Mapping Solid Waste – II
Sample Collection & Analysis

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Presentation Outline

- Procedures for Collection of Samples
- Methods for Sample Analysis
- Methods for Waste Composition
Collection & Analysis of Samples

- Flow of Composition Study
  - Sampling
  - Drying: Moisture Content
  - Classification: Component Rate
  - Heating: Water, Ash Content
  - Calorie meter: Calorific Value
  - Chemical Analysis: N, Cl, S, C, H
## Number of Samples

<table>
<thead>
<tr>
<th>Materials</th>
<th>C.L 95%</th>
<th>C.L 90%</th>
<th>C.L 80%</th>
<th>C.L 70%</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Residential</td>
<td>Commercial</td>
<td>Residential</td>
<td>Commercial</td>
</tr>
<tr>
<td>Aluminum</td>
<td>275-1437</td>
<td>754-4399</td>
<td>70-350</td>
<td>191-1100</td>
</tr>
<tr>
<td>Ferrous</td>
<td>194-554</td>
<td>552-3411</td>
<td>50-139</td>
<td>138-953</td>
</tr>
<tr>
<td>Organic</td>
<td>12-47</td>
<td>26-92</td>
<td>5-14</td>
<td>8-25</td>
</tr>
</tbody>
</table>
Timing

- To collect data that covers entire period of disposal

- To collect data that may be assembled later in a way that represents the entire period

- Local knowledge for primary disposal timings during a day and days of a week

- Records at disposal site for the vehicles’ timings

- Seasonal variations (Rainy / Dry, Summer / Winter)
Selection of Sites

- Virtual numbering of primary disposal sites (Piles/hypes/bins at collection point in a street)

- Virtual numbering of waste collection vehicles at final disposal site

- Based on the minimum number of samples, generate random numbers and select the sites (either primary disposal sites or vehicles) accordingly
Quantification of Waste

- Measurements at the point of generation
- Quantification of waste by examination of records at the point of generation (industries, hospitals, etc.)
- Quantification of waste based on survey of waste collection vehicles
- Quantification of waste by examination of records at waste disposal facility
Characterization of Waste

– Hand sorting of samples (at generation and from vehicles at disposal facility)

– Visual characterization of samples (at generation and from vehicles at disposal facility)
Collecting Samples

(1) Sampling
from waste pit or collection vehicle
(2) Mix (depending on type of waste)
to get average sample
(3) Dividing
to formulate 4 blocks to reduce
(4) Reducing
by discarding diagonally opposite waste
Prepare 200~300kg of Waste from waste pit / collection vehicle
Waste Reduction Method

Sampled Waste

Divide into 4 blocks

2nd reduction

Remove

Remain

Remain

Remove
Mix & Flatten the waste
Divide into 4 blocks
Remove 2 blocks of Waste diagonally opposite ends
Another diagonal opposite ends waste are remained.
Mix & flatten remained waste
Divide into 4 blocks again.
Crash big waste into small pieces
Tear plastic bag
Pick up cans & bottles to reduce equally instead of crushing
3rd reduction by same method
Remained waste through 3~4 times reduction
Prepare 2 buckets (100 litter) to accommodate remained waste
Pull up the bucket with waste 30 cm high from the floor & drop it
Measure the weight to check Specific Gravity
(Volume to Weight Factor)

Specific Gravity = Weight/Volume
Composition Analysis  
(Dried vs. Raw Samples)

If the purpose of the waste analysis is for plan for waste incineration system, then waste will be dried to make it easy to proceed next steps.

But, in case of improvement of collection / final disposal, waste component study will be made by wet base (without drying)
Moisture Content
Caution for Waste in Oven / Heater

Never mix

- Matches
- Lighters
- Paints
- Fireworks, Firecrackers

To avoid explosion & fire
Put sample waste in trays of Oven/Heater
Temperature
80~90 °C

Heating Time
48 hours

Cooling Time
2 Days
Put sample waste out from the heater

Moisture Content is equal to difference in weight of raw and dry waste
Moisture Content

- **Weight of raw waste** = A kg
- **Weight of dried waste** = B kg

**Moisture Content** = \[
\frac{(A-B)}{A} \times 100 \%
\]
Moisture Meters
Waste Composition Study

- Classify a waste sample into several categories by manual sorting

- Prepare sheet on the floor, and spread all sample waste on it

- Prepare proper containers with designated name card

- Sort from big materials to small
Sample waste to be sorted into different categories
Kitchen Waste
Paper
Textile
Grass & Wood
Plastic
Others (less than 5 mm)
Glass
Ceramic & Stone
Steel
Metal without Steel
Weighing individual component
Moisture & Ash Content Study

1. Heat melting pot for 16 hours under 105°C.
2. Cool them in decicater and weigh (Ag)
3. Put the sample on them and weigh (Bg)
4. Dry them for 16 hours under 105°C.
5. Cool them in decicator and weigh (Cg)
6. Heat the melting pot w/ sample by burner to burn out.
7. Keep them in the electric heater under 600°C for 2 hours.
8. After complete burning, put melting pot w/ sample out from the electric heater, and cool them in the decicator.
9. After cooling down, weigh them. (Dg)

- Moisture Content (%) = \(\frac{(B-C)}{(B-A)} \times 100\)
- Ash Content (%) = \(\frac{(D-A)}{(B-A)} \times 100\)
The sample is burned by Bunsen burner
6 hours heating in electric heater under 600°C

Weight of Welting Pot = A g
Weight of Welting Pot w/ Waste Sample = B g
Weight of Welting Pot with Waste Sample which were burned completely = D g

Ash Content(%) = \frac{(D-A)}{(B-A)} \times 100
Calorific Value

Each sample is set to measure its calorific value after measuring its weight.
Nickel wire is used for ignition
Oxygen is filled to the cylinder which accommodate sample w/ ignition wire
B-Type Calorimeter

The cylinder w/ sample is set into Calorimeter in which water is filled. After ignited, sample is burned completely and raise water temperature. Calorific value can be get by temperature change before & after burning.
Calorific Value – Alternative Method

\[ CV_{\text{raw}} = ((1 - MC) \times (CV_{\text{upper}} - (2241 \times 9) \times H)) - 2441 \times MC \]

Where:
\( CV = \) calorific value (‘raw’ is real ‘as delivered’ value, ‘upper’ is value for dried material) in kJ/kg
\( MC = \) % moisture content (by weight)
\( H = \) % hydrogen content (from literature)
* vaporization enthalpy of water (241kJ/kg at 25°C)

To determine the calorific value of waste stream the following steps to be carried out:

• Sample to be sorted and analyzed into the fractions;
• \( CV_{\text{upper}} \) is applied from know data (literature);
• \( CV_{\text{upper}} \) is analyzed for unknown fractions;
• % Hydrogen is applied from know data (literature);
• Moisture of fractions is determined; and

Calculate value for \( CV_{\text{raw}} \).
### Result of the Study

<table>
<thead>
<tr>
<th>Sample</th>
<th>Component Rate (%)</th>
<th>Moisture Content (%)</th>
<th>Ash Content (%)</th>
<th>Calorific Value Ho (Kcal/kg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Kitchen Waste</td>
<td>3.73</td>
<td>11.20</td>
<td>15.37</td>
<td>3466</td>
</tr>
<tr>
<td>Paper</td>
<td>39.22</td>
<td>4.24</td>
<td>8.99</td>
<td>4178</td>
</tr>
<tr>
<td>Textile</td>
<td>6.14</td>
<td>2.65</td>
<td>1.76</td>
<td>4934</td>
</tr>
<tr>
<td>Grass &amp; Wood</td>
<td>12.02</td>
<td>6.47</td>
<td>11.04</td>
<td>4274</td>
</tr>
<tr>
<td>Plastic</td>
<td>17.33</td>
<td>2.38</td>
<td>7.40</td>
<td>7898</td>
</tr>
<tr>
<td>Others (less than 5mm)</td>
<td>4.39</td>
<td>4.79</td>
<td>40.16</td>
<td>2723</td>
</tr>
<tr>
<td>Total of Combustible</td>
<td>(82.83)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Typical Combustible Sample</td>
<td>-</td>
<td>3.92</td>
<td>10.22</td>
<td>4900</td>
</tr>
<tr>
<td>Glass</td>
<td>9.04</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ceramic &amp; Stone</td>
<td>1.00</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Steel</td>
<td>5.47</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Metal w/o Steel</td>
<td>1.66</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total of Incombustible</td>
<td>(17.17)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>100.00</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Nitrogen Content Analysis by Kjedahl Method
Sulfur Content Analysis
Chlorine Analysis
## Chemical Composition Factors

<table>
<thead>
<tr>
<th>Material in MSW</th>
<th>Moisture</th>
<th>Hydrogen content</th>
<th>CV upper kJ/kg</th>
<th>CV raw kJ/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Eligible Components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Kitchen Organics – vegetable</td>
<td>80.9%</td>
<td>6.2%</td>
<td>19,800</td>
<td>1,540</td>
</tr>
<tr>
<td>Kitchen Organics – meat</td>
<td>52.9%</td>
<td>9.4%</td>
<td>11,900</td>
<td>3,340</td>
</tr>
<tr>
<td>Municipal Garden Organics</td>
<td>46.5%</td>
<td>6%</td>
<td>16,800</td>
<td>7,140</td>
</tr>
<tr>
<td>Paper composite</td>
<td>12%</td>
<td>7.5%</td>
<td>21,450</td>
<td>17,130</td>
</tr>
<tr>
<td>Mixed Paper</td>
<td>29.7%</td>
<td>5.8%</td>
<td>15,150</td>
<td>9,030</td>
</tr>
<tr>
<td>Liquid Paper Board</td>
<td>4.5%</td>
<td>7.5%</td>
<td>21,450</td>
<td>12,520²</td>
</tr>
<tr>
<td>Newspaper</td>
<td>7.2%</td>
<td>6.1%</td>
<td>17,330</td>
<td>14,660</td>
</tr>
<tr>
<td>Magazines</td>
<td>5%</td>
<td>5.1%</td>
<td>13,500</td>
<td>11,640</td>
</tr>
<tr>
<td>Cardboard</td>
<td>6.7%</td>
<td>5.9%</td>
<td>18,670</td>
<td>16,050</td>
</tr>
<tr>
<td>Disposable Nappies</td>
<td>55%</td>
<td>6.4%</td>
<td>22,900</td>
<td>4,190²</td>
</tr>
<tr>
<td>Wood(timber)³</td>
<td>19%</td>
<td>6%</td>
<td>20,630</td>
<td>15,070</td>
</tr>
<tr>
<td><strong>Non-Eligible Components</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Textiles¹</td>
<td>26.8%</td>
<td>6.4%</td>
<td>16,780</td>
<td>10,600</td>
</tr>
<tr>
<td>Liquid Paper Board</td>
<td>4.5%</td>
<td>7.5%</td>
<td>21,450</td>
<td>6,360</td>
</tr>
<tr>
<td>Disposable Nappies</td>
<td>55%</td>
<td>6.4%</td>
<td>22,900</td>
<td>4,140</td>
</tr>
<tr>
<td>Compounds (radios etc)</td>
<td>10%</td>
<td>5.1%</td>
<td>12,000</td>
<td>9,570</td>
</tr>
<tr>
<td>Mixed Plastics</td>
<td>10%</td>
<td>10%</td>
<td>39,000</td>
<td>32,880</td>
</tr>
<tr>
<td>Plastic composite</td>
<td>&lt;1%</td>
<td>10%</td>
<td>37,100</td>
<td>34,900</td>
</tr>
<tr>
<td>Plastic Film</td>
<td>&lt;1%</td>
<td>10%</td>
<td>40,000</td>
<td>37,800</td>
</tr>
<tr>
<td>Polystyrene (PS)</td>
<td>&lt;1%</td>
<td>8.4%</td>
<td>40,000</td>
<td>38,150</td>
</tr>
<tr>
<td>Polyethylene (PE)</td>
<td>&lt;1%</td>
<td>14.2</td>
<td>45,000</td>
<td>41,880</td>
</tr>
<tr>
<td>Polystyrene teraphthalate (PET)</td>
<td>&lt;1%</td>
<td>6%</td>
<td>25,000</td>
<td>23,770</td>
</tr>
<tr>
<td>Polypropylene (PP)</td>
<td>&lt;1%</td>
<td>14%</td>
<td>44,000</td>
<td>40,920</td>
</tr>
<tr>
<td>Rubber</td>
<td>18.7%</td>
<td>8.7%</td>
<td>23,100</td>
<td>16,770</td>
</tr>
</tbody>
</table>

Note 1 – Caution: Moisture content changes seasonally, regionally and due to rainfall.
Note 2 – For these mixed materials the CV has been adjusted to 10% plastic (LPB), 10% plastic (Disposable Nappies) and split into eligible and non-eligible components.
Note 3 – Excludes green organics and wood waste from forestry or land clearing operations.
Note 4 – Textiles may be eligible if from known source of natural fibre.
Flow of Waste Analysis

(Combustible Sample)
• Kitchen Waste
• Paper
• Textile
• Grass & Wood
• Plastic
• Others (less than 5mm)

Calorific Value $Hu$

Heating

Moisture/Ash Content

Calorimeter

Chemical Element Analysis
N, Cl, S, C, H

Necessary Air Volume for combustion

Calorific Value $Ho$

Calorific Value $Hu$
Thank You…

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