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Making and Using Compost in Residential and Community Gardens and Landscapes

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Making and using compost can be an excellent way to practically and productively implement sustainable practices. Composting is essentially managing the biological breakdown process of organic matter to ensure a stable, safe and beneficial product. The benefits of compost include recycling organic materials and plant debris, supporting soil quality and enhancing plant growth or resilience through building the soil microbial community, which enables nutrient cycling. Composting can also be an important way to keep materials out of the solid waste stream. The US EPA estimates that yard trimmings represent just over 12 percent of the municipal solid waste stream while food represents nearly 22 percent (US EPA 2018). Much of this 34 percent of solid waste could be composted to produce useful materials with a significant portion of the waste stream.

Small-scale composting enables the recycling of plant residues and food waste to support soil quality and plant nutrition in the garden or landscape. The proper utilization and management of compost materials is essential to realize the full benefits of composting in your home lawn, landscape or community garden. Understanding the composting process, compostable materials and proper management of a compost pile are vital to avoid food safety risks and situations where compost alters soil pH, nutrients or composition negatively. This publication is designed to introduce residents and gardeners to the basic process of composting and provide information on making and using compost to support sustainability and productivity in residential or community spaces.

The Biology of Composting

Compost is the product of the breakdown of organic materials by the action of a range of bacteria, fungi and other microbes. While organic matter breakdown is constantly occurring naturally, composting is different because of the intentional management of the process. When composting, we are managing the activity and reproduction of the microbes that are present during organic matter breakdown. Essentially, organisms (fungi, bacteria and more) break apart organic materials to utilize the basic components. The microbial community gets the benefit of the energy and nutrients released during this process while we use the product.

Different kinds of microbes can break down different types of organic matter. Some break down simple sugars, amino acids and proteins, while others break down more complex carbohydrates in plants called hemicellulose and cellulose.

The goal of composting is to provide conditions that support microbes that will break down a range of organic materials rapidly and efficiently. When the type and mixture of organic materials is carefully selected and the process is managed to provide good access to oxygen and water, heat is produced. There are two temperature ranges utilized for this decomposition. Mesophilic is the term used for breakdown between 50 F and 105 F. While it will eventually produce compost, it is not sufficient to destroy weed seeds or pathogens. The breakdown of organic matter will still occur at lower temperatures—we often call this cold composting. Thermophilic composting, on the other hand, has a target temperature range between 110 F and 150 F. The ideal temperature for reducing hazardous foodborne pathogens is 131 F, and weed seeds are best destroyed at 145 F. So, it is common to aim for composting in the 131-to-150 F range (Rynk, 1992). If the compost has too little oxygen or too little or too much water, the conditions won't be ideal for the intended microbial community, and the temperature will be lower. It is also possible for so much heat (over 160 F) to be produced that the most desirable microbes can be killed off, but this is uncommon for in-home composting systems. For small-scale residential composting, it is most common for temperatures to be lower than ideal for speed and efficacy of the composting process. With good planning and management, it is possible for home composting to attain temperature levels in that ideal thermophilic range. But, temperatures should be measured to be certain they are in this ideal range. It should not be taken for granted that the temperature is sufficient for optimum composting.

The equation for composting:

Organic matter + oxygen and water (O_2 and H_2O) → (with bacteria, fungi, actinomycetes) = humus, plant available nutrients, non-plant available nutrients + heat, water, and carbon dioxide

The Raw Materials for Composting

The materials that we recommend for small-scale composting are readily accessible to most homeowners. They are selected to reduce the risk of odors and wildlife attraction as well as lowering the food safety risks when used in food gardens. We recommend that no animal manures be used in small-scale composting if any of the compost will be used in fruit or vegetable growing areas. Small compost piles or bins are not able to reliably attain the temperature or duration needed to kill potential human pathogens as commercial compost systems. Similarly, there are now a wide range of consumer goods (plates, single-use silverware, plant containers) that are labeled as compostable but are only able to be fully composted in commercial systems and do not break down in small-scale systems.

This publication will focus on composting yard waste and kitchen waste plant materials. A critical aspect of the composting process is the carbon (C) to nitrogen (N) ratio of the initial material. A shorthand for different organic materials used in composting has been developed based on the C to N ratio with the term "green" being used for materials having more N and, therefore, a lower C to N ratio. Grass clippings, fresh (non-woody) plant material and kitchen scraps are examples of green materials. The term "browns" is used for those with little N and a high C to N ratio. Woody materials (paper, bark, wood chips, straw, sawdust) have mostly C with little N, resulting in a high C to N ratio.

The balance between C and N is related to the microbial communities that the compost pile supports and, therefore, the speed of breakdown. An important thing to keep in mind is that N is needed to support the reproduction and growth of the microbes. So, if the compost pile contains too much woody materials (browns), then there will not be enough N to support the growth of the ideal mix of thermophilic organisms, and decomposition will be slow.

Items to put INTO your compost pile	Estimated Carbon to Nitrogen (C/N ratio) *	Notes on use
Greens		
Grass clippings	12-25:1	Know what was sprayed on your lawn
Vegetable wastes	12-20:1	Bury in pile
Corn stalks	60:1	
Fruit wastes	35:1	Bury in pile
Coffee grounds	18:1	
Hay	15-30:1	Alfalfa low ratio, grass higher ratio
Eggshells	35:1	Crush
Browns		
Cardboard	500:1	Don't use more than 10 percent
Bark	100-300:1	
Paper	170:1	Don't use more than 10 percent of paper in your compost pile. Also, avoid glossy paper
Leaves	100:1	
Pine needles	90:1	
Sawdust	100-500:1	Be careful with volume
Straw	80:1	
Wood chips	700:1	Don't use black walnut
*Values from PB 1479 and On-farm composting handbook citations.		

This type of decomposition is what occurs naturally in forests or other systems where fungi break down woody materials slowly through time and at a moderate temperature. While this works great naturally, it is our goal with small-scale composting to intentionally speed up the process and increase the temperature. The setup and management techniques presented below are designed to be possible and effective in supporting good composting at a small-scale on your own property or in a community garden.

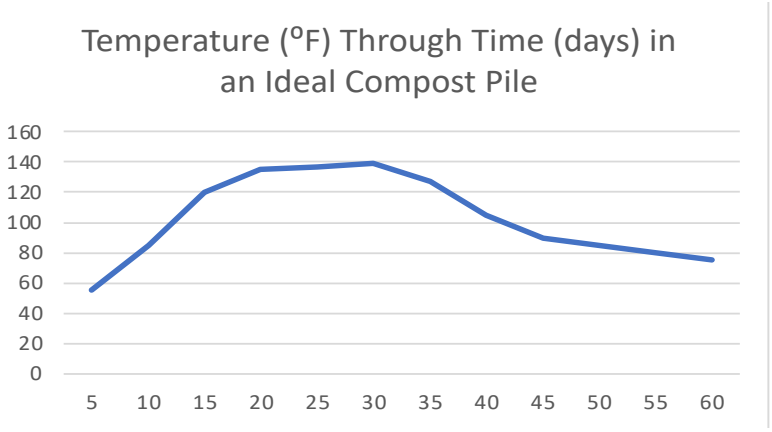
Items to keep OUT of your compost pile	Reason
Meat	Attraction of scavengers, potential host for foodborne pathogens, unpleasant odors
Animal manures	Food safety risks, uncertain nutrient composition
Pet wastes	Food safety risks
Bones, fish waste	Difficulty in breakdown, attraction of scavengers
Cheese, oils, other fats	Attraction of scavengers, potential host for foodborne pathogens, unpleasant odors
Plants with disease	Risk of disease spread due to incomplete composting
Weeds that can grow from pieces of roots or stems	Risk of spread
Grass clippings (if lawn has been treated with herbicides having a long residual)	Some herbicides can remain active through the composting process
Invasive plants that root or germinate easily	Risk of spread

Selecting or Building Compost Systems

There are a range of small-scale systems suitable for use in the residential or community garden, and they are listed with their pros and cons below. Keep in mind that siting composting systems is important no matter what type of system you are using. Make sure to site your compost system in an area that is easily accessible for moving materials in and out, does not cause issues for your neighbors, is close to a water source and isn't in the shade, which will limit solar temperature gain and slow drying after rains.

Type	Pros	Cons
Open pile	• Cheap and simple to begin • Easily expandable	• Messy • Open to all weather • Accessible to all wildlife/contamination • May not comply with community guidelines • May be harder to manage without a support structure
Square compost bin	• Can be made of pallets, other low-cost materials (wire cage or fencing supported by posts) • Can be easily divided into sections to support multiple piles • Support structure/bins can help with turning and aeration • Wooden bins can also be covered if needed	• Takes up quite a bit of space • Accessible to all wildlife/contamination • Open to all weather
Compost tumbler or contained unit	• Protected from weather and wildlife • Does not lose heat as quickly • Simple to turn • Vents often allow control over aeration • Aesthetic benefit	• Smaller volumes can be difficult to get up to ideal temperatures • Can be more expensive

Managing Compost Systems



The ideal conditions for composting are:

- Oxygen levels typically range between 5-15 percent under good/normal/ideal conditions.
- A carbon to nitrogen ratio of 30:1
- Temperatures between 131-150 F for several days to weeks are needed to reduce plant disease or food safety risks as well as reduce viability of any weed seeds. Fifteen days is the requirement for organic producers for certification.
- Moisture: 40–60 percent (wet basis), meaning roughly half of the compost's weight is water.
- Time: under the best conditions, small-scale composting can be accomplished in a month, but often longer time periods are needed because maintaining ideal conditions is often challenging on a small-scale.

Setting up a home compost pile using the batch method for optimum speed and efficacy

1. Prepare your site and materials located in a full sun or mostly sunny spot and provide a wood or wire bin or cage.

   It is recommended that the compost pile be at least 3 ft by 3 ft by 3 ft (a cubic yard).
2. Shred paper or cardboard and chip large woody materials such as limbs into smaller pieces.
3. Layer the pile to alternate green and brown material.
   a. Six inches of browns
   b. Two to four inches of greens
   c. Two inches of soil or finished compost (this supplies microbes)
   d. Repeat layering process a. to c. until the pile is at least 3x3x3 ft tall but not more than 5x5x5 ft

Under ideal conditions, this batch method should take four to eight weeks but could take four to six months if not properly constructed or managed. When a single compost pile is continuously added to, the composting process will slow down, and a pile may take 12 to 18 months to compost fully.

Maintaining good aeration and appropriate moisture levels

The turning process is important for aeration (introduction of vital oxygen for the microbes) as well as providing microbes access to new organic materials. There are completely different populations of microbes that function in well aerated conditions (aerobic) versus conditions without good oxygenation (anaerobic). It is recommended that a compost pile be turned every two to five days under warmer conditions but less often under cooler conditions. Close monitoring of temperature will help determine turning needs. So, a compost thermometer is a great tool to purchase (costing anywhere from $30-$100). Use the pile temperature and odor as the guide (odors are discussed below in the troubleshooting).

Assuming the materials are combined in adequate quantities, low temperatures often indicate either low moisture or low oxygenation, so turning (and possibly adding moisture) should cause the temperature to increase. Although less common, turning can also be used to cool the pile if the heat levels get too high.

It is recommended that the compost be about 40 to 60 percent water by weight. A general guide is that if water drips out when squeezed, it is too wet. Ideal moisture levels should make the compost clump but not drip. And, if it does not feel moist to the touch or crumbles and doesn't clump together, it is too dry. While it can be difficult to precisely measure moisture, the smell and temperature of the pile will be clues as to whether the moisture levels are sufficient. Turning will also help find wet or dry spots in the pile and help maintain more consistent moisture conditions. In the first two to four weeks, the pile will likely need to be turned every few days but less frequently as the temperature declines when the pile is close to completion.

Finishing and curing the compost

Finished compost should be similar to the air temperature (ambient) with no odors and look and smell more like soil than the raw materials used in the compost. It will usually not contain readily identifiable organic matter pieces. An exception to this rule of thumb is that sometimes small pieces of wood chips may remain after composting. This could be an asset to support drainage if compost is used in large containers or raised beds. Or, it could be screened out and used in the next compost pile. Remember that the composting process results in a dramatic reduction in volume with often a loss of 50 to 80 percent of the volume and 30 to 50 percent of the weight of the original organic materials.

Curing is the process of keeping the compost aerated and slightly moist for a few weeks after it has cooled down to ensure that decomposition is complete and there won't be adverse effects (such as pulling N from the soil) on plants if used. If the compost is being used for mulch, it can be applied without curing. However, compost to be incorporated into soil or used in a raised bed or container needs to be completely finished and cured.

Troubleshooting issues with the compost pile

Issue	Potential Cause	Action Steps
Compost pile doesn't heat up or heats up and then cools down too quickly	• Too dry • Too wet • Not enough high N materials • Pile settled (poor aeration) • Cold weather or small size	• Add water or high moisture materials • Remix or add drier materials • Add higher N materials • Add wood chips/large particle size material • Make pile larger
Pile gets too hot	• Too much high N materials	• Add more browns and aerate pile
Ammonia smell (N being released to air)	• Too many high N materials like grass clippings that aren't mixed well • Too many food scraps • Low oxygen	• Add higher carbon, brown materials and mix pile well
Rotten egg smell (sulfur meaning anaerobic decomposition)	• Low oxygen – too many small particles • Low oxygen – too much moisture	• Add in larger particle size materials (wood chips) • Tear apart materials clumping together and mix well

This chart was adapted from Appendix C of Rynk, R. (editor). 1992. On farm composting handbook. Plant and Life Sciences Publishing- Cornell University, Ithaca, NY and Compost Pile Troubleshooting by R. Sherman, NCSU

Temperatures staying too low are often due to not having enough N or green materials. If the compost pile lacks enough green materials to supply the N, a readily available nitrogen source mixed with wood chips (1 lb. of ammonium nitrate or 2 to 3 lbs. of blood meal with 30 pounds of wood chips) can be used instead of high N green organic material.

- Compost that is too dry can be easily addressed by adding water. Keep in mind that moisture additions will vary by season because outdoor piles experience ambient temperature and rainfall that speed up or slow down drying.
- Compost that is too wet may be a result of rainfall or it could be that there is not enough brown material added. One of the signs of a pile that is too moist is a sour or sulfur like odor that results from anaerobic (without oxygen) decomposition. While the composter can't adjust rainfall, adding wood chips could be a way to increase porosity, speed drying and move towards more ideal conditions.

Utilizing Compost in the Residential or Community Garden or Landscape

The benefits of compost use in gardens and landscape beds include:

- Can increase organic matter percentage in soil over time
- Can add beneficial microbial communities
- Can increase water holding capacity
- Can support soil organisms including insects and microbes
- Can add small amounts of macro- and micro-nutrients

Only stable (or finished) compost that is cool or only slightly warm, smells earthy and does not contain identifiable original material should be used. If too much undecomposed high carbon material is present when incorporated, microbes will use the N in the soil to support their growth and reproduction as they break down the remaining brown organic materials. Adding too much browns with high C organic matter directly to your garden will create demand for N as microorganisms rapidly reproduce and break down those materials. This can pull nutrients away from crops and damage plant productivity in addition to slowing down decomposition. Conversely, adding materials that are too high in N content can increase the likelihood of nutrient losses and runoff as N is released faster than plants can take it up.

Compost can be produced on-site (e.g. at home or in community gardens) or purchased as bags or bulk. However, it is critical to understand that not all composts are created equal. If purchased, care should be taken to use a source that has consistent quality and is free from weed seeds, pathogens or herbicide residues that could impact soils and crops. Always inquire about the materials used when purchasing composts. If composted animal wastes were used, be aware of the soluble salts content, which can be higher than in compost from plant waste. Frequent applications of compost over many years will impact the pH and nutrient availability in your garden soil. Use consistent soil testing to ensure that an oversupply of specific nutrients is not occurring. Compost is an excellent tool to address organic matter needs in the home garden, but additional tools may be needed to ensure soil quality and productivity.

Why don't we recommend using animal manures in small-scale composting?

We strongly urge all home composters not to use manure of any kind in small-scale composting because of the food safety risk associated with their use around edible crops. Small-scale systems are not usually able to maintain the needed temperature or duration to reduce the pathogen load. Commercial composting operations are better situated to compost in a way that properly addresses food safety risks. Therefore, we recommend focusing on compost made solely from plant materials for use in fruit and vegetable growing areas. Compost made with animal manures should be reserved for ornamental plantings. This recommendation also applies to compost teas using small-scale compost that contains animal manure.

Food safety isn't the only concern. Another issue is the composition of the manure. Manure can have high salt content which can reduce plant growth. Manures may also have high nitrogen levels, which could lead to nutrient loss through the air (volatilization) or picked up by rainfall and moved across the soil surface or down through the soil (leaching).

Manures can also contain weed seeds or herbicide residues if animals grazed on pasture or were fed hay that had been treated with certain herbicides (see Davis et al referenced below for specific products). Even if composting for use only in ornamental plants, it is essential to verify the source and feed materials of the animals that produced the manure and ensure the composting process is complete and thorough. This helps minimize the risk of herbicide residue damage.

A final important note on utilizing compost is that while it does contain plant nutrients, they are often not present in quantities sufficient to utilize compost in place of fertilizer. In well-finished compost, the actual levels of nitrogen, phosphorus and potassium (N-P-K) are often around 1-1-1. Often, nutrients are also found in compost in forms that must be broken down by microbes to be taken up by plants, which means the nutrients are not available for plant use as quickly as conventional fertilizers. Organic-N is an example. In fact, compost is generally classified as a soil conditioner and not a fertilizer for these reasons. Compost can be paired well with either conventional or organic fertilizer materials and can aid them in being broken down, stored in the soil and available to plants. Even if the raw nutrient levels of compost are low, the roles compost plays in sustainable soil and garden management are many!

Sources Cited and Additional References

Some tables were edited and updated from UT Extension Publication PB1479, Composting yard, garden and food wastes at home, written by Tom Samples and Mark Nash

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