Phosphorus release from biochars prepared from rice husks, grape pomace and olive tree prunings

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WHAT IS BIOCHAR?

Biochar (BC) is a high-carbon solid produced by pyrolysis of biomass and intended for soil applications.

AGRONOMIC APPLICATIONS

- Biochar increases the capacity of the soil holding water and nutrients reducing the need for fertilizers
- Macro- and micronutrients retained in biochar could be released and made available to the plants
- BC is a potential P soil amendment as reserves of phosphorus-rich ores will become depleted in 30-100 years

ENVIRONMENTAL APPLICATIONS

- Atmospheric carbon sink mitigating climate change
  - Estimated residence time of carbon in soil: 200-1000 years
- Reduction of N₂O emissions from soil (strong greenhouse gas)
- Adsorbent in water phase (low-grade activated carbon)
OBJECTIVES

◆ Production of biochar via pyrolysis from
  ➢ Rice husks (RH)
  ➢ Grape pomace (GP)
  ➢ Olive tree prunings (OP)

◆ Release of P already present in biochar and raw biomass in water
  ➢ Batch desorption and successive leaching experiments

◆ Do P-leached biochars have the potential to become sorbents of fertilizer P?

◆ Agronomic application of biochar for cultivation of ryegrass
EXPERIMENTAL PART

- Biomass pyrolysis temperature: 300°C and 500°C

- Phosphate desorption/leaching tests
  - Batch desorption kinetics (Biomass/Biochar : Water = 1:100)
  - Successive leaching experiments (4 successive extractions; Contact time: 24 h)

- Phosphate sorption experiments
  - Completely leached GP-300 and RH-300 biochar samples

- Cultivation of ryegrass (*Lolium perenne* L.)
  - Two types of soil: Sandy loam, Loam
  - Presence (2%) and absence of biochar
  - Presence (2%) and absence of compost
  - Additional fertilization (N and micro-nutrients) or not
### RESULTS

#### Properties of raw biomass and biochars

<table>
<thead>
<tr>
<th>BIOCHARS</th>
<th>Units</th>
<th>Rice husk</th>
<th>Grape pomace</th>
<th>Olive tree prunings</th>
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</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>300°C</td>
<td>500°C</td>
<td>300°C</td>
</tr>
<tr>
<td>Ca²</td>
<td>%</td>
<td>44.00</td>
<td>35.70</td>
<td>46.60</td>
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<tr>
<td>Na</td>
<td>%</td>
<td>2.00</td>
<td>0.88</td>
<td>1.60</td>
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<tr>
<td>Ash³</td>
<td>%</td>
<td>63.54</td>
<td>91.25</td>
<td>25.67</td>
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<tr>
<td>pH</td>
<td></td>
<td>7.50</td>
<td>7.60</td>
<td>10.80</td>
</tr>
<tr>
<td>EC</td>
<td>μS/cm</td>
<td>265</td>
<td>252</td>
<td>1058</td>
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</table>

<table>
<thead>
<tr>
<th>RAW BIOMASS</th>
<th>Units</th>
<th>Rice husk</th>
<th>Grape pomace</th>
<th>Olive tree prunings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ca²</td>
<td>%</td>
<td>37.00</td>
<td>49.60</td>
<td>55.50</td>
</tr>
<tr>
<td>Na</td>
<td>%</td>
<td>0.43</td>
<td>2.00</td>
<td>0.65</td>
</tr>
<tr>
<td>Ash³</td>
<td>%</td>
<td>4.73</td>
<td>1.82</td>
<td>2.22</td>
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<tr>
<td>pH</td>
<td></td>
<td>6.10</td>
<td>5.00</td>
<td>5.80</td>
</tr>
<tr>
<td>EC</td>
<td>μS/cm</td>
<td>118.6</td>
<td>207</td>
<td>153.5</td>
</tr>
</tbody>
</table>

² As received basis  
³ Dry basis
## Nutrient content of raw biomass and biochar samples by ICP-MS

<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>P</td>
<td>mg g⁻¹</td>
<td>0.65</td>
<td>4.36</td>
<td>5.34</td>
<td>0.21</td>
<td>1.80</td>
<td>3.48</td>
<td>0.99</td>
<td>3.63</td>
<td>5.99</td>
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<tr>
<td>Mg</td>
<td>mg g⁻¹</td>
<td>0.47</td>
<td>5.99</td>
<td>6.09</td>
<td>0.18</td>
<td>0.65</td>
<td>1.09</td>
<td>0.77</td>
<td>4.86</td>
<td>6.93</td>
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<tr>
<td>K</td>
<td>mg g⁻¹</td>
<td>4.95</td>
<td>65.9</td>
<td>64.2</td>
<td>4.5</td>
<td>14.5</td>
<td>20.5</td>
<td>29.1</td>
<td>164.7</td>
<td>219.2</td>
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<tr>
<td>Ca</td>
<td>mg g⁻¹</td>
<td>0.11</td>
<td>3.18</td>
<td>3.18</td>
<td>0.01</td>
<td>0.04</td>
<td>0.07</td>
<td>0.10</td>
<td>1.13</td>
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<td>Mn</td>
<td>mg g⁻¹</td>
<td>0.01</td>
<td>0.17</td>
<td>0.16</td>
<td>0.09</td>
<td>0.34</td>
<td>0.35</td>
<td>0.01</td>
<td>0.12</td>
<td>0.17</td>
</tr>
<tr>
<td>Fe</td>
<td>mg g⁻¹</td>
<td>0.03</td>
<td>0.53</td>
<td>0.62</td>
<td>0.01</td>
<td>0.08</td>
<td>0.18</td>
<td>0.06</td>
<td>1.75</td>
<td>2.64</td>
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<tr>
<td>Cu</td>
<td>mg g⁻¹</td>
<td>0.00</td>
<td>0.05</td>
<td>0.02</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>0.00</td>
<td>1.02</td>
<td>1.37</td>
</tr>
<tr>
<td>Zn</td>
<td>mg g⁻¹</td>
<td>0.01</td>
<td>0.15</td>
<td>0.13</td>
<td>0.01</td>
<td>0.02</td>
<td>0.00</td>
<td>0.01</td>
<td>0.09</td>
<td>0.15</td>
</tr>
</tbody>
</table>

Unpyrolyzed grape pomace and rice husk biochars at 300°C and 500°C showed the highest P desorption level in batch experiments.
Successive leaching of P

A continuous release of P from all biochars as compared to raw biomass samples, where the highest concentrations were detected during the first extraction.

Biochars, at 500°C, leached more P in all four extractions, compared to biochars at 300°C, apart from olive tree prunings biochars, where both pyrolysis temperatures presented a similar trend.
Sorption of P on leached biochars was not observed.
At the end of the 3rd harvest, application of compost/biochar provided fertilization in the absence of additional Phosphorus at statistically significance difference

Yet, fertilization with N and micro-nutrients was still necessary
CONCLUSIONS

◆ Release of phosphates varies with biochar type.

◆ All six biochars showed a continuous phosphate release into the water phase.

◆ Both biochars tested (after previously being leached from their P content) showed small additional P sorption capacity, therefore they could not be characterized sorbents of fertilizer P.

◆ Agronomic application of compost/biochar provided phosphorus to a loam soil.

BUT

◆ The efficiency of biochar agronomic applications depends on
  ➢ Type of soil
  ➢ Type of biochar
    ➢ Additional nutrients/soil conditioners
    ➢ Environmental conditions