Investigation of the Physical, Chemical and Microbiological Parameters Influencing the Small-scale In-vessel Composting of Food Waste

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CYPRUS 2016
Food Waste (FW): a challenging feedstock

- Needs bulking agents, otherwise it becomes highly homogeneous
- High moisture content
- Often very acidic
- Collection in closed containers can lead to anaerobic conditions, further lowering pH
- Must be treated in an enclosed environment, specified time-temperature conditions
The role of VFAs in FW composting

- Initial decrease in pH is often observed after FW addition to IVC. In severe cases this can lead to significant decline in temperature and malodours
- VFAs in compost mixture play key role in regulating pH during mesophilic phase
- Acidic compost mix (pH<6) $\rightarrow$ undissociated VFAs $\rightarrow$ inactivation of aerobic microorganisms $\rightarrow$ accumulation of VFAs $\rightarrow$ further acidification
- Mesophilic aerobes are more acid tolerant than thermophilic organisms
- Maintaining the compost temperature below 46°C until the pH value increases above pH 6.5, allows aerobic organisms to degrade VFAs, thus shortening the mesophilic phase and increasing the composting temperature in a shorter period of time
In-vessel FW composting at the Eden Project

- FW shredded to 20mm particle size
- Retention time between 60 and 110 days (depending on feeding rate)
## Feedstock

<table>
<thead>
<tr>
<th>Feedstock</th>
<th>pH</th>
<th>Characteristics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Waste (FW)</td>
<td>4.0-4.4 after shredding</td>
<td>High MC, little porosity</td>
</tr>
<tr>
<td>Green Waste (GW)</td>
<td>6.0-8.0</td>
<td>Increases C/N ratio. Adds microbial population</td>
</tr>
<tr>
<td>Corrugated Board Dust (CBD)</td>
<td>8.0</td>
<td>Low MC (~11%). Drying agent</td>
</tr>
<tr>
<td>Sawdust (SD)</td>
<td>5.6-5.8</td>
<td>Drying agent</td>
</tr>
<tr>
<td>Sawdust Pellets (PEL)</td>
<td>4.7</td>
<td>Low MC (~15%). Expands on rehydration, increases free air space</td>
</tr>
<tr>
<td>Finished Compost (FC)</td>
<td>7.5-8.5</td>
<td>Drying agent. Adds thermophilic organisms</td>
</tr>
</tbody>
</table>
Eight week feedstock management strategy

<table>
<thead>
<tr>
<th>Input (kg):</th>
<th>Week</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1</td>
</tr>
<tr>
<td>FW</td>
<td>572</td>
</tr>
<tr>
<td>GW</td>
<td>208</td>
</tr>
<tr>
<td>FC</td>
<td>80</td>
</tr>
<tr>
<td>CBD</td>
<td>99</td>
</tr>
<tr>
<td>SD</td>
<td>-</td>
</tr>
<tr>
<td>PEL</td>
<td>-</td>
</tr>
<tr>
<td>Total Input:</td>
<td>959</td>
</tr>
<tr>
<td>Total Output (kg):</td>
<td>194</td>
</tr>
</tbody>
</table>

* Value in brackets represents the material removed from the discharge end of the vessel and recycled to the feed end.
Changes in temp., moisture content and pH

Hatch 1

Hatch 2

Hatch 3

Hatch 4
The effect of MC and pH on the temperature of the compost mixture

**A**

Temp °C = 103.2 - 1.18 MC

$R^2 = 0.75$

$P < 0.001$

**B**

Temp °C = 25.81 + 18.12 pH - 1.03 pH^2

$R^2 = 0.84$
The effect of % moisture content on pH
Interstitial gas concentrations

Hatch 1

Hatch 2

Hatch 3

Hatch 4
Relationship between temperature and CO2 and temperature and O2

\[ %\text{CO}_2 = 15.0 + 0.65 \text{Temp } ^\circ\text{C} \]
\[ R^2 = 0.66 \]
\[ P < 0.001 \]

\[ %\text{O}_2 = 32.1 - 0.56 \text{Temp } ^\circ\text{C} \]
\[ R^2 = 0.69 \]
\[ P < 0.01 \]
Conclusions

■ The rapid biodegradation of FW makes its composing susceptible to acid accumulation and pH decline.

■ The results show that process acidification is highly sensitive to increasing MC.

■ Possible reason: MC influences the thermodynamic balance of the process. A wet mixture leads to greater heat losses, causing a decline in temperature and a decline in VFA metabolism. Feedback mechanism leading to more VFA accumulation and pH reduction → microbial toxicity → process inhibition.

■ MC between 41-48% were associated with a marked transitional increase in compost pH above 6.0 and a concomitant rise in temperature to thermophilic values

■ Moisture contents over 48% caused severe acidogenesis and mesophilic temperatures

■ Under the conditions of this investigation the upper critical MC for in-vessel composting of food waste was 40% (whereas the recommended MC for composting is in the range of 40-60%).

Thank you!