Soil amendment with pyrolysed grape marc residue: a circular economy study


NAXOS 2018

13th – 16th June, 2018, Naxos, Greece

6th International Conference on Sustainable Solid Waste Management
Outline

1. Introduction - Context
2. Biochar elaboration
3. Soil amendment – Biodisponibility of P and K
4. Conclusion
Recovery procedures for GM

- **Wine**
  - Distillation column
  - Concentration
  - Tartaric extraction
  - Concentration
  - Alcohol
  - Wine vinasse (Organic fertilizer)

- **Wine lees**
  - Distillation column
  - Concentration
  - Biogas
  - Energy

- **Grape marc**
  - Distillation, alcohol removal and/or diffusion
  - Piquette
  - Distillation column
  - Concentration
  - Calcium tartrate
  - Acidification
  - Agri-food industry (cannery)
  - Retardant
  - Anthocyanin, tannin, polyphénols grape seeds
  - Animal feed
  - Agri-food industry (dyes)
  - Organic fertilizer
  - Compost
  - Biofuel

- **Dryer**
  - Dry marc
  - Triage crush

- **Boiler**

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Grape marc deposit

Alsace (North-east of France) :
25 500 tons of raw GM/year

Champagne (North-east of France) :
102 000 tons of GM/year

France :
850 000 tons/year

Distribution of grape marc deposit in France
en France (IFV, 2013)
Alsatian vineyard – GM deposit location

Romann distillery (Sigolsheim)
→ 18 000 tons of raw GM/year

Grape varieties:
Gewurztraminer, Riesling, Muscat, Pinot Gris, Pinot Noir, Sylvaner, Pinot Blanc
Strategy of the project

- **Benefits:**
  - Agronomic valorizing of chars
  - C sequestration in the soil (objective 4/1000)
  - Hygienisation of grape marc
  - Volume reduction for storage and transport
  - Production of renewable energy (syngaz, bio-oil).
Objectives

- Elaboration of biochars from GM at different temperatures → 300°C to 600°C
- Characterization of the different biochars
- Soil fertilisation
Experimental procedure

Pyrolysis tests:

Experimental parameters:

- 2 kg of raw biomass (250-400 µm)
- Pyrolysis temperature: 300-400-500-600°C
- 5°C/min
- Flow rate (N₂): 25 NL/h
- Residence time: 1h

Mass yields:

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>Yield (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>300</td>
<td>65.8%</td>
</tr>
<tr>
<td>400</td>
<td>59.1%</td>
</tr>
<tr>
<td>500</td>
<td>33.8%</td>
</tr>
<tr>
<td>600</td>
<td>32.5%</td>
</tr>
</tbody>
</table>
### Chemical analysis:

<table>
<thead>
<tr>
<th>Element</th>
<th>DB (wt %)</th>
<th>GM 300°C</th>
<th>GM 400°C</th>
<th>GM 500°C</th>
<th>GM 600°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>60.21</td>
<td>67.42</td>
<td>72.91</td>
<td>72.13</td>
<td></td>
</tr>
<tr>
<td>H</td>
<td>6.04</td>
<td>5.07</td>
<td>3.15</td>
<td>2.16</td>
<td></td>
</tr>
<tr>
<td>N</td>
<td>2.51</td>
<td>2.71</td>
<td>2.72</td>
<td>1.71</td>
<td></td>
</tr>
<tr>
<td>S</td>
<td>1.09</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td></td>
</tr>
<tr>
<td>O deduced</td>
<td>30.2</td>
<td>24.8</td>
<td>21.2</td>
<td>24</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Element</th>
<th>DB (mg/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Al</td>
<td>554</td>
</tr>
<tr>
<td>Ca</td>
<td>7010</td>
</tr>
<tr>
<td>Fe</td>
<td>512</td>
</tr>
<tr>
<td>K</td>
<td>11000</td>
</tr>
<tr>
<td>Mg</td>
<td>1150</td>
</tr>
<tr>
<td>Na</td>
<td>199</td>
</tr>
<tr>
<td>Ti</td>
<td>19</td>
</tr>
<tr>
<td>P</td>
<td>3370</td>
</tr>
<tr>
<td>Si</td>
<td>3150</td>
</tr>
<tr>
<td>Ni</td>
<td>-</td>
</tr>
<tr>
<td>pH</td>
<td>7.23</td>
</tr>
<tr>
<td>H/C</td>
<td>0.10</td>
</tr>
<tr>
<td>O/C</td>
<td>0.50</td>
</tr>
</tbody>
</table>

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Characterization of the biochars:

CO₂ adsorption → textural properties

<table>
<thead>
<tr>
<th>Temperature (°C)</th>
<th>300</th>
<th>400</th>
<th>500</th>
<th>600</th>
</tr>
</thead>
<tbody>
<tr>
<td>Surface area (m²/g)</td>
<td>24.8</td>
<td>130.4</td>
<td>204.8</td>
<td>253.4</td>
</tr>
<tr>
<td>Microporous volume (cm³/g)</td>
<td>-</td>
<td>0.03</td>
<td>0.06</td>
<td>0.08</td>
</tr>
</tbody>
</table>

⇒ Stabilization of the biochars properties for pyrolysis temperature higher than 500° C
Biodisponibility of P and K for the plant:

Reaping of the air biomass (after 4 and 8 weeks): DM, P wt% and K wt%

Production trials:
- Char 300°C → 200 U K₂O/ha (12.5 t/ha → 106 U P₂O₅/ha)
- Char 400°C → 200 U K₂O/ha (8.33 t/ha → 93 U P₂O₅/ha)
- Char 500°C → 200 U K₂O/ha (6.25 t/ha → 121 U P₂O₅/ha)
- Char 500°C → 100 U K₂O/ha (3.13 t/ha → 60.5 U P₂O₅/ha)

Standards (references):
- KNO₃ → 100 et 200 U K₂O/ha
- TSP → 60.5 ; 93 ; 106 et 121 U P₂O₅/ha

4 repetitions for each trial
**Dry matter content:**

![Graph showing dry matter content with different temperatures and treatments.]

Best results are obtained with the biochar 500°C → comparable with TSP + KNO₃ references

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**Biodisponibility of P for the plant:**

![Graph showing phosphorous content](image)

- **Negative control**
- **500°C (60.5 U.P205, ha)**
- **400°C (69.5 U.P205, ha)**
- **300°C (106 U.P205, ha)**
- **500°C (121 U.P205, ha)**
- **Réf. TSP (60.5 U.P205, ha)**
- **Réf. TSP (69.5 U.P205, ha)**
- **Réf. NPO3 (60.5 U.P205, ha)**
- **Réf. NPO3 (69.5 U.P205, ha)**
- **Réf. 500°C (60.5 U.P205, ha)**
- **Réf. 500°C (69.5 U.P205, ha)**
- **Réf. 500°C (121 U.P205, ha)**

\[ (p\text{-value} = 0.0709) \]

**Biodisponibility of P limited in comparison with the TSP references**

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Biodisponibility of K for the plant:

(p-value = 0.0088)

Good biodisponibility of K especially for the biochar 300°C sample

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Effect of the biochars on pH and soil conductivity:

- Increase of soil pH according to the temperature of pyrolysis
- Soil conductivity is higher for the biochar 300°C sample
Biochar elaboration and characterization:
- High K and P contents for biochars prepared at 500 and 600°C
- Devolatilization ends at 500°C
- Textural properties of biochars prepared at 500 and 600°C are more favorable for soil application

Efficiency of the different biochars for plant growth:

<table>
<thead>
<tr>
<th></th>
<th>300°C</th>
<th>400°C</th>
<th>500°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biodisponibility</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>DM yield</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Phosphorous</td>
<td>-</td>
<td>-</td>
<td>+</td>
</tr>
<tr>
<td>Potassium</td>
<td>++</td>
<td>+</td>
<td>+</td>
</tr>
</tbody>
</table>

Effect of biochars on soil structuration, suppressive effect and water retention have to be done
| Context and problematic | Method of synthesis | Results and discussion | Conclusion & perspectives |

**Acknowledgements to**

[INSTITUT CARNOT MICA]

&

PHC Utique n° 34863VB
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Apparent utilization coefficient:

![Graphs showing apparent utilization coefficient for CAU Phosphate and CAU Potassium.]
Characterization of the biochars:
Scanning Electron Microscopy characterization

Devolatilization seems to be complete from 500°C