Approaches to selecting food waste processing technologies

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SWRC/SWANA
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Background
City of Edmonton

• Population: 932,500 (2016).
• Material streams available:
  • Residential:
    • curbside & multi-family.
    • ICI sectors.
• Technology available:
  • Composting:
    • Windrow (Leaf & YW).
    • Covered aerated static pile (biosolids & woodchips).
    • In-vessel basin (OFMSW).
  • Anaerobic digestion (dry).
  • Gasification to biofuels.
• Match streams to best technology.
Background

Where Should Food Waste Go?
General Framework to Approach Technology Selection

1. Waste Stream Material Properties:
   - Physical
   - Chemical
   - Biological:
     - Biodegradability
     - Contaminants.

2. High Level Technology Choices:
   - Landfill
   - MBT
   - Composting
   - Anaerobic digestion
   - Thermal conversion

3. Environmental Quality Objectives or Product Specifications:
   - Physical
   - Chemical
   - Biological
   - Visual

Food Waste Technology Selection
Physical Contamination & BMP

<table>
<thead>
<tr>
<th>Technology</th>
<th>Key Feedstock Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bioreactor Landfill</td>
<td>MC; BMP</td>
</tr>
<tr>
<td>MBT to Landfill</td>
<td>MC; C:N; BMP</td>
</tr>
<tr>
<td>Composting</td>
<td>Physical contamination; MC; C:N</td>
</tr>
<tr>
<td>Anaerobic Digestion</td>
<td>Physical contamination; BMP; C:N:S; MC</td>
</tr>
<tr>
<td>Thermal Conversion</td>
<td>Physical contamination; MC; energy yield</td>
</tr>
</tbody>
</table>
Objectives For Today

- Understand impacts of material source on:
  - Contaminants &
  - Biodegradability (BMP).

Source of Food Waste Material

Impact of Collection Method on Feedstock
(Cecchi et al. 2003)

- Three general methods to separate organics from MSW:
  1. Separate collection (SC):
     - e.g. pure waste streams from ICI sector.
  2. Source separation (SS):
     - e.g. household separation of residential waste also known as BioWaste.
  3. Mechanical separation (MS) at central facility:
     - co-mingled collection and then treatment, e.g. MBT in Europe and Edmonton Compost Facility.
Source of Food Waste Material

Percent Contamination by Source Type

<table>
<thead>
<tr>
<th>Separate Collection (as received)</th>
<th>Source Separation (as received)</th>
<th>Mechanical Separation (~3” screen)</th>
</tr>
</thead>
<tbody>
<tr>
<td>ICI 0.3\textsuperscript{a} to 2.2\textsuperscript{a}</td>
<td>R 1.8\textsuperscript{b} to 20.0\textsuperscript{c}</td>
<td>MBT 22.8\textsuperscript{d} to 36.8\textsuperscript{e}</td>
</tr>
<tr>
<td>3.0\textsuperscript{f} to 14.0\textsuperscript{g}</td>
<td>Edm 6.8\textsuperscript{f} to 16.4\textsuperscript{f}</td>
<td></td>
</tr>
</tbody>
</table>

\textsuperscript{a} Cecchi et al. 1997
\textsuperscript{b} Seattle 2012
\textsuperscript{c} Levis et al. 2010
\textsuperscript{d} Montejo et al. 2010
\textsuperscript{e} Montejo et al. 2015

Source of Food Waste material

Monthly Variable of Residential (Seattle 2012)

<table>
<thead>
<tr>
<th>Material</th>
<th>Curbside (%)</th>
<th>Multi-family (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yard waste</td>
<td>66.2 (27.4 - 88.0)</td>
<td>35.4 (34.8 - 53.0)</td>
</tr>
<tr>
<td>Food waste</td>
<td>26.2 (8.9 - 57.1)</td>
<td>43.4 (34.4 - 51.8)</td>
</tr>
<tr>
<td>Compostable paper</td>
<td>5.0 (1.9 - 11.5)</td>
<td>7.8 (6.9 - 10.3)</td>
</tr>
<tr>
<td>Contaminants</td>
<td>1.8 (0.5 - 4.3)</td>
<td>4.0 (3.0 - 5.9)</td>
</tr>
</tbody>
</table>
**ICI Sector: Pre- versus Post-Consumer**
(Yan & McCartney 2014, 2017)

<table>
<thead>
<tr>
<th>Sample Level</th>
<th>Source</th>
<th>Contamination % (min to max)</th>
<th>Recovery, % (min to max)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between Buildings</td>
<td>Pre-consumer</td>
<td>3 (0 to 7)</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>Post-consumer</td>
<td>14 (2 to 19)</td>
<td>NA</td>
</tr>
<tr>
<td>Between Buildings</td>
<td>Buildings with Significant Food Services</td>
<td>5 (0 to 10)</td>
<td>25 (0 to 69)</td>
</tr>
</tbody>
</table>

**Background**

**Objectives For Today**

- Understand impacts of material source on:
  - Contaminants &
  - Biodegradability (BMP).
Food Waste Risk & Reward

Reward - Substrate Biodegradability

- Most important design & operation factor for:
  - Composting.
  - Anaerobic digestion.

- Used to determine:
  - oxygen demand;
  - air demand to remove heat;
  - biomethane potential; and
  - final product mass.

Food Waste Reward - Biodegradability

Relative to Other Organic Waste Feedstock

- Biodegradability function of macromolecules.
- Relative biodegradability:
  - carbohydrates/sugar > protein > lipids/fats > > cellulose/hemicellulose >> lignin

- Food waste highly degradable plant and animal material:
  - Manures once digested.
  - Biosolids twice digested.
  - Leaf & yardwaste less biodegradable.
### Food Waste - Biodegradability

#### Methane Yield Based on Source of OFMSW

**(Cecchi et al. 2003)**

<table>
<thead>
<tr>
<th>Source</th>
<th>Methane Yield (m³ CH₄ per tonne VS)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Separate Collection</td>
<td>Source Separated</td>
</tr>
<tr>
<td>450 to 490</td>
<td>370 to 400</td>
</tr>
</tbody>
</table>

Lower methane potential from MS material.

### Food Waste - Biodegradability

#### Methane Yield Based on Source of OFMSW

**(Lopez et al. 2016)**

<table>
<thead>
<tr>
<th></th>
<th>Residential</th>
<th>ICI Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature Review</td>
<td>m³ CH₄ per tonne VS</td>
<td>n = 7</td>
</tr>
<tr>
<td>Lopez Data</td>
<td>m³ CH₄ per tonne VS</td>
<td>NA</td>
</tr>
</tbody>
</table>
Food Waste Composting Risk
Risk - Food Waste Can Also Be Very Wet
Prince George’s County, Maryland Composting Facility

Summary & Conclusions

- Understand impacts of material source on food waste contamination & BMP.
- Feedstock source significant impact on contamination & BMP:
  1. Separate Collection – ICI
  2. Source Separated
  3. Mechanical Separation
Questions?
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