Basics of Composting Poultry Litter and Swine Bedding

Sanjay Shah
North Carolina State University
16 November 2010
Composting Facts

• Compost: stable organic material with earthy smell
• Microorganisms convert less stable organic material into compost
• Similar to natural decay but faster due to better control of conditions
Composting Benefits

• Can generate revenues
• Safer & easier to handle vs. raw waste
• Can kill fly eggs and weed seeds
• Good soil amendment
Composting Benefits

• Amount reduced by 25 to 50%
• Greater forage palatability
• Less nitrate concern in forage
• Apply more per acre due to lower N content
Before we get started …

• Swine waste and broiler litter are compostable materials!
• Piling up waste is not really composting!
• Composting requires management & costs money!
• Composting is both science and art!
Factors Affecting Composting Process

1. Aeration
2. Moisture content
3. Carbon/Nitrogen ratio
4. Temperature
5. Time
6. Porosity, structure, texture & particle size
7. pH or acidity level
Aeration

- Supplies oxygen
- Removes excessive heat & moisture
- Reduces packing
- Turn, force air, or chimney effect
- Poor aeration causes anaerobic activity (bad) – smelly site
- Too much aeration cools compost (bad)

Windrow turner with watering attachment at CEFS
Moisture content (MC)

\[ MC(\%) = \frac{Wt.\ of\ water}{Total\ wet\ wt.} \times 100 \]

- Microbes require moisture
- Need MC for initial mix & periodic watering
- Desirable: 50% (range: 40-65%)
- Less than 40%: reduced microbial activity (spontaneous combustion risk)
Moisture content (cont.)

• Greater than 65%: anaerobic activity (poor aeration)
• Crude method: Squeeze compost ball in hand
  - only 1-2 drops: MC is just right
  - no water: MC too low
  - more water: MC too high
Moisture content (cont.)

- Microwave drying most accurate but need microwave, weighing scale ($120, Grainger), brown paper bags
- Need representative sample!
- Soil or hay moisture probes give indication faster but less accurate than drying method
Moisture content (cont.)

Reotemp ‘backyard moisture meter’, $40 (www.reotemp.com)

Reotemp ‘moisture meter’, $150 for 4-ft stem

Moisture meter from Grainger, $100
Example: Farmer Joe wants to determine moisture content of compost sample. He takes a 54-gram compost sample plus brown paper bag (weight 4 grams) and places in microwave and heats it for 1 min. He weighs and the new weight is 42 grams. He again heats for another minute and the new weight is 36 grams. During the 3\textsuperscript{rd} heating, he stops before 1 min. when the sample starts to singe. The final weight of bag plus sample is 28 grams.

- Total sample wt. = 54 grams
- Total wet wt. = Total sample wt. - Bag wt. = 54 − 4 = 50 g
- Solid wt. = Final wt. − Bag wt. = 28 − 4 = 24 g
- Wt. of water = Total wet wt. − Solid wt. = 50 - 24 = 26 g
- MC (%) = Wt. of water X 100/ Total wet wt. = 26\times100/50 = 52%
Carbon/Nitrogen (C/N) Ratio

- Microbes require different proportions of C & N (also other nutrients)
- Desirable C/N: 30 (range 20-40)
- N loss with low C/N
- Slower composting with high C/N
- Composting stops when usable C used up
- Challenge is with multiple materials varying in C, N, and also moisture contents (example later)
# Some C/N Ratios

<table>
<thead>
<tr>
<th>Source</th>
<th>Average</th>
<th>Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Horse manure (&amp; bedding)</td>
<td>30</td>
<td>22-50</td>
</tr>
<tr>
<td>Broiler litter</td>
<td>14</td>
<td>12-15</td>
</tr>
<tr>
<td>Swine waste</td>
<td>14</td>
<td>9-19</td>
</tr>
<tr>
<td>Saw dust</td>
<td>442</td>
<td>200-750</td>
</tr>
<tr>
<td>Grain straw</td>
<td>80</td>
<td>48-150</td>
</tr>
<tr>
<td>Grass clippings</td>
<td>17</td>
<td>9-25</td>
</tr>
<tr>
<td>Non-legume Hay</td>
<td>32</td>
<td></td>
</tr>
</tbody>
</table>

Source: NRAES 54
C/N Ratio (contd.)

- When possible, have raw material & compost samples analyzed instead of using literature values
- Need to ask NCDA to do C analysis for animal waste (no extra cost); C/N analysis on compost done automatically
- Mail samples same day to NCDA lab or refrigerate
  NCDA&CS Agronomic Division
  1040 Mail Service Center
  Raleigh, NC 27699-1040
  Phone: (919)733-2655
- Waste analysis results available online
  - Go to: http://www.ncagr.com/agronomi/pwshome.htm
  - Click on: Find Your Plant, Waste, or Solution Report
  - Report available in as little as 2 days
C/N ratio calculation problem

Example: Farmer John has 4,000 lb of broiler litter (MC = 35%, C = 26%, N = 20,000 ppm; all from NCDA analysis). He wants to mix it with spoiled hay (MC = 25%). From literature, hay has C/N of 32 and N of 1.3% on dry basis. If he wants to have a C/N ratio of 30 for his compost, how much hay should be mixed in with 4,000 lb of litter?

Note: 1% = 10,000 ppm

Important equation:

\[
\frac{Wt.\, C_{\text{litter}} + Wt.\, C_{\text{hay}}}{Wt.\, N_{\text{litter}} + Wt.\, N_{\text{hay}}} = \frac{30}{1}
\]
C/N ratio calculation problem (contd.)

<table>
<thead>
<tr>
<th>Materials</th>
<th>Total wt., lb</th>
<th>MC, %</th>
<th>Dry wt, lb</th>
<th>Wt. of water, lb</th>
<th>Wt. of N, lb</th>
<th>N, %</th>
<th>Wt. of N, lb</th>
<th>C/N</th>
<th>Wt. of C, lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Litter</td>
<td>4,000</td>
<td>26</td>
<td>(100 - 26) *4,000 /100 = 3,040</td>
<td>4,000 - 3,040 = 960</td>
<td>20,000 /10,000 = 2.0</td>
<td>3,040*2.0/100 = 61</td>
<td>26/2.0 = 13</td>
<td>3,040*26/100 = 790</td>
<td></td>
</tr>
<tr>
<td>Hay</td>
<td>X</td>
<td>25</td>
<td>(100 - 25) *X/100 = 0.75X</td>
<td>X-0.75X = 0.25X</td>
<td>1.3</td>
<td>1.3*0.75X/100 = 0.00975X</td>
<td>32</td>
<td>0.00975X*32 = 0.312X</td>
<td></td>
</tr>
<tr>
<td>TOTAL</td>
<td>4000 + X</td>
<td></td>
<td>3,040 + 0.75X</td>
<td>960 + 0.25X</td>
<td>61 + 0.00975X</td>
<td>790 + 0.312X</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

\[
\frac{790 + 0.312X}{61 + 0.00975X} = 30
\]

\[
X = 53,333 \text{ lb}
\]

So, we need to add 53,333 lb of hay to 4,000 lb of litter to get C/N of 30
Temperature

• Temperature affects speed of composting & destruction of pathogens & weed seeds
• Composting at thermophilic (above 105 F) and mesophilic (50 to 105 F) ranges
• NC regulations: Need 131 F for 15 days (windrow) or 3 days (static pile or in-vessel) for pathogen reduction in Type 3 (manure) facilities
Temperature (cont.)

• 130-145 F kills many weed seeds & pest eggs
• Composting reduced above 150 F
• Aerate at 140 F
• Long-stem thermometer needed ($100-150)

Monitoring temperature in a composting bin
Source: National Engineering Handbook
Typical Temperature Rhythm of Windrow Method

Source: National Engineering Handbook
Time

• Depends on many factors, including method, management, source material, and weather
• Composting faster with proper moisture content and C/N and frequent aeration
• Composting delayed by dry material, high C/N, cold weather, and infrequent aeration
• Compost longer for dry & stable product
• Composting period shorter when applied to cropland
### Impact of source and method on composting time

**Source:** NRAES-54

<table>
<thead>
<tr>
<th>Method</th>
<th>Materials</th>
<th>Active composting time</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Range</td>
<td>Typical</td>
<td>Curing</td>
</tr>
<tr>
<td>Passive composting</td>
<td>Leaves</td>
<td>2–3 years</td>
<td>2 years</td>
<td>—</td>
</tr>
<tr>
<td></td>
<td>Well-bedded manure</td>
<td>6 months to 2 years</td>
<td>1 year</td>
<td>—</td>
</tr>
<tr>
<td>Windrow—infrequent turning</td>
<td>Leaves</td>
<td>6 months to 1 year</td>
<td>9 months</td>
<td>4 months</td>
</tr>
<tr>
<td></td>
<td>Manure + amendments</td>
<td>4–8 months</td>
<td>6 months</td>
<td>1–2 months</td>
</tr>
<tr>
<td>Windrow—frequent turning</td>
<td>Manure + amendments</td>
<td>1–4 months</td>
<td>2 months</td>
<td>1–2 months</td>
</tr>
<tr>
<td>Passively aerated windrow</td>
<td>Manure + bedding</td>
<td>10–12 weeks</td>
<td>—</td>
<td>1–2 months</td>
</tr>
<tr>
<td></td>
<td>Fish wastes + peat moss</td>
<td>8–10 weeks</td>
<td>—</td>
<td>1–2 months</td>
</tr>
<tr>
<td>Aerated static pile</td>
<td>Sludge + wood chips</td>
<td>3–5 weeks</td>
<td>4 weeks</td>
<td>1–2 months</td>
</tr>
<tr>
<td>Rectangular agitated bed</td>
<td>Sludge + yard waste or Manure + sawdust</td>
<td>2–4 weeks</td>
<td>3 weeks</td>
<td>1–2 months</td>
</tr>
<tr>
<td>Rotating drums</td>
<td>Sludge and/or solid wastes</td>
<td>3–8 days</td>
<td>—</td>
<td>2 months</td>
</tr>
<tr>
<td>Vertical silos</td>
<td>Sludge and/or solid wastes</td>
<td>1–2 weeks</td>
<td>—</td>
<td>2 months</td>
</tr>
</tbody>
</table>

---

*a* For example, with bucket loader.

*b* For example, with special windrow turner.

*c* Often involves a second composting stage (for example, windrows or aerated piles).
Porosity, structure, texture & particle size

• All influence aeration
• Adjust by selection of raw materials, grinding or mixing
• Amendments (e.g., lime) or bulking agents (e.g., nuggets) can improve properties
• Particles 1/8 to 1/2 in. in size compost faster
pH or acidity

• pH (0-14): Acidic (less than 7); Neutral (7); Basic or alkaline (more than 7)
• Composting good near 6.5-8 pH
• pH changes due to chemical changes
• Properly done compost close to neutral
• Take care while adding lime to increase pH
Curing

- Critical but often neglected
- No turning needed but need natural aeration
- Microbial reactions slower
- Begin curing when pile no longer heats up after turning
- End curing when pile temperature near ambient
- Cure for at least one month
Small Composting Operations

1. Passive composting
2. Turned piles
3. Aerated static piles

(Source: Washington State University)
1. Passive composting

- Waste piles 5-7 ft wide, 3-4 ft high
- Build piles in bins, 8 ft \( \times \) 8 ft & 4 ft height
- Extra bin for curing
- Turn piles when adding material
- One bin ready in 2-4 months

Bin composting of poultry mortalities. Note that gap between lumber allows aeration.
2. Turned piles

- Great if tractor available
- Concrete or graveled pad desirable
- Turning improves composting
- 30 ft × 30 ft pad adequate for 3 piles or windrows
3. Aerated static piles

- No need to turn
- Perforated plastic pipes
- Air may be pulled or pushed
- Higher initial investment but saves labor
Aerated static pile
Source: NRAES-54

- 6 inches of compost or peat moss cover
- 3-4 feet
- 10 feet
- 6- to 9-inch base of compost, peat moss, or straw
- 12-18 inches between pipe centers
- 12-inch spacing between holes within the row
- 4-inch diameter pipe with two rows of 1/2-inch diameter holes
Conclusions

• Composting a feasible waste management strategy
• Can help generate farm revenues
• Provides environmental benefits
• Requires management
Contact information and references

Sanjay Shah
NC State Univ.
Biological & Agricultural Engineering Dept.
Campus Box 7625, Raleigh, NC 27695
Phone: (919)515-6753, Email: sanjay_shah@ncsu.edu

Good books on compost:
1. On-farm composting handbook (NRAES 54) - $25
2. Field guide to on-farm composting (NRAES 114) - $14

Natural Resource, Agriculture, and Engineering Service
Cooperative Extension
Ithaca, NY 14852-4557
Phone: (607)255-7654, Email: nraes@cornell.edu
Website: www.nraes.org