HOW TO COMPOST

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Introduction

There are many benefits to composting organic waste such as food and yard waste, crop residuals, and even cardboard or paper. Creating compost from yard waste, food waste, and other organic waste is a great way to manufacture a valuable product, compost, with a plethora of benefits including:

- Increased nutrients and microbiome found in soils
- Suppressed weeds and weed seeds
- Moisture maintenance
- Improved soil texture
- Reduced erosion
- Increased plant productivity
- Reduced reliance and costs associated with chemical fertilizers
- Reduced methane emissions associated with organic waste in landfills
- Bioremediation of contaminated soils
- Reduced pollutants found in stormwater runoff
- Increased carbon sequestration of soils

Keeping your compost operation healthy and active is important to prevent environmental degradation, limit vectors, and prevent offensive odors that could potentially shut down your operation. Many things can go wrong during the composting process if you don't know what you're doing, so following some simple and general guidelines of best practices will help you on your way.

Davenport, Iowa Compost Facility

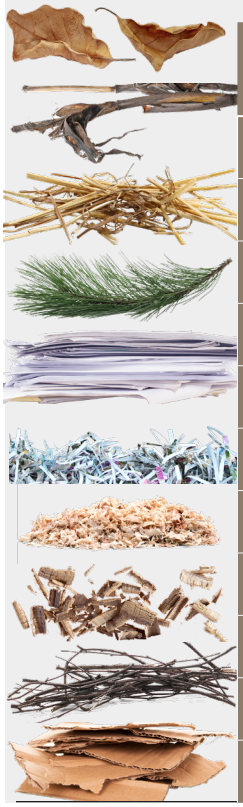
Feedstocks and **Carbon to Nitrogen** Ratios

Your optimal carbon to nitrogen ratio should be about 25-30:1 however this can be highly variable depending on the feedstocks you are composting. You can also use the bulk density and free air space tests detailed in this training guide in lieu of a 30:1 carbon to nitrogen ratio if your recipe needs an altogether different ratio dependent on your unique blend of feedstocks and recipe. But for simplicity's sake, starting with a 30:1 carbon to nitrogen ratio when developing your compost recipe is a great place to start. Conversely, you can adapt your recipe by volume and start with 3 parts carbon to 1 part nitrogen and adjust from there.

Each feedstock you use has its own C:N ratio, some are considered carbon sources because they are high in carbon, while others are considered nitrogen sources because they are low in carbon. Feedstocks that are considered carbon sources include wood chips, shredded cardboard, and corn stalks while feedstocks considered high in nitrogen include food waste, grass clippings, manure and weeds.

A simple mathematical formula can help estimate the C:N ratio of combined feedstocks, however there are more precise formulas and equipment that can be used to dial in the C:N ratio if necessary. Shown at left is the simplest equation to estimate your mixed feedstock C:N ratio. All you need to do is look-up the C:N ratio of each one of your feedstocks and know the weight of each as well.

Estimated Carbon to Nitrogen Ratios (C:N)



BROWNS *High in Carbon*	
Leaves	60:1
Corn Stalks	75:1
Straw	75:1
Pine Needles	80:1
Office Paper	129:1
Newspaper (shredded)	175:1
Sawdust	325:1
Wood Chips	400:1
Twigs	500:1
Corrugated Cardboard	600:1

GREENS *High in Nitrogen*	
Hair/Fur	10:1
Manures	15:1
Seaweed	19:1
Food Waste	20:1
Grass Clippings	20:1
Coffee Grounds	20:1
Fresh Weeds	20:1
Vegetable Scraps	25:1
Clean Wood Ash	25:1
Finished Compost	25-30:1
Fruit Waste	35:1

How to Estimate the C:N Ratio of Mixed Feedstocks

The simplest equation for estimating you C:N ratio of mixed feedstocks is below:

C:N Ratio Equation

$$\frac{(\text{CARBON VALUE OF FEEDSTOCK A} \times \text{WEIGHT OF FEEDSTOCK A}) + (\text{CARBON VALUE OF FEEDSTOCK B} \times \text{WEIGHT OF FEEDSTOCK B})}{\text{WEIGHT OF FEEDSTOCK A} + \text{WEIGHT OF FEEDSTOCK B}}$$

Solving the Equation with Sample Data

If you have the following data:

FEEDSTOCK A
Food Waste .... 2000 pounds (C:N Ratio 20:1)

FEEDSTOCK B
Wood Chips .... 50 pounds (C:N Ratio 400:1)

Find the C:N Ratio this way:

$$\frac{(20 \times 2000) + (400 \times 50)}{2000 + 50} \rightarrow \frac{40{,}000 + 20{,}000}{2{,}050} \rightarrow \text{C:N Ratio} = 29$$

In summary, the C:N ratio of wood chips and food waste equals 29:1 at 2000 pounds food waste and 50 pounds wood chips. If you have a third and fourth feedstock, just continue the equation by adding Feedstock C and D with weights and carbon values.

Composting **Best Management** Practices

Mixing

Making certain to mix feedstocks well limits anaerobic conditions, methane pockets, and pockets of offensive odors and excessive heat that may cause fires. Mixing also helps your feedstocks breakdown quicker by providing microbes with enough air, water, and food within a uniform mix. Turning and mixing can be done every 2 - 5 weeks and every time new feedstocks are introduced into the pile. But please note that mixing during cold winter months will cool down your pile so it's not recommended to mix compost much if at all in the winter.

Moisture

A compost pile needs moisture to create a thriving habitat for microorganisms. Generally, 40-60% moisture is ideal. You can gauge your moisture content by grabbing a handful of compost and squeezing it. A squeezed handful of compost should drip water, but shouldn't drip a steady stream of water. Nor should a handful be so dry that not even a few drops of water escape when squeezed. You can also buy a moisture meter to get a more exact percentage of water in your compost pile. Not enough moisture will slow or halt decomposition while too much moisture can cause odor issues and anaerobic conditions. Just add water according to your measurements and needs or in instances where your compost pile is too wet, you can add more carbon to soak up excess water.

Air

Your compost pile needs air to keep microorganisms alive and thriving. Air also prevents anaerobic conditions that generate methane and offensive odors. The best way to get air into your compost is to have properly sized bulking agents that promote air flow into the pile while limiting compaction. Bulking agents are carbon sources that can include wood chips, sawdust, corn stalks, and twigs. A mixture of different sized bulking agents is optimal, but experimentation for the best recipe is essential when using different sources of bulking agent.

Temperature

Using a compost thermometer, take temperatures throughout the height, width and depth of the pile to acquire a representative measurement. Optimal temperatures that facilitate breakdown of materials is anywhere between 135-165° Fahrenheit. You will notice that as you add feedstocks to your pile, especially those high in nitrogen, your compost pile will heat up as microorganisms get to work breaking down materials. Once you stop adding feedstocks to your pile, the temperature will gradually decrease but will still be breaking down until you finally get to the curing stage.

Once a compost pile gets hotter than 165° Fahrenheit, there is a risk of fire while microbes are dying within the pile. An overly hot pile can indicate too much nitrogen, not enough air, or not enough bulking agent at the correct particle size. To reduce the heat, add carbon or bulking agent. You can also mix the pile to help temporarily cool it down by introducing air flow.

Alternatively, if your compost pile is lower than 135° Fahrenheit, this could indicate there is absolutely nothing wrong if your compost pile is on its way to maturity, meaning the hot initial period of breakdown is winding down. But, this could also mean you need more water, more nitrogen, and less carbon and bulking agent. Adding food waste, grass clippings, and other nitrogen rich feedstocks will heat up your pile. A lack of moisture to keep microbes alive could also be the issue and adding water may help heat your pile up as well.

Curing

Once you stop adding feedstocks to your pile, and the temperature of your compost is getting closer to ambient temperature, and the pile is about half as big as it was initially, you may be nearing the curing phase. Checking that your compost is fully finished takes lab testing or a bioassay test. A bioassay test is simply testing your compost as a growing medium for radish seeds. Since radishes grow quickly, fill a couple pots with compost and plant radish seeds within. If 75% of the seeds sprout into healthy plants then radishes, your compost is ready to go.

There is also the widely-used Solvita compost maturity test that can be purchased that measures carbon dioxide and anhydrous ammonia level. The test is extremely easy to use by placing a sample of compost in a jar for 4 hours with color-changing CO^2 and NH^3 indicator probes. The probes change color according to the levels detected and this can then be compared to the color chart included as well as the interpretation guide.

Limiting Odors

It is very important to limit offensive odors that can shut down your compost site. It is a great idea to cover mixed compost piles with 6 inches of finished compost to minimize odors. Of course, odors arise for various reasons and figuring out the solution can prevent complaints that can shut you down.

- Too much moisture - wet and soggy compost piles get stinky when anaerobic conditions are favorable. Adding newspaper, cardboards, or straw can help soak up excess moisture.
- Too much nitrogen - too much nitrogen such as food scraps can emit foul odors. Adding additional carbon sources and mixing well is a good rule of thumb
- Not enough airflow - in this scenario, not enough air space can cause anaerobic conditions that smell bad. Adding bulking agent that is course enough to allow air to infiltrate the pile is a great practice to limit odors caused by compaction
- Not mixed well enough - compost piles that aren't thoroughly mixed can develop pockets of densely matted nitrogen material such as grass clippings that smell bad. Make sure to mix your feedstocks thoroughly to limit odors.
- Incorporate your feedstocks and mix well right away when they are delivered. Never let your feedstocks sit around in piles waiting to be mixed. A pile of grass quickly becomes horrendously smelly and can cause environmental degradation and contamination.

Limiting Leachate/Contact Water Contamination

Leachate or "contact water" is liquid that seeps out of your compost pile during the decomposing process of feedstocks. Leachate can also seep out of your pile after rain events. While the high heat from the composting process neutralizes most contamination, leachate from unfinished compost can be highly toxic as your feedstocks carry bacteria, fungi, pathogens, parasites and sometimes chemicals. It is essential that leachate is controlled and prevented from running off your site to contaminate both ground and surface water as well as soils, gardens, and other potential sources that can cause dangerous levels of contamination. Additionally, composting manure can be problematic if leachate runs off your site to contaminate surface and groundwater or soils as E.coli and/or salmonella can also be present in compost leachate. Leachate must be mitigated as soon as you notice standing liquid around your pile or running off your pile.

- Turn and mix your compost piles if you notice standing water/leachate after a rain event while trying to soak up the standing water/leachate
- Tarp your compost pile before rain events to keep the water out and leachate from running out of your compost piles.
- Place bales of straw/hay on top of standing water/leachate puddles to soak up the moisture, then mix into your compost pile.
- Place windrows perpendicular to the slope of the land to act as a barrier for runoff.
- Add more carbon and/or bulking agent to your compost pile to help soak up excess moisture and potential leachate runoff.

FIELD EXERCISES

Bulk Density Test and Free Air Space Test

Here is where bulk density and free air space become important. Bulk density is a measurement of compaction while free air space measures exactly that, available pore spaces where air will keep your microbes active. Compaction can lead to anaerobic conditions, bad odors, overheating your pile and possibly fire. A lack of free air space can kill off your microbes as they need oxygen to survive.

Food waste and grass clippings both create an awful odor and turn into a smelly slop quickly so adding a bulking agent is essential to maintaining aerobic conditions and the health of your compost pile. Bulking agent can be any dry carbon source such as dry leaves, sawdust, wood chips, corn stalks, twigs and etc. that help balance the nitrogen of your food waste with the carbon of your bulking agent. You will want to limit compaction by using various sizes of dry bulking agent that are 1" or less in size so that air can infiltrate through your compost pile and limit bad odors.

You will find information on how to perform the Bulk Density Test on page 8 and the Free Air Space Test on page 10

All you need is:

- 5-gallon bucket with a handle
- Measuring tape
- Permanent Marker
- Luggage or fish scale
- Water if you want to also measure free air space (page 10).

Bulk Density Test

01 Weigh your empty 5-gallon bucket and record the weight here. Ours weighs 1.6 lbs.

Empty Bucket Weight:	lbs.

02 Since some 5-gallon buckets, when filled to the rim, are more than 5-gallons, you'll need to find out exactly where the 5-gallon line is within your bucket. Fill the bucket with exactly 5 gallons of measured water and mark the top of the bucket where the actual 5-gallon line lies.

03 Empty the water from your bucket.

04 Then you'll want measurements marked inside and outside your bucket at the ⅓ line, the ⅔ line, and the 5 gallon line. To do this, measure the distance from the bottom of the inside of the bucket to your 5-gallon line and divide this number by 3 while marking the ⅓, ⅔, and 5 gallon lines.

05 Fill your marked bucket to the 1/3rd line with representative samples of compost throughout your pile. Don't use the more dried out compost on the outside of your pile, but rather, take samples from a couple feet within your pile near the bottom, middle, and top to get a representative sample of the entire pile.

06 Once your compost is up to the 1/3rd line, squarely drop the bucket on the ground from approximately a foot high 10 times using gravity, not force.

07 Keeping the compost in the bucket, now fill the bucket up to the ⅔ line with representative samples of compost and do the drop method again, squarely dropping the bucket from a foot above the ground 10 times.

08 Next, fill the bucket all the way to the 5-gallon line with a representative sample of compost. Squarely drop the bucket again 10 times from a foot off the ground.

09 Fill the bucket the rest of the way up to the 5-gallon line with a representative sample of compost. Do NOT drop the bucket this time.

10 Weigh your full bucket in pounds using your fish or luggage scale and subtract the weight of the empty bucket recorded in #1.

Weight of 5-gallons of compost MINUS empty bucket weight:	lbs.

11 Multiply the weight recorded above in #10 by 40 (volume of 5-gallons) to get the bulk density.

Bulk Density:	lb/yd^3

12 Keep your bucket full of the compost and move on to the "free air space" test on page 10.

What your bulk density measurement means

Once you have your bulk density measurement, you can gauge the compaction of your compost pile and troubleshoot some potential issues.

- Optimal bulk density is **1,000 lb/yd^3** while **800 - 1,200 lb/yd^3 is reasonable**
- Anything over **1,200 lb/yd^3** indicates compaction, possibly anaerobic conditions and bad odors, and the potential for overheating and fire. You will want to add dry bulking agents to your pile. Dry bulking agents provide carbon for your pile but also permit air in your pile and soak up excess moisture. Dry wood chips, corn stalks, straw, and animal bedding are great bulking agents.
- Anything under **800lb/yd^3** indicates moisture will be easily evaporated and the compost breakdown has stalled. Because this measurement indicates the opposite of compaction with too much air space, you will need to keep adding moisture to your pile and possibly some nitrogen (food waste) and finer particle sizes of bulking agent so you won't have to water it as often.

NOTES:

Free Air Space Test

You will need to have some measurements handy that you calculated during the bulk density test. You will need the following:

- Weight of the bucket alone[1] (#1 Bulk Density Test - page 9)
- Weight of exactly 5-gallons of water which is **41.7 lbs**[2].

01 Using your bucket from the bulk density test, with the compost from the test still in it, fill the bucket with water up to the 5-gallon line.

02 Weigh the bucket and then subtract the weight of the empty bucket.

Divide the result from #2 above by the

Weight of bucket with compost and water MINUS empty bucket weight[1]:
lbs.

03 weight of 5-gallons of water which equals 41.7 lbs[2].

Multiply by 100

$$\frac{\text{Weight of bucket with compost and water MINUS empty bucket weight } \textbf{(result \#2)}}{\textbf{41.7}}$$

04 This is your percentage of free air space. Record this percentage.

05

Percentage free air space:	%

What your free air space measurement means

Your free air space range should be between 30% and 65%. *The ideal percentage of free air space is 50%.*

If your compost pile has

- less than 30% free air space, bulk it up with compostable cardboard tubes, paper towel tubes, twigs, wood chips, or small branches. Putting these at the bottom of the pile especially, will help to pull in air and move it through the top of the pile (since heat rises). Alternatively, if you have too much air,
- Over 65% free air space is too much. Add some food waste or other organic matter high in nitrogen to help increase microbes that use up the over-abundance of free air space. Or use smaller sized particles of bulking agent to limit airflow through the pile such as sawdust, shredded leaves or cardboard.

NOTES:

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