Master Composting Program

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Overview of Section I

• Introduction to soils
• What is CEC
• The role of organic matter in plant nutrition
• What is composting
• Why compost
• What to compost
• The C:N ratio
Soils Defined

• An ecological system consisting of inorganic minerals, organic matter, living organisms, water & air and plant roots; and it is not = dirt

• Ideal ratio by volume:
  – ½ Soil particles (5% OM by weight)
  – ½ Pore spaces (½ water, ½ air)
Soil Composition

- Mineral: 45%
- Organic: 5%
- Soil gases: 25%
- Water: 25%

% by volume (but % weight for OM)

Ideally, a volume of soil should be ½ solid material and ½ pore space.

Ron Smith, 2005
Pore Space & Particle Space - Magnified
Micropores
Filter & detoxify pollutants

- Micropores = water holding capacity, minerals
- Macropores = earthworms & root channels (drainage)
Plant Nutrients

- Soil nutrients are in form of +vely charged ions (cations) and & –vely charged ions (anions)
  - Cations e.g. NH$^+$, Mg$^{2+}$, Ca$^{2+}$ = +ve
  - Anions e.g. Cl$^-$, H$_2$PO$_4^-$ and HPO$_4^{2-}$ = -ve
- Clay & OM particles are –negatively charged
- So cations are adsorbed to these particles
- A soil’s capacity to hold these cations is the Cation Exchange Capacity or CEC
Cation Exchange Capacity

- Soil particles and organic matter are negatively charged, attract positively charged ions (cations)

- CEC measure of the number of adsorption sites in a soil to adsorb and release cations

- A soil with a CEC of one (1) has $600,000,000,000,000,000,000,000$ adsorption sites in 100 grams of soil
  - = About 25 tsps or 8 tablespoons of soil
  - These adsorption sites can be filled with 1mg of H$^+$ ions

- Low CEC soils leach & store less nutrients
Uptake of Minerals by Plants

(a) Water film around soil particles
(b) Cation exchange in soil

- Soil particle surrounded by film of water
- Root hair
- Water available to plant
- Air space

Water flow
respiration

- K⁺
- Cu²⁺
- Mg²⁺
- Ca²⁺

H₂CO₃ → H⁺ + H⁺ + CO₃²⁻
OM Importance

• First, the organic matter coats soil particles, physically separating clay particles and aggregates from each other.

• Second, and more important, microorganisms that degrade organic matter produce a by-product called glomalin that bind individual clay particles together into stable aggregates.
After adding water...

Gruver, 2005

photo by Ray Weil
Composting

Its Recycling...

Fast - Naturally
Compost – What is it?

• Resultant material from aerobic breakdown by microorganisms of organic plant & animal materials
Why compost?

• Long term soil fertility – optimum yields
• Soil structure that makes better use of water and nutrients and easier to till
• Desirable microorganisms thrive in compost soils reducing incidents of pests and diseases
Municipal Solid Waste Production in the U.S. 2007

- Paper and paperboard 32.7%
- Food scraps 12.5%
- Yard trimmings 12.8%
- Plastics 12.1%
- Metals 8.2%
- Glass 5.3%
- Wood 5.6%
- Rubber, leather, & textiles 7.6%
- Other 3.2%

Total = 236 million tons/yr
(4.5 lb/person/day)
or 3.7 lb/person/day in OR

Source: EPA, 2007
Materials Recovered in Oregon

- Papers 35%
- Wood waste 20%
- Yard debris 19%
- Metals 14%
- Glass 4%
- Plastic 1%
- Other 7%
What do You Need to Make Compost?

• **Decomposers** – Your composting work crew. These are the microbes (mainly bacteria and fungi) that do all the work for you (Bugs)

• **Food for the decomposers**
  The organic materials to be composted

• The right amount of **air**, **water**, and **warmth** to keep the work crew happy
Conditions Good for Composting

• Proper conditions for composting
  – Adequate $O_2$ you need free air space of 55-65% by volume.
  – Moisture content 40-65%
  – Particle size 1/8- 2 inches
  – C:N ratio of 25:1 to 40:1
Composting Methods
(to be covered in week 2)

• Passive Pile Method
  – *not approved for certified organic production*
• Windrow Method
• Aerated Static Pile Method
• Aerated static and windrow methods should have:
  – temperature of 120 to 140° F
  – moisture content of 50 to 60 percent.
  – pH of 6.5 to 8.5
  – bulk density of less than 1,100 pounds per cubic yard (40 lb per cubic foot)
Where do the Decomposers Come From?

If you build it, they will come…

• Soil
• Leaves
• Food scraps
• Manure, and
• Finished compost

Each of these will add microorganisms to the compost pile
One teaspoon (4g) of good garden soil to which compost has been added contains

- 100 million bacteria
- 800 feet of fungal threads
What is the Best Food for your Decomposers?

All organic materials will compost, but not all should be added to a backyard compost pile.

Organic wastes that **should** be composted include:

- Garden trimmings
- Grass clippings
- Leaves
- Kitchen scraps
- Used potting soil
- Manure
- Sawdust
- Hair
Food for Decomposers

Wood Waste

Others:
• Dryer and vacuum lint (no plastic)
• Napkins & paper towels
• Shredder newspaper and cardboard
• Coffee grounds
• Sea weed
Materials to Avoid...

Avoid organic materials that could cause problems during or after composting

• Oil, fat, grease, meat, fish or dairy products, unwashed egg shells (tend to attract pests, vermin)

• Hard to kill weeds (bindweed, quackgrass) and weeds that have gone to seed (could infest garden area when compost is used).
Materials to Avoid...

Manure: Pig manure, and Cat or dog waste (parasites survive a long time) (attracts pests, could spread disease)

Diseased or insect ridden plants (could infect or attack garden plants when compost is used)
Materials to Avoid...

- Lime (increases compost pH and promotes ammonia odor problems = loosing N)

- If large quantities of acid materials such as pine needles, spruce needles, or fruit wastes are composted, additional lime may be necessary.

- Wood ash - add sparingly to the pile - add no more than 1/2 cup per five gallon bucket
Is Shredding Necessary?

Smaller particles decompose faster:
about 18 days

Greater surface area per unit volume

Allows microbes to get at more of the food (particle size = 1/8 to ½ inches diameter)

Chipping or shredding coarse materials (twigs, stems) will speed up the rate at which they decompose.
More about Food for your Decomposers

Provide a balanced “diet”

• Feed them a mix of carbon rich and nitrogen rich materials.

• Carbon rich organic wastes are known as “BROWNS” (>30:1) = bulking agents

• Nitrogen rich organic wastes are known as “GREENS” (<25:1) = energy materials

• Balanced Materials: Have right C:N ratio for direct composting [C:N ratio of 25-40:1]
C:N Ratio

• The proportion of carbon to nitrogen in an organic material.

• High lignin based organic compounds have a high carbon ratio to nitrogen.

• If this ratio is 365:78 then 78 is used as a denominator to 365 to get corresponding C:1N ratio.

• In this case the C:N ratio will be 4.7:1.
Why is C:N Ratio Important

• This ratio is an important factor determining how easily bacteria are able to decompose an organic material.

• The microorganisms in compost use carbon for energy and nitrogen for protein synthesis, just as we use carbohydrates for energy and protein to build and repair our bodies.

• The optimal proportion of these two elements used by the bacteria averages about 30 parts carbon to 1 part nitrogen.

• Given a steady diet at this 30:1 ratio, they can decompose organic materials very quickly.
Can Be Used

- Apples
- Apple peels
- Cabbage
- Carrots
- Celery
- Coffee grounds/filters
- Egg shells
- Grapefruit
- Lettuce
- Onion peel
- Orange peel
- Pears
- Pineapple
- Potatoes
- Pumpkin shell
- Squash
- Tea leaves and bags
- Tomatoes
- Turnip leaves

Cannot Be Used

- Butter
- Bones
- Cheese
- Chicken
- Fish scraps
- Lard
- Mayonnaise
- Meat scraps
- Milk
- Peanut butter
- Sour cream
- Vegetable oil
- Yogurt

**Figure 5.8 — COMPOSTABLE FOOD SCRAPS**

**Figure 5.9 — AVERAGE CARBON-NITROGEN RATIOS**
<table>
<thead>
<tr>
<th>Material</th>
<th>C:N ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Wood chips</td>
<td>641:1</td>
</tr>
<tr>
<td>Corrugated cardboard</td>
<td>563:1</td>
</tr>
<tr>
<td>Sawdust</td>
<td>500:1</td>
</tr>
<tr>
<td>Rotted sawdust</td>
<td>208:1</td>
</tr>
<tr>
<td>Newspaper</td>
<td>170:1</td>
</tr>
<tr>
<td>Wheat straw</td>
<td>128:1</td>
</tr>
<tr>
<td>Dried leaves</td>
<td>70:1</td>
</tr>
<tr>
<td>Corn stalks</td>
<td>60:1</td>
</tr>
<tr>
<td>Horse manure with litter</td>
<td>60:1</td>
</tr>
<tr>
<td>Pine needles</td>
<td>60:1 to 110:1</td>
</tr>
<tr>
<td>Peat Moss</td>
<td>58:1</td>
</tr>
<tr>
<td>Timothy hay</td>
<td>58:1</td>
</tr>
<tr>
<td>Oat straw</td>
<td>48:1</td>
</tr>
<tr>
<td>Fresh leaves</td>
<td>40:1</td>
</tr>
<tr>
<td>Hay</td>
<td>40:1</td>
</tr>
<tr>
<td>Horse manure</td>
<td>30:1</td>
</tr>
<tr>
<td>Red clover</td>
<td>28:1</td>
</tr>
<tr>
<td>Oak leaves</td>
<td>26:1</td>
</tr>
<tr>
<td>Coffee grounds</td>
<td>20:1</td>
</tr>
<tr>
<td>Alfalfa pellets</td>
<td>20:1</td>
</tr>
<tr>
<td>Cattle manure</td>
<td>19:1</td>
</tr>
<tr>
<td>Vegetable produce</td>
<td>19:1</td>
</tr>
<tr>
<td>Alfalfa hay</td>
<td>18:1</td>
</tr>
<tr>
<td>Composted dry chicken manure</td>
<td>15:1</td>
</tr>
<tr>
<td>Fresh grass clippings</td>
<td>17:1</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>7:1</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>6:1</td>
</tr>
<tr>
<td>Blood meal</td>
<td>4:1</td>
</tr>
<tr>
<td>Urine</td>
<td>0.6:1</td>
</tr>
</tbody>
</table>
Browns

High carbon materials such as

Leaves (30-80:1)
Straw (40-100:1)
Paper (150-200:1)
Sawdust (100-500:1)
Animal bedding mixed with manure (30-80:1)
Greens

High nitrogen materials such as

- Vegetable scraps (12-20:1)
- Coffee grounds (20:1)
- Grass clippings (12-25:1)
Calculating the C:N Ratio

• To calculate the C:N Ratio in a compost recipe, multiply the C:N value of the material by the parts used of that material.

• Total the combined C:N of all the parts and divide that amount by the number of parts in each recipe.
Calculating the C:N Ratio

• For example: let us say you are using
  – 2 part of grass clippings (C:N = 15)
  – One part of chicken manure (C:N = 15)
  – One part of dry leaves ((C:N = 70)

• Now calculate
  – 2 parts of grass clippings x 15 = 30)
  – plus (1 part chicken manure x 15 = 15)
  – plus (1 part dry leaf x 70 = 70)

• Add 30 + 15 + 70 = 115; divide by four (4) parts
  (i.e., 115 ÷ 4 = 28.75  cumulative overall C:N
  recipe in your container
Compost Mix Calculator

Choose a material. Enter a cubic foot measurement. Press TAB. The Total C:N ratio for your recipe will appear.

**Aim for a TOTAL C:N RATIO of 30.** (25-30 is good, 20-40 is OK.)

<table>
<thead>
<tr>
<th>Material</th>
<th>CuFt</th>
<th>Lb Wet</th>
<th>% H2O</th>
<th>Available % C</th>
<th>% N</th>
<th>Available Lb C</th>
<th>Lb N</th>
<th>Available C:N</th>
</tr>
</thead>
<tbody>
<tr>
<td>Leaves Fresh 37:1</td>
<td>1</td>
<td>11.11</td>
<td>65</td>
<td>48.32</td>
<td>1.3</td>
<td>1.88</td>
<td>0.05</td>
<td>37.17</td>
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<tr>
<td>Food Waste 15:1</td>
<td>1</td>
<td>55.56</td>
<td>69</td>
<td>37.1</td>
<td>2.5</td>
<td>6.39</td>
<td>0.43</td>
<td>14.84</td>
</tr>
<tr>
<td>Grass (loose) 15:1</td>
<td>1</td>
<td>11.11</td>
<td>82</td>
<td>52.31</td>
<td>3.4</td>
<td>1.05</td>
<td>0.07</td>
<td>15.38</td>
</tr>
<tr>
<td>Wood Chips Softwood 226:1</td>
<td>5</td>
<td>74.07</td>
<td>40</td>
<td>20.38</td>
<td>0.09</td>
<td>9.06</td>
<td>0.04</td>
<td>226.41</td>
</tr>
</tbody>
</table>

**TOTALS:**

18.37 | 0.59 | 31.18

For a total C:N Ratio of 31:1 mix:
1 part(s) Leaves Fresh
1 part(s) Food Waste
1 part(s) Grass (loose)
5 part(s) Wood Chips Softwood

[About this Compost Mix Calculator](#)

[Top of Page](#)
Solve & C:N ratio -Online

- [http://www.klickitatcounty.org/solidwaste/fileshtml/organics/compostcalc.htm](http://www.klickitatcounty.org/solidwaste/fileshtml/organics/compostcalc.htm)
Approximate ratio: 2/3 browns to 1/3 greens
The one page handout summarizes most common composting ingredients’ C:N ratios.
<table>
<thead>
<tr>
<th>Material</th>
<th>% N (dry wt)²³</th>
<th>C:N (wt/wt)⁴</th>
<th>Moisture % (wet wt)</th>
<th>Bulk Density (lb/cu yd, wet wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Plant Residues</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Apple filter cake</td>
<td>1.2</td>
<td>13</td>
<td>60</td>
<td>1,197</td>
</tr>
<tr>
<td>Apple pomace</td>
<td>1.1</td>
<td>48</td>
<td>88</td>
<td>1,559</td>
</tr>
<tr>
<td>Corn stalks</td>
<td>0.6 - 0.8</td>
<td>60-73</td>
<td>▲ 12</td>
<td>32</td>
</tr>
<tr>
<td>Cottonseed meal</td>
<td>7.7</td>
<td>7</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Cull potatoes</td>
<td>-</td>
<td>18</td>
<td>▲ 78</td>
<td>1,540</td>
</tr>
<tr>
<td>Fruit wastes</td>
<td>0.9-2.6</td>
<td>20-49</td>
<td>▲ 62-88</td>
<td>-</td>
</tr>
<tr>
<td>Potato processing sludge</td>
<td>-</td>
<td>28</td>
<td>75</td>
<td>1,570</td>
</tr>
<tr>
<td>Rice hulls</td>
<td>0.3</td>
<td>121</td>
<td>14</td>
<td>202</td>
</tr>
<tr>
<td>Soybean meal</td>
<td>7.4</td>
<td>4-6</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Vegetable produce</td>
<td>2.7</td>
<td>▲</td>
<td>87</td>
<td>1,585</td>
</tr>
<tr>
<td>Material</td>
<td>% N (dry wt)</td>
<td>C:N (wt/wt)</td>
<td>Moisture % (wt/wt)</td>
<td>Bulk F (lb/acre)</td>
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<tr>
<td>----------</td>
<td>--------------</td>
<td>-------------</td>
<td>-------------------</td>
<td>-----------------</td>
</tr>
<tr>
<td><strong>Municipal Wastes</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Food waste</td>
<td>1.9-2.9</td>
<td>14-16</td>
<td></td>
<td>69</td>
</tr>
<tr>
<td>Paper</td>
<td>0.2-0.25</td>
<td>127-178</td>
<td></td>
<td>18-20</td>
</tr>
<tr>
<td>Refuse (mixed)</td>
<td>0.6-1.3</td>
<td>34-80</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Sludge</td>
<td>2.0-6.9</td>
<td>5-16</td>
<td>72-84</td>
<td>1,075</td>
</tr>
<tr>
<td><strong>Straw, Hay, Silage</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Corn silage</td>
<td>1.2-1.4</td>
<td>38-43</td>
<td>65-68</td>
<td></td>
</tr>
<tr>
<td>Hay (legume)</td>
<td>1.8-3.6</td>
<td>15-19</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Hay (non-legume)</td>
<td>0.7-2.5</td>
<td>32</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td>Straw (wheat)</td>
<td>0.3-0.5</td>
<td>100-150</td>
<td></td>
<td>-</td>
</tr>
<tr>
<td><strong>Wood and Paper</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bark (hardwood)</td>
<td>0.1-0.4</td>
<td>116-436</td>
<td>59</td>
<td></td>
</tr>
<tr>
<td>Bark (softwood)</td>
<td>0.04-0.39</td>
<td>131-1,285</td>
<td>40-50</td>
<td>225</td>
</tr>
<tr>
<td>Material</td>
<td>% N (dry wt)²³</td>
<td>C:N (wt/wt)⁴</td>
<td>Moisture % (wet wt)</td>
<td>Bulk Density (lb/cu yd, wet wt)</td>
</tr>
<tr>
<td>--------------------------------------------------------</td>
<td>----------------</td>
<td>-------------</td>
<td>---------------------</td>
<td>-------------------------------</td>
</tr>
<tr>
<td>Bark (hardwood)</td>
<td>0.1-0.4</td>
<td>116-436</td>
<td>59</td>
<td>471</td>
</tr>
<tr>
<td>Bark (softwood)</td>
<td>0.04-0.39</td>
<td>131-1,285</td>
<td>40-50</td>
<td>225-370</td>
</tr>
<tr>
<td>Corrugated cardboard</td>
<td>0.1</td>
<td>563</td>
<td>-</td>
<td>259</td>
</tr>
<tr>
<td>Newsprint</td>
<td>0.06-0.14</td>
<td>398-852</td>
<td>-</td>
<td>195-242</td>
</tr>
<tr>
<td>Sawdust</td>
<td>0.06-0.8</td>
<td>200-750</td>
<td>-</td>
<td>350-450</td>
</tr>
<tr>
<td>Wood chips/shavings (hardwood)</td>
<td>0.06-0.11</td>
<td>451-819</td>
<td>-</td>
<td>445-620</td>
</tr>
<tr>
<td>Wood chips/shavings (softwood)</td>
<td>0.04-0.23</td>
<td>212-1,313</td>
<td>-</td>
<td>445-620</td>
</tr>
</tbody>
</table>

**Yard Wastes**

<table>
<thead>
<tr>
<th>Material</th>
<th>% N (dry wt)²³</th>
<th>C:N (wt/wt)⁴</th>
<th>Moisture % (wet wt)</th>
<th>Bulk Density (lb/cu yd, wet wt)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grass clippings</td>
<td>2.0-6.0</td>
<td>9-25</td>
<td>82</td>
<td>300-400</td>
</tr>
<tr>
<td>Leaves</td>
<td>0.5-1.3</td>
<td>40-80</td>
<td>38</td>
<td>100-300</td>
</tr>
<tr>
<td>Seaweed</td>
<td>1.2-3.0</td>
<td>5-27</td>
<td>53</td>
<td>-</td>
</tr>
<tr>
<td>Shrub trimmings</td>
<td>1</td>
<td>53</td>
<td>15</td>
<td>429</td>
</tr>
<tr>
<td>Tree trimmings</td>
<td>3.1</td>
<td>16</td>
<td>70</td>
<td>1,300</td>
</tr>
</tbody>
</table>

1. Source: *On-Farm Composting Handbook*, NRAES 54
2. Where a range is not given, data indicate an average value.
3. A dash indicates that information is not available.
4. All ratios are expressed relative to 1; e.g., the C:N of apple filter cake is 13:1
Be proud: Made Locally in Oregon Using Local Ingredients and Local “Bugs” by ….
End of Week One