

Composting

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Science of Composting

Composting carries out part of the earth's biological cycle of growth and decay.

Plants grow by capturing energy from the sun, carbon dioxide from the air, and nutrients and water from the soil. When plants (and the animals that eat them) die, they become raw material for the composting process. Microorganisms, fungi, insects, worms, mites, and other creatures convert the carbon from dead plants into energy for their own growth, releasing carbon dioxide into the air and generating heat in the process (Figure 13.1). They also recycle nutrients from decaying plants into their own bodies and eventually back into the soil through their waste or as decayed products as they die. Other plants and microorganisms use the carbon and nutrients released by the composting process, and the cycle begins again.

The material that remains from the decay process is similar to soil organic matter. It holds water and nutrients in the soil and makes the soil more porous and easier to dig.

The decay process can be manipulated to make it proceed quickly. The key is to balance food, water, and air in the compost pile to favor the growth of thermophilic (heat-loving) microorganisms.

One byproduct of microbial activity is heat. When conditions are favorable for high-temperature microorganisms, compost piles heat rapidly to 120°F to 150°F. The high temperature kills most weed seeds and pathogens (disease organisms) but does not kill mycorrhizae (beneficial fungi that help plant roots absorb nutrients). Once the hot phase is complete,

Gardeners have long made and used compost to improve garden soil.

Today, we also compost plant and vegetable matter because it is an important way to reduce the waste burned or dumped in landfills. Yard wastes and vegetable scraps can make up as much as 20 percent of household garbage. Composting effectively recycles that waste into valuable organic matter that can be used as soil amendments.

Backyard composting is a simple, yet important, way to improve our communities and the environment.

The benefits are the same whether you compost in carefully tended hot piles or in passively managed slow piles.

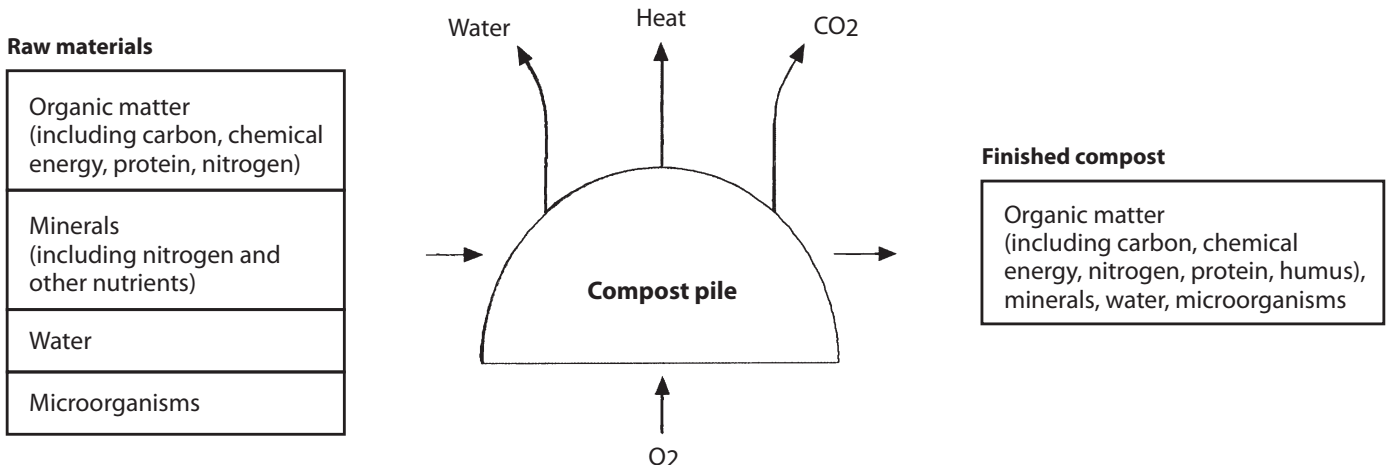


Figure 13.1. The composting process. The amounts of carbon, chemical energy, protein, and water in the finished compost are less than in the raw materials, and the finished compost has more humus. The volume of the finished compost is 50 percent or less of the volume of raw material.

lower-temperature microorganisms, worms, insects, and other invertebrates complete the decay process.

If ideal conditions for hot composting are not maintained, microorganisms still break down wastes, though decay is slower, cooler, and less effective at killing weed seeds and pathogens. Compost produced this way is still useful as a soil amendment, but it may contain weed seeds or pathogens if they were in the components used to make this “cold” compost.

Managing the Decay Process

The speed of the composting process and the quality of the finished compost are influenced by food, particle size, mixing, pile size, moisture, aeration, microorganisms, and nutrients.

Food (Raw Materials)

For fast composting, the initial mix must have the proper moisture and air content as well as organic materials that provide a rich food (energy) source for bacteria. Table 13.1 shows some materials commonly used in making compost. They are separated into energy materials, bulking agents, and balanced materials.

Energy materials provide the nitrogen and high-energy carbon compounds needed for fast microbial growth. If compost lacks bulking agents, these materials usually are too wet and dense to allow much air into the compost pile. When the pile is opened, it will have a foul, “rotten egg” smell.

Bulking agents are dry, porous materials that help aerate the compost pile. They are too low in moisture and nutrients to decay quickly on their own.

Balanced raw materials have both energy and bulking agent properties. These materials compost readily without being blended with other ingredients. Examples include horse

manure mixed with bedding, spoiled alfalfa hay, and deciduous leaves. These materials are handy for ensuring the success of hot compost piles.

If balanced raw materials are not available, mixing bulking agents with energy sources provides the right balance of moisture, air, and nutrients for rapid composting. A mixture of one part energy source with two parts bulking agent (by volume) usually gives a reasonable mix for rapid composting. If energy materials are not available, a high-nitrogen fertilizer such as urea (44–0–0) or a high-nitrogen lawn-type fertilizer (without pesticides) may be added at a rate of about four ounces (one-half cup) per bushel, or about two to three pounds per cubic yard of starting compost material.

Particle Size

Small particles have more surface area for microbial activity and are easier to mix. Grinding, cutting, smashing, or chopping raw materials reduces particle size. Hot composting requires a relatively uniform particle that is one-eighth to one-half inch in diameter.

Often, woody branches that have not been ground make it difficult to turn a pile. They also decompose very slowly. Grinding or chipping woody branches or piling them separately to allow them to slowly decay on their own may make the composting process work more efficiently.

Mixing

Contrary to popular opinion, layering is not the best way to build a pile. If all the materials are on hand when the pile is being built, mix them thoroughly throughout the pile. If materials accumulate over time, add new materials to the center of the pile. This practice helps aerate the center, where lack of oxygen is likely to occur.

Pile Size

If you are hot composting, the pile must be big enough to hold heat. A pile of about one cubic yard is big enough for year-round composting, even in cold-winter areas. A hot pile decays much faster than a cold pile. Small piles are usually colder because they have small cores that hold less heat. They also dry out faster.

Moisture

All materials in the pile must be moist but not soaking wet. Check moisture when the pile is turned. The mixed material should feel moist, but you should not be able to squeeze water out of it. At dry times of the year, you may need to add water.

Air

The microorganisms responsible for fast decomposition need oxygen, so the pile needs to be porous enough to pull in

Table 13.1. Compost raw materials.

<p>Energy materials (<i>High moisture, low porosity, high nitrogen</i>)</p> <ul style="list-style-type: none"> • Grass clippings • Fresh dairy, chicken, or rabbit manure • Fruit and vegetable waste • Garden trimmings
<p>Bulking agents (<i>Low moisture, high porosity, low nitrogen</i>)</p> <ul style="list-style-type: none"> • Wood chips • Sawdust • Grass hay • Wheat straw • Corn stalks • Plain cardboard (not coated in slick paper or plastic)
<p>Balanced raw materials (<i>Low to medium moisture, medium porosity, medium nitrogen</i>)</p> <ul style="list-style-type: none"> • Ground-up tree and shrub trimmings • Horse manure and bedding • Deciduous leaves • Legume hay • Cow/dairy manure with bedding

outside air to replenish oxygen as it is used. Including bulking agents in the mix creates a porous pile. As the pile decomposes, it will settle, reducing its exposure to air (aeration). Turning the pile or adding more bulking agents improves aeration.

Microorganisms

Raw materials used to form a compost pile usually contain all the microorganisms needed to make compost. If they're needed, the best source of microorganisms is finished compost. You don't need compost starters with special microorganisms. For a new compost pile, a few cups of garden soil may help start the process.

Nutrients

Just like people, microorganisms need nutrients (such as nitrogen, phosphorus, and sulfur) to grow and reproduce. These nutrients occur in the raw materials used in the compost mix. You usually don't need additional fertilizer from any source (organic or inorganic).

Nitrogen fertilizer may be beneficial for mixes consisting mainly of bulking agents. The best way to add fertilizer is to dissolve it in water and wet the pile with a dilute solution.

Additives such as blood meal and bone meal are simply organic fertilizers; they do not contribute anything magical to the compost pile.

How to Make Compost

You don't need a bin or other container to make compost. Piles work well. Some people prefer containers, however, because they look neater or because it is easier to shield them from pests. Containers can be simple or fancy. Make them from materials such as old pallets, lumber, mesh fencing, or cinder blocks (Figure 13.2).

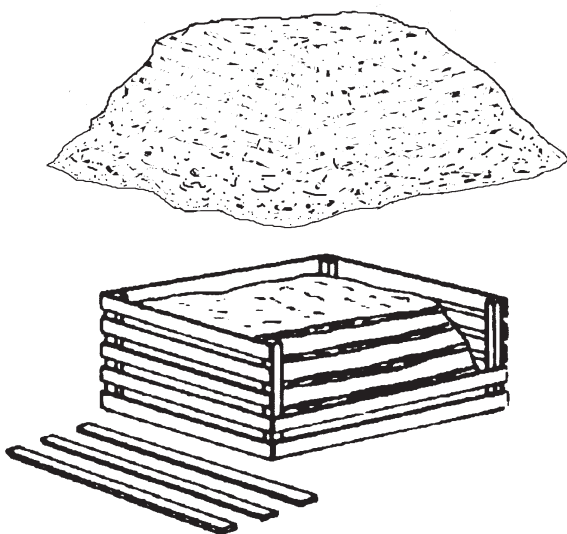


Figure 13.2. Some people compost in open piles; others prefer using bins.

Slow (Cold) Composting

You can turn yard wastes into a useful soil amendment conveniently and easily by slow composting. It often is the best method for people who do not have the time to tend a hot compost pile. Simply mix nonwoody yard wastes into a pile and let them sit for a year or so. Microorganisms, insects, earthworms, and other decomposers will slowly break down the wastes. A mixture of energy materials and bulking agents provides the best food source and environment for decomposition (see Table 13.1).

Add fresh wastes by opening the pile, placing the wastes in the center, and covering them. This method helps aerate the pile and also buries the fresh wastes so they do not attract pests such as flies, rats, and raccoons.

Fruit and vegetable wastes are particularly appealing to pests, so be sure to bury these wastes within the pile. If pests are still a problem, you may need to screen the pile or use another method of composting those wastes.

One option is to bury them directly in your garden. Dig a hole or trench about a foot deep, add a few inches of waste, mix it with the soil, and refill the trench with soil.

Another way to avoid pests is to compost fruit and vegetable wastes in a worm bin (described later in this chapter).

Slow composting does not produce the heat needed to kill many weed seeds. It is best to pull and compost weeds before they go to seed. If you put seeds in the compost pile, be prepared for more weeding.

Fast (Hot) Composting

If you create and maintain a balance of air, moisture, and energy for compost microorganisms, they produce a hot pile that breaks down quickly. The heat kills many weed seeds and disease organisms. Making hot compost takes extra effort, but it produces a high-quality product quickly.

One method for making hot compost is described below.

Steps for building the pile

1. Collect enough material to make a pile at least one cubic yard in volume. (An open pile five feet wide at the base by three feet high holds about a cubic yard.) Use roughly two parts bulking agent to one part energy material (see Table 13.1). Chop, shred, mow, or smash coarse materials so they will break down faster.
2. Start the pile by adding energy material and bulking agent, then mix with a pitchfork.
3. Squeeze a handful of the mixed material to check its moisture level. If you can barely squeeze out a drop of water, the moisture level is ideal. If the pile is too dry, add water and check the moisture again. If it is too wet, mix in some drier material.
4. Continue adding energy material and bulking agent, mixing, and checking moisture until the pile is built.

Turning

Use a pitchfork to turn the pile weekly, and add water when needed. Turning improves the porosity of the pile and speeds decay. It also mixes material from the outside of the pile into the hot center. Cover the pile during rainy periods so it will not get too wet.

Curing

After initial mixing, a regularly turned pile usually stays hot (120°F to 150°F) for several weeks to a month. It will shrink to about half its original volume by the end of this time.

The pile then needs to sit another four to eight weeks to cure. Curing affects the availability of nitrogen and the microbial activity of the compost. Uncured compost may harm some plants, especially when compost is used in potting soil or to start seeds. Curing is less critical when small amounts of compost are worked into soil. With two compost piles, one batch can cure while another batch is started in the second pile.

Temperatures during curing are 80°F to 110°F. The compost is ready to use when at least eight weeks have passed since initial mixing, the pile no longer heats when turned, and the material looks dark and crumbly.

What if Hot Compost Isn't Hot?

If the pile isn't hot, do the following:

- If the pile is dry, add more moisture.
- If the pile is mostly bulking agent, add energy materials or nitrogen fertilizer.
- If the pile is too wet, add more bulking agent. In the rainy season, cover the pile or build a larger one.
- If the pile has a foul smell, try turning it more often or adding more bulking agent to increase the amount of air.
- If the pile is too small, try building a larger pile to better hold heat.

Sometimes you may have several problems to overcome. If the pile will not heat, all is not lost, because the pile will eventually break down by the slow method.

Using Compost

Compost's biggest benefit is to the garden. Mix compost with soil to add organic matter or use it as mulch.

Amending Soil

Well-decomposed, earthy compost is a good soil amendment. It makes soil easier to work and creates a better medium for plant growth. Mix one to two inches of compost into your soil before you plant a vegetable garden, lawn, flower bed, or cover crop.

Mulching

Compost applied to the soil surface helps to control weeds, conserve water, and protect soil from erosion. The best time to apply compost mulches is in early summer, after plants are established and the soil has warmed. Later, the mulch can be dug or tilled into the soil. When you are mulching perennial plantings, choose compost made from woody bulking agents; it decomposes slowly, resists compaction, and slows the establishment of weeds.

Sometimes compost will form a mat, crusting on the soil surface and impeding water movement into the soil. If matting does occur, simply work the compost into the upper soil layers to prevent crusting.

Worm Bins: A Way to Compost Food Wastes to Avoid Pests

Kitchen scraps composted in an outdoor bin sometimes attract pests, so you might prefer to compost them using worm bins.

Starting a Worm Bin

Most worm bins are made of plywood, but large plastic tubs with covers also work, as long as it is possible to drain off excess moisture. One solution is to nest two plastic containers and make holes in the bottom and the lower third of the sides of the upper container, allowing excess moisture to escape and collect in the lower container. Worms avoid light, so the container's interior should be dark, and it should have a good lid. The lid should cover the top but does not need to be securely attached. The container should have air holes—either on the lid, sides, or, if the container is not sitting directly on the ground, on the bottom. If you use a plastic bin, be sure to add both drainage and air holes. Never use a container that has been used for storing toxic chemicals. Construction plans for worm bins are available from many Extension offices or county solid waste departments.

The size depends on how much food waste you add per week. A box measuring one foot by two feet by three feet can handle six pounds of kitchen waste per week, which is about average for a family of four to six.

Place worm bins where you can control temperature and moisture. An ideal temperature range for worms is from 55°F to 77°F. Worms also need a moist environment (more on this below), and air circulation is a must in and around a worm box. Choose a location that is convenient for maintaining the box.

Start by putting bedding in the worm box. Corrugated cardboard, newsprint, and newspaper shredded in one-inch-wide strips make excellent bedding. Worms need some grit for breaking down their food, so add a little topsoil for this purpose. Put the worms in the bedding with their first feeding of food waste.

Many food wastes can be composted in worm bins. These wastes include fruit and vegetable peels, grains, pasta, baked

Commonly Asked Questions About Worms

Can a worm see?

No, worms don't have eyes. However, they are very sensitive to light, and they try to hide as soon as they are exposed to light.

Where is the worm's mouth?

The worm's mouth is in the first anterior segment. There is a small protruding lip just over the mouth. When the worm is foraging, this lip stretches out to sense food.

Does a worm have teeth?

Worms have no teeth for chewing their food. They grind food in their gizzard by muscle action.

How does a worm grind his food?

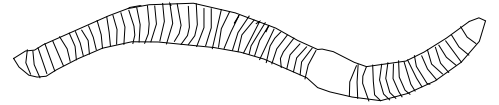
A worm can take only a small particle of soft, moistened food in its mouth. It ingests the food along with a grinding material such as sand, topsoil, or limestone. Contractions from muscles in the gizzard compress the particles against each other, thus mixing them with fluid and grinding them into smaller pieces.

Do worms need air?

Worms need a constant supply of oxygen from the air. The oxygen diffuses across the moist tissue of their skin, from the region of greater oxygen concentration (air) to that of lower concentration (inside the worm).

How do I use worm compost?

Use worm compost like any other compost. Sterilizing is not necessary.



goods, coffee grounds, and (in moderation) even coffee filters. Again, do not use animal products, including cheese, other dairy products, or meat.

Moisture

In order to survive, worms require 75 to 90 percent moisture in both their bodies and their bedding. To achieve this percentage, add three pounds of water for each pound of dry bedding (a ratio of 3:1). An easy way to check the moisture content of bedding is to squeeze it. If you release a few drops of moisture,

the bedding is moist enough. If you can squeeze out five or more drops, the bedding is probably too wet.

Kinds of worms to use

Two varieties of red worms adapt to a box environment: *Lumbricus rubellus* and *Eisenia foetida*. These red worms feed on the surface of organic matter.

Nightcrawlers and other garden earthworms are very important for soil improvement but won't survive in a worm box. They live only in furrows in the soil.

Health and Safety Questions

Are there any plant materials to keep out of a compost pile?

When composting by the slow method, keep diseased plants and seed heads of weeds out of the compost pile. For any compost, avoid coarse, woody materials because they break down slowly and make the pile hard to turn.

Some plants contain compounds that slow microbial decay. Eastern redcedar (*Juniperus*), often used for fence posts because of its resistance to decay, can break down slowly in compost piles. Also, avoid black walnut leaves and wood as these contain juglone, a compound that inhibits the growth of many plants. Some extremely dense, woody materials, such as avocado pits, do not compost.

Can a compost pile catch fire?

A compost pile will ignite only if it has a very hot zone next to a dry zone. Fires do not start in moist or small piles.

Can I use manure in my compost?

Fresh animal manures sometimes contain organisms that can make people sick (pathogens), such as the bacteria *Salmonella* sp. and *E. coli* O157:H7, or the parasite

Cryptosporidium parvum. These pathogens are not taken up into plants, but they can be present in soil that adheres to roots or low-growing leaves and fruits. The risk is minimized if no fresh manure is used in the garden.

Careful peeling or washing fruits and vegetables with detergent removes most pathogens, but some risk remains. Thorough cooking effectively kills pathogens.

The greatest risk from manure-borne pathogens is for low-growing or underground crops such as carrots, lettuce, and strawberries. The edible part of these crops may become contaminated with soil, the crops are difficult to wash, and they often are eaten raw.

Pathogens in fresh manure typically die over time, especially when the manure dries out or is exposed to freezing and thawing. The rate of die-off depends on the type of pathogen and manure and on environmental conditions such as temperature, moisture, and sunlight. Thorough, high-temperature composting kills pathogens, but it is difficult to maintain these conditions in a backyard compost pile. **If any manure is used in the garden (even in compost), the gardener should wait at least 120 days between application to the garden and harvest.** You can limit your risk by excluding fresh manure from compost that will be used on fresh garden crops.

Keep dog, cat, and pig manure out of your compost pile and garden. Some of the parasites found in these manures may survive a long time in compost or in the soil and remain infectious to people.

Are herbicides a problem in compost?

On rare occasions, herbicides from compost have harmed plants grown in soils amended with the compost.

Herbicides break down in the environment over time. The rate of breakdown depends on the type of herbicide and environmental conditions. The high temperatures and biological activity in a compost pile accelerate herbicide breakdown. Herbicides also are inactivated by binding with organic matter in compost. Breakdown and binding reduce the risk of herbicide damage.

Lawn clippings can be a source of herbicides in compost. The best way to eliminate this source is to leave treated clippings on the lawn rather than composting them. Other options are to reduce herbicide use in areas where you compost the residues, or to use herbicides that break down quickly.

If you suspect there are herbicides in your compost pile, let the pile sit for a year or more, allowing more time for breakdown and binding.

Troubleshooting Tips

In General:

- Control odors by removing excess or inappropriate waste.
- Make sure you haven't added cheese or other animal products of any type to the compost system.

For Worm Boxes:

- Provide adequate fresh bedding.
- Do not fill the bin with a lot of food waste until the worm population is established.
- Minimize fruit flies by covering fresh food waste completely with several inches of bedding and covering the bedding with a sheet of newspaper, cardboard, or plastic tucked in around the edges.

- If you see signs of rodents or other animals around the worm bin, place a sheet of wire mesh over the bottom of the bin or raise the bin 12 to 18 inches off the ground.
- Keep the lid latched or well secured if possums or raccoons are a problem.

Number of Worms

Measure worms by weight rather than number. The number of worms you'll need depends on the weight of the food waste you plan to add each day, on average. Start by adding one pound of waste each day for each pound of worms.

After that, let the worms tell you how much food to add. If all the food is gone between feedings, add a little more. If the bin starts to smell because food is not being eaten, add less.

Adding Waste

It is a good practice to vary where you bury wastes in the worm box. You can bury kitchen wastes in about nine places in a worm box that is two feet by two feet, and that's nine feedings before you have to bury again at the first location.

Kitchen wastes break down very quickly, so you don't need to grind them. Do pulverize egg shells.

Leaving the Box Untended

When you're away from home for a few days, just feed the worms a little extra and leave them undisturbed. They can go three to four weeks without feeding. Make arrangements with someone else to feed the worms when you'll be away longer.

Changing the Bedding

After some time, the bedding's color will darken. Eventually, it will disappear as worms and microorganisms decompose it. Both processes create a less favorable environment for the worms. Also, as castings accumulate in large amounts, it harms the worms—castings of one worm are toxic to other worms. Decide when to change the bedding based on its condition and the number of worms in the box.

Population Control

Worms multiply fast, so you'll need to take care that they don't overpopulate. Use extra worms to start a new worm box, or give them to someone else who is starting to worm compost.

Worms can be obtained in many ways:

- Ask a friend who already maintains a worm bin.
- Search the internet for worm sources.
- Check with your county Extension office for any upcoming workshops involving composting with worms.

Odor and Pest Control

Control odors by not overloading the box with waste, using only appropriate waste, and providing adequate fresh bedding. Do not fill the bin with a lot of food waste until the worm population is established. Fruit flies are more of a nuisance than a serious problem, but the troubleshooting tips in this chapter can help you deal with them.

For More Information

For more information, contact your county Extension agent.

University of Kentucky Cooperative Extension Service Publications

Home Composting (HO-75)

Constructing a Wire-Mesh Compost Bin (ENRI-307)

Constructing a Wooden-Pallet Compost Bin (ENRI-308)

Constructing a Snow-Fence Compost Bin (ENRI-309)

Constructing a Wood-and-Wire Compost Bin (ENRI-310)

Constructing a Garbage Can Compost Bin (ENRI-311)

Constructing a Worm Composting Bin (ENRI-312)

Vermicomposting: Building a Worm Bin, University of Kentucky Extension Service

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