Chemical Shift (ppm)
Temperature $\leq 900^\circ$C  Temperature $> 900^\circ$C
### III. Some study results

- **Coarse particle bamboo biochar (1-3mm)**

<table>
<thead>
<tr>
<th></th>
<th>pH</th>
<th>Total C (%)</th>
<th>Total N (%)</th>
<th>CEC cmol/kg</th>
<th>Ash content (%)</th>
<th>Exchangeable cation (1 M KCl solution) cmol/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>8.23</td>
<td>71.4</td>
<td>0.22</td>
<td>15.31</td>
<td>4.1</td>
<td>K$_2$O 110.1, CaO 74.2, MgO 36.1</td>
</tr>
</tbody>
</table>
predominant aromatic C peak from bamboo biochar (130 ppm)

Bamboo Biochar (500° C)  
After 4 years in soil

partially oxidized –COO group in condensed aromatic C backbones (173 ppm)  
Aryl-COO⁻

Resonances from carbohydrates (Polysaccharides/cellulose) are probably mixed or attached to biochar materials (63, 72, 83, 104 ppm).

C/N-alkyl from lignin structure and amino acids.
- Cation Exchangable capacity

15.31 cmol/kg → 24.11 cmol/kg

The other data such as: microbial communities associated to biochar, total surface area, surface functional groups, total elements etc, are still to be determined in laboratory.
How can we utilize it economically and ecologically?
Liquid products

The compounds including vapor and gas are collected from the pyrolyzing kettle and condensed into liquid products (bamboo vinegar) and gas products (non-clotted gas and bamboo gas).

Crude bamboo vinegar is a brown-black liquid with more than 300 organic compounds except a quantity of water (include reaction water). Some of the compounds are as follows:

1. Saturated acid: acetic acid, formic acid, propanoic acid, and butanoic acid.
Biochar-based chemical N fertilizer
Leaching experiment result

CUM-mixture of urea and biochar (30%N)
CCU-I biochar coated urea-I (30%N)
CCU-II biochar-coated urea-II (20% N)
Biochar-coated seeds
biochar+microbes products
Inorganic
Plate colony count method

1. Bacteria pure culture
   - after 24h: \(6.85 \times 10^8\)/mL
   - after 48h: \(1.495 \times 10^9\)/mL

2. All Bacteria mixed culture B-Mix
   - after 24h: \(3.0125 \times 10^8\)/mL
   - after 48h: \(4.0375 \times 10^8\)/mL

3. Fungus pure culture
   - after 24h: \(8.25 \times 10^4\)/mL
   - after 48h: \(9.3 \times 10^4\)/mL
Inoculated rice seed coating trail

Control

Mix Bacteria & Fungi

Bacteria

Fungi
- Taking soil samples in rhizome from healthy oak forest
- Cultivating the samples and getting the beneficial microbes from oak soils
- Inoculating the microbes in biochar
- Coating the inoculated-biochar in the oak seeds
- Sowing the coated seeds in the field
Expected results could be:

- Increasing the germination rate at least 15%
- Increasing the height growth rate at least 20% in the first 5 years
- Increasing the healthy status of seedlings, so that increasing the competition ability with other plants

Significantly reduce the regeneration cost
Many Thanks!