Compost Site Management: The Basics

James McSweeney
Compost Basics

Food
(C + N)

O₂

H₂O

Microbes
Compost Basics

Food (C + N) → N, NH₃, N₂O

O₂ → H₂O

H₂O → H₂O

Microbes → CO₂, Heat
Compost Basics

- Raw (Dead) OM
- Stable (Alive) OM
- Volatile Compounds
- O$_2$, Microbe Metabolism
Managed Compost

The presence of oxygen and oxygen loving organisms:

– Fast and complete decomposition

– Higher Temperatures needed to kill pathogens and weed seeds
  
  • All particles reach 131° or greater for at least 3 days
  
  • Achieved through effective aeration and turning

– Minimal odors which are primarily caused by anaerobic organisms
Phases of Composting: Time/Target Temperature Relationship

- **Active Composting**
  - Primary Phase: 2-6 Weeks
  - Secondary Phase: 4-10 Weeks
  - Finishing Phase: 4-24 Weeks
  - Curing Phase: 4-12+ Weeks

(McSweeney, *Community-Scaled Composting Systems*, 2019 forthcoming)
Why Sites Close

• Odor (and odor complaints)
• Over or under capacity
• Also: economic factors, vectors, nimby-ism

Good planning, training, and best management practices can help.
Why use a recipe?

• Create conditions favorable to aerobic and thermophilic organisms
  • Pathogen and weed seed inactivation
• Retention of carbon and nitrogen/nutrients
• Odor mitigation
• Your eyes can’t perform chemical analysis
• To be in compliance with State & other regulations
• To have a reference point
Compost BMPs: Compost Recipe

• Balance:
  – Protein w/ Carbon (C:N Ratio)
  – Moisture w/ dry matter (Moisture Content)
  – Dense material w/ bulking agent (Bulk Density)
  – Analytically developed

• Effective blending
<table>
<thead>
<tr>
<th>Components</th>
<th>Quantity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Part High Nitrogen (Green)</td>
<td>1</td>
</tr>
<tr>
<td>1-2 Parts High Carbon (Brown)</td>
<td>1-2</td>
</tr>
<tr>
<td>1-2 Parts Neutral (Balanced C:N)</td>
<td>1-2</td>
</tr>
<tr>
<td>½-1 Part Bulking Agent (Porous)</td>
<td>½-1</td>
</tr>
</tbody>
</table>
Compost BMPs: Temperature Treatment

- Monitoring
- Turning

0 Degrees outside!
## Monitoring Pile Activity

**Compost Monitoring Log**

**Pile Identification:** FW28  
**Date Pile Built:** 6/22/11

<table>
<thead>
<tr>
<th>Date</th>
<th>Pile Temperature</th>
<th>Air Temp</th>
<th>MC</th>
<th>Odor</th>
<th>Visual</th>
<th>Notes (mgmt, weather, vectors):</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/28</td>
<td>142/130 144/117</td>
<td>80</td>
<td>55</td>
<td>NH4</td>
<td></td>
<td>Drilled 1/3 7/27 (half of pile)</td>
</tr>
<tr>
<td>8/1</td>
<td>137/121 154/130</td>
<td>80</td>
<td>70</td>
<td>mature</td>
<td></td>
<td>Turned 1/3 8/3</td>
</tr>
<tr>
<td>8/4</td>
<td>154/138 137/141</td>
<td>75</td>
<td>65</td>
<td>mature</td>
<td>NH4</td>
<td></td>
</tr>
<tr>
<td>8/8</td>
<td>150/133 133/120</td>
<td>70</td>
<td>65</td>
<td>NH4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/11</td>
<td>146/126 152/130</td>
<td>75</td>
<td>60</td>
<td>NH4</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8/18</td>
<td>134/119 142/114</td>
<td>77</td>
<td>55</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/22</td>
<td>140/124 125/124</td>
<td>75</td>
<td>60</td>
<td>earthy</td>
<td></td>
<td>Turned 1/3</td>
</tr>
<tr>
<td>8/25</td>
<td>150/138 136/127</td>
<td>70</td>
<td>60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9/29</td>
<td>117/123 129/123</td>
<td>70</td>
<td>65</td>
<td>musty</td>
<td>9/19</td>
<td>132/113 121/115</td>
</tr>
<tr>
<td>9/1</td>
<td>130/120 120/124</td>
<td>70</td>
<td>65</td>
<td>NH4</td>
<td>9/30</td>
<td></td>
</tr>
</tbody>
</table>

Feedstocks and Mix Proportions:
Pathogen Reduction Mechanisms

- Thermal destruction
- Production of toxic byproducts such as gaseous ammonia
- Competition between indigenous microorganisms and pathogens
- Antagonistic relationships between organisms
- Antibiotics produced by certain fungi and actinomycetes
- Natural die-off in the compost environment (which is non-ideal for enteric (gut) pathogens)
- Nutrient depletion

FIGURE 8.4. Heat inactivation of *Salmonella enteritidis* serotype Montivideo in composted biosolids. (Data from Ward and Brandon, 1977.)
Process to Further Reduce Pathogens (PFRP) & National Organic Program (NOP) Standards

Turned Windrows

- **PFRP standard** is to turn pile at least five times while maintaining $\geq 131$ Degrees F for at least 15 days

Aerated Static Pile or In-Vessel

- **PFRP requirement** is that the material reaches 131 Degrees F or greater for a minimum of 3 days
Key Factors to Ensure Pathogen Inactivation

- Institutionalize BMPs
- Track batches
- Consistent temperature monitoring (1’ and 3’, multiple points)
- Adopt maturity standard
- Prevent reintroduction of pathogens (keep high and dry)
- Maintain aerobicity (small pile sizes)
- Periodic testing
Compost BMPs: Moisture Management

- Improved pad surfaces
- Graded
- Level
- Clean water diversion
- Clean pad
- Recipe
Compost BMPs: Compost Maturation

- Earthy smell
- Friable
- Temps below 100 F
- O$_2$ demand, CO$_2$ & N$_2$O production minimal (test)
- Alive!
Compost BMPs: Vector Controls

- Immediate incorporation of food sources
- Cover piles (w/ compost & covers)
- Avoid odors
- Hit temps
Compost BMPs: Housekeeping

- Aesthetics matter! People smell with their eyes
- Remove trash
- Organized space
- Size properly
“Despite all our achievements we owe our existence to a six-inch layer of topsoil”

Anonymous

Making the argument - for the soil.
Compost Cycle Ecosystem Services

• Return – Energy, nutrients, life
• Soil Health – Organic matter, structure, soil food web
• Hydrological Cycles – Infiltration, retention, drought resistance, runoff & pollution mitigation
• Plant Health – root density, disease resistance & antagonism, reduction in agrochemicals
• Goal of soil as sink vs emitter of GHG
Avoidable food waste contributes 2% of total GHG Emissions in US.

Campbell and Ingram, 2012.
One 5 gallon bucket of food scraps composted = 1 gallon of gasoline C emissions mitigated

(Assumes Community wide and regional collection programs – Source: Highfields Center to Composting)
Soil Organic Matter

Jessica Chiartas, PhD Candidate, UC Davis, Digging Deeper: How Compost and Cover Crops Can Sequester Soil Carbon
Scanning Electron Microscopy: bacteria cell wall (yellow) and contents inside bacteria (red) bonded to mineral particle.
Runaway GHG emissions

- **8.9 Pg C** emitted annually
  (1 Pg = 1 Petagram = 1 Quadrillion Grams)

- Total emissions since Industrial Revolution
  - Conversion to Agriculture: **136±55 Pg C**
  - Intensification: **78±12 Pg C**

- Negative emissions of **150 Pg C** required to prevent **2°C rise** in temperature

Jessica Chiartas, PhD Candidate, UC Davis, Digging Deeper: How Compost and Cover Crops Can Sequester Soil Carbon
Zomer et al., 2017; Hansen et al. 2016
Soil Carbon Stocks

- Plant biomass: 550
- Atmosphere: 800 Pg
- Soil: 2,340
  - 50-75% of soil C below 30 cm
- Fossil fuels: 10,000
- Oceans: 1,000
- Deep oceans: 37,000

Jessica Chiartas, PhD Candidate, UC Davis, Digging Deeper: How Compost and Cover Crops Can Sequester Soil Carbon
Carbon Sequestration to the Rescue?

California's Healthy Soils Program

Incentivizes farmers to build SOM

France's 4 per 1000 Initiative

Aims to sequester 3.5 Pg C yr\(^{-1}\)

Maximum Potential*: 0.9-1.85 Pg C yr\(^{-1}\)

*According to scientific literature

Jessica Chiartas, PhD Candidate, UC Davis, Digging Deeper: How Compost and Cover Crops Can Sequester Soil Carbon

Zomer et al., 2017; van Groenigen et al. 2016
Our soils need compost

Our communities need composting

We have the tools to compost right
Questions?