Key aspects of food waste processing technology selection: physical contaminants & bodegradability

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Background
City of Edmonton

- 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

**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>
Background

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, back-of-house waste streams from ICI sector.
  2. Source separation (SS):
     e.g. household separation of residential waste.
  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(^a) to 2.2(^a)</td>
<td>R 1.8(^b) to 20.0(^c)</td>
<td>MBT 22.8(^d) to 36.8(^e)</td>
</tr>
<tr>
<td>ICI 3.0(^g) to 14.0(^g)</td>
<td></td>
<td>Edm 6.8(^f) to 16.4(^f)</td>
</tr>
</tbody>
</table>

\(^a\) Cecchi et al. 1997
\(^b\) Seattle 2012
\(^c\) Levis et al. 2010
\(^d\) Montejo et al. 2010
\(^e\) Montejo et al. 2015
\(^f\) Rajabpour & McCartney 2015
\(^g\) Yan & McCartney 2014
## 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>
### Source of Food Waste Material

**ICI Sector: Back- versus Front-of-house**  
(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>BofH</td>
<td>3 (0 to 7)</td>
<td>NA</td>
</tr>
<tr>
<td></td>
<td>FofH</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
- But, microbial ecology dampens these differences:
  - Mutualism
- 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>450 to 490</td>
</tr>
<tr>
<td>Source Separated</td>
<td>370 to 400</td>
</tr>
<tr>
<td>Mechanically Separated</td>
<td>160 to 370</td>
</tr>
</tbody>
</table>

Suggests lower methane potential from MS material.
Food Waste - Biodegradability

Methane Yield Based on Source of OFMSW
(Lopez et al. 2016)

<table>
<thead>
<tr>
<th>Source</th>
<th>Residential</th>
<th>ICI Sector</th>
</tr>
</thead>
<tbody>
<tr>
<td>Literature Review</td>
<td>n = 7</td>
<td>n = 9</td>
</tr>
<tr>
<td>m³ CH₄ per tonne VS</td>
<td>298 (225 to 349)</td>
<td>447 (281 to 630)</td>
</tr>
<tr>
<td>Lopez Data</td>
<td>NA</td>
<td>n = 8</td>
</tr>
<tr>
<td>m³ CH₄ per tonne VS</td>
<td></td>
<td>421 (342 to 496)</td>
</tr>
</tbody>
</table>
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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Food Waste Composting Risk

Risk - Food Waste Can Also Be Very Wet

Prince George’s County, Maryland Composting Facility
Background
Where Should Food Waste Go?
General Framework to Approach Technology Selection

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

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

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