Composting of brewery sludge mixed with different bulking agents

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Introduction

• Re-use of waste is the key for sustainable development

• Sludge is **NOT** a waste
• It is rather a source of nutrients
• Composting: one of the most promising technologies allowing recycling of biosolids
Why brewery sludge?

- Solid-waste disposal problem and management

Composting requires

- Biosolids
- Bulking agents
Purpose

Composting of brewery sludge with three different bulking agents
Parameters

- Temperature
- Moisture
- pH
- Conductivity
- Volatile solids
- Organic Nitrogen
- Carbon to nitrogen ratio
- Total phosphorus
- Metals
- Microbiological quality
Composting Stages

- **Thermophilic Stage**: Temperature rises to around 60°C, promoting rapid decompression.
- **Mesophilic Stage**: Temperature drops to around 40°C, slowing down the decomposition process.
- **Pasteurised or Fresh Compost**: Temperature stabilises at a lower level, indicating the compost is safe to use.
- **Stable & Mature Compost**: Further cooling indicates the compost is fully stabilised and ready for use.

The chart shows the temperature over time, highlighting the two distinct stages of intensive decomposition and curing.
Composting set-up

• 3 co-composting materials  – lignite
  – sawdust
  – dried shredded grass

• Temperature measurement three times per week

• Agitation once per week

• Sampling once per week before agitation
Location ...

Greenhouse of University of Patras
Sludge + lignite

Sludge + sawdust

Sludge + shredded grass
Results
Temperature

![Temperature Graph](image)
Moisture

![Graph showing moisture content over days for compost, lignite, sawdust, and grass. The graph illustrates the decrease in moisture percentage over time for each material.](image)
pH

The graph shows the pH levels over time for different materials:
- **compost**
- **lignite**
- **sawdust**
- **grass**

The pH levels are plotted against the number of days. The graph indicates an increase in pH over time for all materials.
## Electrical conductivity

<table>
<thead>
<tr>
<th>Composts</th>
<th>Final Values (mS/cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass mixture</td>
<td>3.3</td>
</tr>
<tr>
<td>Lignite mixture</td>
<td>1.8</td>
</tr>
<tr>
<td>Sawdust mixture</td>
<td>1.1</td>
</tr>
</tbody>
</table>
Volatile Solids
Organic nitrogen
C/N ratio

- C/N ratio → stable at 10:1 (during the whole process)

- According to bibliography initial optimum ratio 30:1
Total Phosphorus
## Metals

<table>
<thead>
<tr>
<th>Elements</th>
<th>Lignite</th>
<th>Sawdust</th>
<th>Dried grass</th>
<th>Legislative guidelines $^a$ (mg kg$^{-1}$ DM)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cd</td>
<td>0.14</td>
<td>&lt;0.02</td>
<td>&lt;0.02</td>
<td>1</td>
</tr>
<tr>
<td>Pb</td>
<td>7.5</td>
<td>8.9</td>
<td>7.6</td>
<td>100</td>
</tr>
<tr>
<td>Cr</td>
<td>110</td>
<td>56.3</td>
<td>52.7</td>
<td>100</td>
</tr>
<tr>
<td>Ni</td>
<td>377</td>
<td>60.3</td>
<td>32.5</td>
<td>50</td>
</tr>
<tr>
<td>As</td>
<td>43.3</td>
<td>3.1</td>
<td>3.2</td>
<td>10</td>
</tr>
<tr>
<td>Cu</td>
<td>56.2</td>
<td>54.0</td>
<td>74.5</td>
<td>100</td>
</tr>
<tr>
<td>Zn</td>
<td>93.5</td>
<td>35.6</td>
<td>126</td>
<td>300</td>
</tr>
<tr>
<td>Co</td>
<td>23.6</td>
<td>14.3</td>
<td>11.2</td>
<td>-</td>
</tr>
<tr>
<td>Mn</td>
<td>672</td>
<td>591</td>
<td>479</td>
<td>-</td>
</tr>
<tr>
<td>Fe</td>
<td>23800</td>
<td>19000</td>
<td>14800</td>
<td>-</td>
</tr>
<tr>
<td>Na</td>
<td>2980</td>
<td>3520</td>
<td>6710</td>
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</tr>
<tr>
<td>K</td>
<td>6440</td>
<td>7040</td>
<td>8790</td>
<td>-</td>
</tr>
<tr>
<td>Ca</td>
<td>11600</td>
<td>17900</td>
<td>19800</td>
<td>-</td>
</tr>
<tr>
<td>Mg</td>
<td>11800</td>
<td>6630</td>
<td>5600</td>
<td>-</td>
</tr>
</tbody>
</table>

$^a$: Commission Decisions 2006/799/EC and C(2006) 6962 (ECO Label to soil improvers and growing media, respectively)
## Microbiological quality

<table>
<thead>
<tr>
<th>Pathogen</th>
<th>Lignite (CFU g(^{-1}) dw)</th>
<th>Sawdust (CFU per 25 g dw)</th>
<th>Dried grass (CFU g(^{-1}) dw)</th>
<th>2006/799/EC</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>E. coli</em></td>
<td>483</td>
<td>1291</td>
<td>68</td>
<td>1000</td>
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<tr>
<td>Salmonella</td>
<td>absence</td>
<td>absence</td>
<td>absence</td>
<td>absence</td>
</tr>
<tr>
<td>Enterococci</td>
<td>57</td>
<td>459</td>
<td>2411</td>
<td>-</td>
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<tr>
<td>Clostridia</td>
<td>352</td>
<td>0</td>
<td>221</td>
<td>-</td>
</tr>
</tbody>
</table>
Conclusions

✓ Mixtures with dried grass and sawdust yielded composts of acceptable quality for specific uses, such as soil remediation

✓ Lignite was considered as an inappropriate bulking agent due to high metals concentrations measured in the final product

✓ The most promising, suitable and low cost bulking agent was the dried shredded grass

✓ Co-composting of brewery sludge with lower than optimum initial C/N ratios is feasible and allows the minimization of the required amount of bulking agent, if composting aims at solving the sludge disposal problem

✓ Final products were categorized as Class B. Characterization of Class A will be feasible, by constructing bigger piles and thus, achieving higher temperatures during composting
Thank you!!!