Lesson 7: Operations – Active Composting

Learning Objectives:

■ Know the three stages of composting and their function
■ Understand proper compost monitoring procedures
■ Be familiar with proper windrow management to optimize composting
■ Be clear on how to diagnose and correct common problems
Three Stages of Composting Process

- Thermophilic (high temperature) composting
- Mesophilic (moderate temperature) composting
- Curing (stabilization and maturation)
Three Stages of Composting

Active Composting

Mixing & Pile Construction → Thermophilic Phase → Mesophilic Phase → Curing → Screening → High-quality Finished Compost
Thermophilic Composting

- Occurs at 35°C - 65°C (95°F - 150°F)
- Thermophilic bacteria do the work
- Most rapid and efficient composting method – organic materials decompose in several weeks to two months
- 55°C (131°F) is needed to destroy weed seeds, human and plant diseases and parasites
- Avoid temperatures above 65°C (150°F)
Mesophilic Composting

- Occurs at 20ºC - 35ºC (70ºF - 95ºF)
- Mesophilic bacteria, actinomycetes, fungi, earthworms & insects do the work
- Follows thermophilic stage and allows further decomposition
- Does not destroy weed seeds, diseases or parasites
Pathogen Reduction Requirement

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- **Option 1:**
  - Pathogens: Fecal coliform <1,000 MPN/gm *Or* Salmonella sp. <3 MPN/4gm
  - and
  - Time, temperature & turnings regime

- **Option 2:**
  - Pathogens: Fecal coliform <1,000 MPN/gm *Or* Salmonella sp. <3 MPN/4gm, *And* Enteric virus <1 PFU/4gm, *And* Helminth ova <1/4gm
Time and Temperature Regimes

- Turned Windrow
  - 15 consecutive days with temperature $\geq 55^\circ C$ with 5 turnings

- Aerated Static Pile
  - 3 days with temperature $\geq 55^\circ C$ (insulated pile)

- In-vessel
  - 3 days with temperature $\geq 55^\circ C$
Controllable Variables

- Pile size and mechanics
- Temperature
- Aeration
- Moisture
- Porosity
- Residence time
Windrow Turning

- Do not compact windrows
- Move materials from surface to center of windrow and vice versa
- Thoroughly mix materials
- Turning subjects all materials to +55°C temperature to kill pathogens and weed seeds

Photo source: FORCE Reedy Creek
Windrow Turning
(continued)

- When turning with front end loader, lift material and let it cascade to maximize aeration and porosity
- Re-shape the windrow for consistent dimensions and smooth sides

Photo source: FORCE Reedy Creek
Compost Monitoring

- Observations of temperature, moisture, porosity, oxygen, odor, and ambient conditions are basis for maintaining optimum composting conditions.

- Observations are the basis for decisions & actions:
  - Windrow turning
  - Moisture adjustment
  - Correcting problem
  - When composting is complete
Temperature Monitoring

- Overall indicator of other factors: moisture, oxygen, progress of biological process
- Measure temperatures at least 2x weekly at various depths (e.g., 1 & 3 ft) at least every 75 feet along the windrow

Photo source: FORCE Reedy Creek
Compost Thermometer

- 3 – 4 ft. long pointed steel stem
- Minimum 3/8 inch thick stem
- Measurement range from 0°C – 100°C (~30°F - 200°F)
- Calibration screw
Moisture Monitoring

- Ideal moisture content for composting is 50% - 60%
- Use the “squeeze test” described in Lesson 6
- Moisture meters are also available however they require regular calibration

Photo source: biconet.com
Moisture Analysis

- One methodology to measure moisture content quantitatively:
  - Collect 100 g (3.5 ounces) sample of material and measure weight (wet weight)
  - Dry sample in a microwave oven (using short intervals and mixing) until weight difference is <1 g
  - Measure dry weight and calculate moisture content
Moisture Management

- If windrow is too **dry**:  
  - Add water when turning and rebuilding  
  - Moisten exterior before mixing into the core  
  - Shape windrow to increase rain infiltration

- If windrow is too **wet**:  
  - Turn it to release excess water vapor  
  - Turn it on a dry sunny day  
  - Mix in more dry carbon material when turning  
  - Shape pile to minimize infiltration
Windrow Shapes to Control Rain Infiltration

- Peak Shape Sheds Water
- Trapezoid Shape Traps Some Water
- Concave Shape Traps Most Water
Oxygen and Pore Space Monitoring

- Oxygen level in active compost pile should be ≥5% (ambient $O_2 = 21\%$)
- Oxygen meters are available
- Lab procedures exist to measure pore space
- Monitoring these can be beneficial but is not essential

Photo source: woodsend.org
Weather Monitoring

- Wind direction
- Wind speed
- Temperature
- Cloud cover
- Precipitation

Photo source: FORCE Reedy Creek
Putting It Together
(and reading between the lines)

Composting Monitoring Chart

Thermophilic

Mesophilic

Temperature (°C)

Rainfall (in.)

Day

Rain Fall  Windrow Temperature  Windrow Turning
Vector and Pest Prevention and Control

- Immediately mix wet putrescible materials to correct C:N ratio and moisture content, and move into compost windrow
- Cover windrow with >6 inch layer of well-aged mulch or coarse compost
- Do not turn windrows during initial 10-14 days
- Maintain integrity and slope of working surfaces and prevent standing water
Odor Prevention and Control

In addition to vector control practices…

- Build windrows with good porosity and not too large
- If odors from turning are unavoidable, turn windrows when wind is blowing away from sensitive receptors
- Do not turn windrows during early morning or evening
- Understand basic principles of atmospheric dispersion
Monitoring and Recordkeeping

- Ambient conditions: Daily
  - Precipitation, high temperature, sky conditions (wind speed & direction if necessary)
- Odor conditions: Daily
- Windrow Temperature: 2x weekly
- Windrow Moisture: 1x weekly
## Diagnosing and Correcting Problems

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>If windrow is moist and has earthy smell, it may not have enough nitrogen</td>
<td>Mix in fresh nitrogen (grass, food waste, manure)</td>
</tr>
<tr>
<td>If windrow is very wet or smells sour, it may need more dry matter and/or air</td>
<td>Turn and aerate - mix in dry carbon (yard trimmings, straw, sawdust)</td>
</tr>
<tr>
<td>If windrow is dry, it needs more water</td>
<td>Spread out and add more water, mix well, and rebuild windrow</td>
</tr>
<tr>
<td>Windrow may be too small to retain heat</td>
<td>Gather enough material to make windrow 6-8 ft tall</td>
</tr>
</tbody>
</table>
## Pile Smells Bad (garbage, rotten eggs, or vinegar)

<table>
<thead>
<tr>
<th>Possible Cause</th>
<th>Solution</th>
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<tbody>
<tr>
<td>Windrow has too much nitrogen</td>
<td>Mix in dry, rapid source of carbon (leaves, straw, sawdust)</td>
</tr>
<tr>
<td>Nitrogen &amp; carbon not fully mixed</td>
<td>Break apart clumps of nitrogen material (food scraps, grass, manure) and mix with carbon material</td>
</tr>
<tr>
<td>Windrow is anaerobic</td>
<td>Turn the pile and mix in coarse dry material (yard trimmings, straw, wood chips); protect pile from rain</td>
</tr>
</tbody>
</table>
## Diagnosing and Correcting Problems (continued)

<table>
<thead>
<tr>
<th>Pile Smells Bad (ammonia)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Cause</strong></td>
</tr>
<tr>
<td>Too much nitrogen and pH is &lt;7.5</td>
</tr>
</tbody>
</table>
## Windrow Attracts Animals or Flies

<table>
<thead>
<tr>
<th>Cause</th>
<th>Solution</th>
</tr>
</thead>
<tbody>
<tr>
<td>Windrow contains un-decomposed putrescible materials</td>
<td>Place a 12-18 inch layer of well-aged mulch or compost over the entire windrow</td>
</tr>
<tr>
<td></td>
<td>Ensure proper C:N ratio, moisture and porosity, then turn the pile several times after it reaches high temperature</td>
</tr>
<tr>
<td></td>
<td>Remove problem materials (dairy, meat, oils, feces)</td>
</tr>
</tbody>
</table>
Fire Prevention

- Well-managed compost windrows will not spontaneously ignite.
- Fire is a possibility if moisture is <40%, piles are very large (i.e. anaerobic) and very hot, i.e. >230°C (>450°F).
- Other potential for fire is very dry material and open flame or spark.
- Site design elements:
  - Access for fire-fighting vehicles
  - Source of water
  - Secure site access to prevent vandalism.
Protecting Workers

- Personal protective equipment
- Health screening for immune & respiratory conditions
- Health and safety standards, training and enforcement
- Proper signage where applicable
- Clear communication and ownership